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# TensorLayer Documentation

*Release 1.11.1*

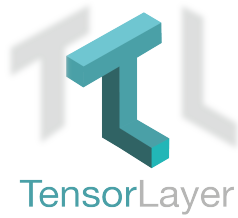
**TensorLayer contributors**

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**Documentation Version:** 1.11.1

**Good News:** We won the **Best Open Source Software Award** @ACM Multimedia (MM) 2017.

TensorLayer is a Deep Learning (DL) and Reinforcement Learning (RL) library extended from Google TensorFlow. It provides popular DL and RL modules that can be easily customized and assembled for tackling real-world machine learning problems. More details can be found [here](#).

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**Note:** If you got problem to read the docs online, you could download the repository on [GitHub](#), then go to `/docs/_build/html/index.html` to read the docs offline. The `_build` folder can be generated in `docs` using `make html`.

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The TensorLayer user guide explains how to install TensorFlow, CUDA and cuDNN, how to build and train neural networks using TensorLayer, and how to contribute to the library as a developer.

## 1.1 Installation

TensorLayer has some prerequisites that need to be installed first, including [TensorFlow](#) , numpy and matplotlib. For GPU support CUDA and cuDNN are required.

If you run into any trouble, please check the [TensorFlow installation instructions](#) which cover installing the TensorFlow for a range of operating systems including Mac OS, Linux and Windows, or ask for help on [tensorlayer@gmail.com](mailto:tensorlayer@gmail.com) or [FAQ](#).

### 1.1.1 Step 1 : Install dependencies

TensorLayer is build on the top of Python-version TensorFlow, so please install Python first.

---

**Note:** We highly recommend python3 instead of python2 for the sake of future.

---

Python includes `pip` command for installing additional modules is recommended. Besides, a [virtual environment](#) via `virtualenv` can help you to manage python packages.

Take Python3 on Ubuntu for example, to install Python includes `pip`, run the following commands:

```
sudo apt-get install python3
sudo apt-get install python3-pip
sudo pip3 install virtualenv
```

To build a virtual environment and install dependencies into it, run the following commands: (You can also skip to Step 3, automatically install the prerequisites by TensorLayer)

```
virtualenv env
env/bin/pip install matplotlib
env/bin/pip install numpy
env/bin/pip install scipy
env/bin/pip install scikit-image
```

To check the installed packages, run the following command:

```
env/bin/pip list
```

After that, you can run python script by using the virtual python as follow.

```
env/bin/python *.py
```

### 1.1.2 Step 2 : TensorFlow

The installation instructions of TensorFlow are written to be very detailed on [TensorFlow](#) website. However, there are something need to be considered. For example, [TensorFlow](#) officially supports GPU acceleration for Linux, Mac OS and Windows at present.

**Warning:** For ARM processor architecture, you need to install TensorFlow from source.

### 1.1.3 Step 3 : TensorLayer

The simplest way to install TensorLayer is as follow, it will also install the numpy and matplotlib automatically.

```
[stable version] pip install tensorlayer
[master version] pip install git+https://github.com/tensorlayer/tensorlayer.git
```

However, if you want to modify or extend TensorLayer, you can download the repository from [Github](#) and install it as follow.

```
cd to the root of the git tree
pip install -e .
```

This command will run the `setup.py` to install TensorLayer. The `-e` reflects editable, then you can edit the source code in `tensorlayer` folder, and import the edited TensorLayer.

### 1.1.4 Step 4 : GPU support

Thanks to NVIDIA supports, training a fully connected network on a GPU, which may be 10 to 20 times faster than training them on a CPU. For convolutional network, may have 50 times faster. This requires an NVIDIA GPU with CUDA and cuDNN support.

#### CUDA

The TensorFlow website also teach how to install the CUDA and cuDNN, please see [TensorFlow GPU Support](#).

Download and install the latest CUDA is available from NVIDIA website:

- [CUDA download and install](#)



If CUDA is set up correctly, the following command should print some GPU information on the terminal:

```
python -c "import tensorflow"
```

## cuDNN

Apart from CUDA, NVIDIA also provides a library for common neural network operations that especially speeds up Convolutional Neural Networks (CNNs). Again, it can be obtained from NVIDIA after registering as a developer (it take a while):

Download and install the latest cuDNN is available from NVIDIA website:

- [cuDNN download and install](#)

To install it, copy the \*.h files to /usr/local/cuda/include and the lib\* files to /usr/local/cuda/lib64.

## 1.1.5 Windows User

TensorLayer is built on the top of Python-version TensorFlow, so please install Python first. Note We highly recommend installing Anaconda. The lowest version requirements of Python is py35.

[Anaconda download](#)

## GPU support

Thanks to NVIDIA supports, training a fully connected network on a GPU, which may be 10 to 20 times faster than training them on a CPU. For convolutional network, may have 50 times faster. This requires an NVIDIA GPU with CUDA and cuDNN support.

## 1. Installing Microsoft Visual Studio

You should preinstall Microsoft Visual Studio (VS) before installing CUDA. The lowest version requirements is VS2010. We recommend installing VS2015 or VS2013. CUDA7.5 supports VS2010, VS2012 and VS2013. CUDA8.0 also supports VS2015.

## 2. Installing CUDA

Download and install the latest CUDA is available from NVIDIA website:

[CUDA download](#)

We do not recommend modifying the default installation directory.

## 3. Installing cuDNN

The NVIDIA CUDA® Deep Neural Network library (cuDNN) is a GPU-accelerated library of primitives for deep neural networks. Download and extract the latest cuDNN is available from NVIDIA website:

[cuDNN download](#)

After extracting cuDNN, you will get three folders (bin, lib, include). Then these folders should be copied to CUDA installation. (The default installation directory is *C:\Program Files\NVIDIA GPU Computing Toolkit\CUDA\v8.0*)

## Installing TensorLayer

You can easily install Tensorlayer using pip in CMD

```
pip install tensorflow          #CPU version
pip install tensorflow-gpu      #GPU version (GPU version and CPU version just choose
↪ one)
pip install tensorlayer        #Install tensorlayer
```

## Test

Enter “python” in CMD. Then:

```
import tensorlayer
```

If there is no error and the following output is displayed, the GPU version is successfully installed.

```
successfully opened CUDA library cublas64_80.dll locally
successfully opened CUDA library cuDNN64_5.dll locally
successfully opened CUDA library cufft64_80.dll locally
successfully opened CUDA library nvcuda.dll locally
successfully opened CUDA library curand64_80.dll locally
```

If there is no error, the CPU version is successfully installed.

### 1.1.6 Issue

If you get the following output when import tensorlayer, please read [FQA](#).

```
_tkinter.TclError: no display name and no $DISPLAY environment variable
```

## 1.2 Tutorials

For deep learning, this tutorial will walk you through building handwritten digits classifiers using the MNIST dataset, arguably the “Hello World” of neural networks. For reinforcement learning, we will let computer learns to play Pong game from the original screen inputs. For nature language processing, we start from word embedding and then describe language modeling and machine translation.

This tutorial includes all modularized implementation of Google TensorFlow Deep Learning tutorial, so you could read TensorFlow Deep Learning tutorial at the same time [\[en\]](#) [\[cn\]](#) .

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**Note:** For experts: Read the source code of `InputLayer` and `DenseLayer`, you will understand how `TensorLayer` work. After that, we recommend you to read the codes on Github directly.

---

### 1.2.1 Before we start

The tutorial assumes that you are somewhat familiar with neural networks and TensorFlow (the library which `TensorLayer` is built on top of). You can try to learn the basics of a neural network from the [Deeplearning Tutorial](#).

For a more slow-paced introduction to artificial neural networks, we recommend [Convolutional Neural Networks for Visual Recognition](#) by Andrej Karpathy et al., [Neural Networks and Deep Learning](#) by Michael Nielsen.

To learn more about TensorFlow, have a look at the [TensorFlow tutorial](#). You will not need all of it, but a basic understanding of how TensorFlow works is required to be able to use [TensorLayer](#). If you're new to TensorFlow, going through that tutorial.

## 1.2.2 TensorLayer is simple

The following code shows a simple example of TensorLayer, see `tutorial_mnist_simple.py`. We provide a lot of simple functions like `fit()`, `test()`, however, if you want to understand the details and be a machine learning expert, we suggest you to train the network by using the data iteration toolbox (`tl.iterate`) and the TensorFlow's native API like `sess.run()`, see `tutorial_mnist.py` <[https://github.com/tensorlayer/tensorlayer/blob/master/example/tutorial\\_mnist.py](https://github.com/tensorlayer/tensorlayer/blob/master/example/tutorial_mnist.py)>, `tutorial_mlp_dropout1.py` and `tutorial_mlp_dropout2.py` <[https://github.com/tensorlayer/tensorlayer/blob/master/example/tutorial\\_mlp\\_dropout2.py](https://github.com/tensorlayer/tensorlayer/blob/master/example/tutorial_mlp_dropout2.py)> for more details.

```
import tensorflow as tf
import tensorlayer as tl

sess = tf.InteractiveSession()

# prepare data
X_train, y_train, X_val, y_val, X_test, y_test = \
    tl.files.load_mnist_dataset(shape=(-1, 784))

# define placeholder
x = tf.placeholder(tf.float32, shape=[None, 784], name='x')
y_ = tf.placeholder(tf.int64, shape=[None, ], name='y_')

# define the network
network = tl.layers.InputLayer(x, name='input_layer')
network = tl.layers.DropoutLayer(network, keep=0.8, name='drop1')
network = tl.layers.DenseLayer(network, n_units=800,
                                act=tf.nn.relu, name='relu1')
network = tl.layers.DropoutLayer(network, keep=0.5, name='drop2')
network = tl.layers.DenseLayer(network, n_units=800,
                                act=tf.nn.relu, name='relu2')
network = tl.layers.DropoutLayer(network, keep=0.5, name='drop3')
# the softmax is implemented internally in tl.cost.cross_entropy(y, y_, 'cost') to
# speed up computation, so we use identity here.
# see tf.nn.sparse_softmax_cross_entropy_with_logits()
network = tl.layers.DenseLayer(network, n_units=10,
                                act=tf.identity,
                                name='output_layer')

# define cost function and metric.
y = network.outputs
cost = tl.cost.cross_entropy(y, y_, 'cost')
correct_prediction = tf.equal(tf.argmax(y, 1), y_)
acc = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))
y_op = tf.argmax(tf.nn.softmax(y), 1)

# define the optimizer
train_params = network.all_params
train_op = tf.train.AdamOptimizer(learning_rate=0.0001, beta1=0.9, beta2=0.999,
                                  epsilon=1e-08, use_locking=False).minimize(cost, var_
↪list=train_params)
```

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```
# initialize all variables in the session
tl.layers.initialize_global_variables(sess)

# print network information
network.print_params()
network.print_layers()

# train the network
tl.utils.fit(sess, network, train_op, cost, X_train, y_train, x, y_,
            acc=acc, batch_size=500, n_epoch=500, print_freq=5,
            X_val=X_val, y_val=y_val, eval_train=False)

# evaluation
tl.utils.test(sess, network, acc, X_test, y_test, x, y_, batch_size=None, cost=cost)

# save the network to .npz file
tl.files.save_npz(network.all_params, name='model.npz')
sess.close()
```

### 1.2.3 Run the MNIST example



In the first part of the tutorial, we will just run the MNIST example that's included in the source distribution of [TensorLayer](#). The MNIST dataset contains 60000 handwritten digits that are commonly used for training various image processing systems. Each digit is 28x28 pixels in size.

We assume that you have already run through the [Installation](#). If you haven't done so already, get a copy of the source tree of TensorLayer, and navigate to the folder in a terminal window. Enter the folder and run the `tutorial_mnist.py` example script:

```
python tutorial_mnist.py
```

If everything is set up correctly, you will get an output like the following:

```
tensorlayer: GPU MEM Fraction 0.300000
Downloading train-images-idx3-ubyte.gz
Downloading train-labels-idx1-ubyte.gz
Downloading t10k-images-idx3-ubyte.gz
Downloading t10k-labels-idx1-ubyte.gz
```

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```

X_train.shape (50000, 784)
y_train.shape (50000,)
X_val.shape (10000, 784)
y_val.shape (10000,)
X_test.shape (10000, 784)
y_test.shape (10000,)
X float32    y int64

[TL] InputLayer    input_layer (?, 784)
[TL] DropoutLayer drop1: keep: 0.800000
[TL] DenseLayer    relu1: 800, relu
[TL] DropoutLayer drop2: keep: 0.500000
[TL] DenseLayer    relu2: 800, relu
[TL] DropoutLayer drop3: keep: 0.500000
[TL] DenseLayer    output_layer: 10, identity

param 0: (784, 800) (mean: -0.000053, median: -0.000043 std: 0.035558)
param 1: (800,)      (mean:  0.000000, median:  0.000000 std: 0.000000)
param 2: (800, 800) (mean:  0.000008, median:  0.000041 std: 0.035371)
param 3: (800,)      (mean:  0.000000, median:  0.000000 std: 0.000000)
param 4: (800, 10)  (mean:  0.000469, median:  0.000432 std: 0.049895)
param 5: (10,)      (mean:  0.000000, median:  0.000000 std: 0.000000)
num of params: 1276810

layer 0: Tensor("dropout/mul_1:0", shape=(?, 784), dtype=float32)
layer 1: Tensor("Relu:0", shape=(?, 800), dtype=float32)
layer 2: Tensor("dropout_1/mul_1:0", shape=(?, 800), dtype=float32)
layer 3: Tensor("Relu_1:0", shape=(?, 800), dtype=float32)
layer 4: Tensor("dropout_2/mul_1:0", shape=(?, 800), dtype=float32)
layer 5: Tensor("add_2:0", shape=(?, 10), dtype=float32)

learning_rate: 0.000100
batch_size: 128

Epoch 1 of 500 took 0.342539s
  train loss: 0.330111
  val loss: 0.298098
  val acc: 0.910700
Epoch 10 of 500 took 0.356471s
  train loss: 0.085225
  val loss: 0.097082
  val acc: 0.971700
Epoch 20 of 500 took 0.352137s
  train loss: 0.040741
  val loss: 0.070149
  val acc: 0.978600
Epoch 30 of 500 took 0.350814s
  train loss: 0.022995
  val loss: 0.060471
  val acc: 0.982800
Epoch 40 of 500 took 0.350996s
  train loss: 0.013713
  val loss: 0.055777
  val acc: 0.983700
...

```

The example script allows you to try different models, including Multi-Layer Perceptron, Dropout, Dropconnect,

Stacked Denoising Autoencoder and Convolutional Neural Network. Select different models from `if __name__ == '__main__':`.

```
main_test_layers(model='relu')
main_test_denoise_AE(model='relu')
main_test_stacked_denoise_AE(model='relu')
main_test_cnn_layer()
```

## 1.2.4 Understand the MNIST example

Let's now investigate what's needed to make that happen! To follow along, open up the source code.

### Preface

The first thing you might notice is that besides TensorLayer, we also import numpy and tensorflow:

```
import tensorflow as tf
import tensorlayer as tl
from tensorlayer.layers import set_keep
import numpy as np
import time
```

As we know, TensorLayer is built on top of TensorFlow, it is meant as a supplement helping with some tasks, not as a replacement. You will always mix TensorLayer with some vanilla TensorFlow code. The `set_keep` is used to access the placeholder of keeping probabilities when using Denoising Autoencoder.

### Loading data

The first piece of code defines a function `load_mnist_dataset()`. Its purpose is to download the MNIST dataset (if it hasn't been downloaded yet) and return it in the form of regular numpy arrays. There is no TensorLayer involved at all, so for the purpose of this tutorial, we can regard it as:

```
X_train, y_train, X_val, y_val, X_test, y_test = \
    tl.files.load_mnist_dataset(shape=(-1, 784))
```

`X_train.shape` is `(50000, 784)`, to be interpreted as: 50,000 images and each image has 784 pixels. `y_train.shape` is simply `(50000,)`, which is a vector the same length of `X_train` giving an integer class label for each image – namely, the digit between 0 and 9 depicted in the image (according to the human annotator who drew that digit).

For Convolutional Neural Network example, the MNIST can be load as 4D version as follow:

```
X_train, y_train, X_val, y_val, X_test, y_test = \
    tl.files.load_mnist_dataset(shape=(-1, 28, 28, 1))
```

`X_train.shape` is `(50000, 28, 28, 1)` which represents 50,000 images with 1 channel, 28 rows and 28 columns each. Channel one is because it is a grey scale image, every pixel has only one value.

### Building the model

This is where TensorLayer steps in. It allows you to define an arbitrarily structured neural network by creating and stacking or merging layers. Since every layer knows its immediate incoming layers, the output layer (or output layers)

of a network double as a handle to the network as a whole, so usually this is the only thing we will pass on to the rest of the code.

As mentioned above, `tutorial_mnist.py` supports four types of models, and we implement that via easily exchangeable functions of the same interface. First, we'll define a function that creates a Multi-Layer Perceptron (MLP) of a fixed architecture, explaining all the steps in detail. We'll then implement a Denoising Autoencoder (DAE), after that we will then stack all Denoising Autoencoder and supervised fine-tune them. Finally, we'll show how to create a Convolutional Neural Network (CNN). In addition, a simple example for MNIST dataset in `tutorial_mnist_simple.py`, a CNN example for the CIFAR-10 dataset in `tutorial_cifar10_tfrecord.py`.

## Multi-Layer Perceptron (MLP)

The first script, `main_test_layers()`, creates an MLP of two hidden layers of 800 units each, followed by a softmax output layer of 10 units. It applies 20% dropout to the input data and 50% dropout to the hidden layers.

To feed data into the network, TensorFlow placeholders need to be defined as follow. The `None` here means the network will accept input data of arbitrary batch size after compilation. The `x` is used to hold the `x_train` data and `y_` is used to hold the `y_train` data. If you know the batch size beforehand and do not need this flexibility, you should give the batch size here – especially for convolutional layers, this can allow TensorFlow to apply some optimizations.

```
x = tf.placeholder(tf.float32, shape=[None, 784], name='x')
y_ = tf.placeholder(tf.int64, shape=[None, ], name='y_')
```

The foundation of each neural network in TensorLayer is an `InputLayer` instance representing the input data that will subsequently be fed to the network. Note that the `InputLayer` is not tied to any specific data yet.

```
network = tl.layers.InputLayer(x, name='input')
```

Before adding the first hidden layer, we'll apply 20% dropout to the input data. This is realized via a `DropoutLayer` instance:

```
network = tl.layers.DropoutLayer(network, keep=0.8, name='drop1')
```

Note that the first constructor argument is the incoming layer, the second argument is the keeping probability for the activation value. Now we'll proceed with the first fully-connected hidden layer of 800 units. Note that when stacking a `DenseLayer`.

```
network = tl.layers.DenseLayer(network, n_units=800, act = tf.nn.relu, name='relu1')
```

Again, the first constructor argument means that we're stacking `network` on top of `network`. `n_units` simply gives the number of units for this fully-connected layer. `act` takes an activation function, several of which are defined in `tensorflow.nn` and `tensorlayer.activation`. Here we've chosen the rectifier, so we'll obtain ReLUs. We'll now add dropout of 50%, another 800-unit dense layer and 50% dropout again:

```
network = tl.layers.DropoutLayer(network, keep=0.5, name='drop2')
network = tl.layers.DenseLayer(network, n_units=800, act = tf.nn.relu, name='relu2')
network = tl.layers.DropoutLayer(network, keep=0.5, name='drop3')
```

Finally, we'll add the fully-connected output layer which the `n_units` equals to the number of classes. Note that, the softmax is implemented internally in `tf.nn.sparse_softmax_cross_entropy_with_logits()` to speed up computation, so we used identity in the last layer, more details in `tl.cost.cross_entropy()`.

```
network = tl.layers.DenseLayer(network,
                                n_units=10,
                                act = tf.identity,
                                name='output')
```

As mentioned above, each layer is linked to its incoming layer(s), so we only need the output layer(s) to access a network in TensorLayer:

```
y = network.outputs
y_op = tf.argmax(tf.nn.softmax(y), 1)
cost = tf.reduce_mean(tf.nn.sparse_softmax_cross_entropy_with_logits(y, y_))
```

Here, `network.outputs` is the 10 identity outputs from the network (in one hot format), `y_op` is the integer output represents the class index. While `cost` is the cross-entropy between the target and the predicted labels.

## Denoising Autoencoder (DAE)

Autoencoder is an unsupervised learning model which is able to extract representative features, it has become more widely used for learning generative models of data and Greedy layer-wise pre-train. For vanilla Autoencoder, see [Deeplearning Tutorial](#).

The script `main_test_denoise_AE()` implements a Denoising Autoencoder with corrosion rate of 50%. The Autoencoder can be defined as follow, where an Autoencoder is represented by a `DenseLayer`:

```
network = tl.layers.InputLayer(x, name='input_layer')
network = tl.layers.DropoutLayer(network, keep=0.5, name='denoising1')
network = tl.layers.DenseLayer(network, n_units=200, act=tf.nn.sigmoid, name='sigmoid1
↪')
recon_layer1 = tl.layers.ReconLayer(network,
                                    x_recon=x,
                                    n_units=784,
                                    act=tf.nn.sigmoid,
                                    name='recon_layer1')
```

To train the `DenseLayer`, simply run `ReconLayer.pretrain()`, if using denoising Autoencoder, the name of corrosion layer (a `DropoutLayer`) need to be specified as follow. To save the feature images, set `save` to `True`. There are many kinds of pre-train metrics according to different architectures and applications. For sigmoid activation, the Autoencoder can be implemented by using KL divergence, while for rectifier, L1 regularization of activation outputs can make the output to be sparse. So the default behaviour of `ReconLayer` only provide KLD and cross-entropy for sigmoid activation function and L1 of activation outputs and mean-squared-error for rectifying activation function. We recommend you to modify `ReconLayer` to achieve your own pre-train metric.

```
recon_layer1.pretrain(sess,
                       x=x,
                       X_train=X_train,
                       X_val=X_val,
                       denoise_name='denoising1',
                       n_epoch=200,
                       batch_size=128,
                       print_freq=10,
                       save=True,
                       save_name='w1pre')
```

In addition, the script `main_test_stacked_denoise_AE()` shows how to stacked multiple Autoencoder to one network and then fine-tune.



## Convolutional Neural Network (CNN)

Finally, the `main_test_cnn_layer()` script creates two CNN layers and max pooling stages, a fully-connected hidden layer and a fully-connected output layer. More CNN examples can be found in other examples, like `tutorial_cifar10_tfrecord.py`.

```
network = tl.layers.Conv2d(network, 32, (5, 5), (1, 1),
                             act=tf.nn.relu, padding='SAME', name='cnn1')
network = tl.layers.MaxPool2d(network, (2, 2), (2, 2),
                               padding='SAME', name='pool1')
network = tl.layers.Conv2d(network, 64, (5, 5), (1, 1),
                             act=tf.nn.relu, padding='SAME', name='cnn2')
network = tl.layers.MaxPool2d(network, (2, 2), (2, 2),
                               padding='SAME', name='pool2')

network = tl.layers.FlattenLayer(network, name='flatten')
network = tl.layers.DropoutLayer(network, keep=0.5, name='drop1')
network = tl.layers.DenseLayer(network, 256, act=tf.nn.relu, name='relu1')
network = tl.layers.DropoutLayer(network, keep=0.5, name='drop2')
network = tl.layers.DenseLayer(network, 10, act=tf.identity, name='output')
```

## Training the model

The remaining part of the `tutorial_mnist.py` script copes with setting up and running a training loop over the MNIST dataset by using cross-entropy only.

## Dataset iteration

An iteration function for synchronously iterating over two numpy arrays of input data and targets, respectively, in mini-batches of a given number of items. More iteration function can be found in `tensorlayer.iterate`

```
tl.iterate.minibatches(inputs, targets, batchsize, shuffle=False)
```

## Loss and update expressions

Continuing, we create a loss expression to be minimized in training:

```
y = network.outputs
y_op = tf.argmax(tf.nn.softmax(y), 1)
cost = tf.reduce_mean(tf.nn.sparse_softmax_cross_entropy_with_logits(y, y_op))
```

More cost or regularization can be applied here. For example, to apply max-norm on the weight matrices, we can add the following line.

```
cost = cost + tl.cost.maxnorm_regularizer(1.0)(network.all_params[0]) +
          tl.cost.maxnorm_regularizer(1.0)(network.all_params[2])
```

Depending on the problem you are solving, you will need different loss functions, see `tensorlayer.cost` for more. Apart from using `network.all_params` to get the variables, we can also use `tl.layers.get_variables_with_name` to get the specific variables by string name.

Having the model and the loss function here, we create update expression/operation for training the network. TensorLayer does not provide many optimizers, we used TensorFlow's optimizer instead:

```
train_params = network.all_params
train_op = tf.train.AdamOptimizer(learning_rate, beta1=0.9, beta2=0.999,
    epsilon=1e-08, use_locking=False).minimize(cost, var_list=train_params)
```

For training the network, we fed data and the keeping probabilities to the `feed_dict`.

```
feed_dict = {x: X_train_a, y_: y_train_a}
feed_dict.update( network.all_drop )
sess.run(train_op, feed_dict=feed_dict)
```

While, for validation and testing, we use slightly different way. All Dropout, Dropconnect, Corrosion layers need to be disabled. We use `tl.utils.dict_to_one` to set all `network.all_drop` to 1.

```
dp_dict = tl.utils.dict_to_one( network.all_drop )
feed_dict = {x: X_test_a, y_: y_test_a}
feed_dict.update(dp_dict)
err, ac = sess.run([cost, acc], feed_dict=feed_dict)
```

For evaluation, we create an expression for the classification accuracy:

```
correct_prediction = tf.equal(tf.argmax(y, 1), y_)
acc = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))
```

## What Next?

We also have a more advanced image classification example in [tutorial\\_cifar10\\_tfrecord.py](#). Please read the code and notes, figure out how to generate more training data and what is local response normalization. After that, try to implement [Residual Network](#) (Hint: you may want to use the `Layer.outputs`).

## 1.2.5 Run the Pong Game example

In the second part of the tutorial, we will run the Deep Reinforcement Learning example which is introduced by Karpathy in [Deep Reinforcement Learning: Pong from Pixels](#).

```
python tutorial_atari_pong.py
```

Before running the tutorial code, you need to install [OpenAI gym environment](#) which is a popular benchmark for Reinforcement Learning. If everything is set up correctly, you will get an output like the following:

```
[2016-07-12 09:31:59,760] Making new env: Pong-v0
[TL] InputLayer input_layer (?, 6400)
[TL] DenseLayer relul: 200, relu
[TL] DenseLayer output_layer: 3, identity
param 0: (6400, 200) (mean: -0.000009 median: -0.000018 std: 0.017393)
param 1: (200,)      (mean: 0.000000 median: 0.000000 std: 0.000000)
param 2: (200, 3)    (mean: 0.002239 median: 0.003122 std: 0.096611)
param 3: (3,)        (mean: 0.000000 median: 0.000000 std: 0.000000)
num of params: 1280803
layer 0: Tensor("Relu:0", shape=(?, 200), dtype=float32)
layer 1: Tensor("add_1:0", shape=(?, 3), dtype=float32)
episode 0: game 0 took 0.17381s, reward: -1.000000
episode 0: game 1 took 0.12629s, reward: 1.000000 !!!!!!!
episode 0: game 2 took 0.17082s, reward: -1.000000
episode 0: game 3 took 0.08944s, reward: -1.000000
```

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```

episode 0: game 4 took 0.09446s, reward: -1.000000
episode 0: game 5 took 0.09440s, reward: -1.000000
episode 0: game 6 took 0.32798s, reward: -1.000000
episode 0: game 7 took 0.74437s, reward: -1.000000
episode 0: game 8 took 0.43013s, reward: -1.000000
episode 0: game 9 took 0.42496s, reward: -1.000000
episode 0: game 10 took 0.37128s, reward: -1.000000
episode 0: game 11 took 0.08979s, reward: -1.000000
episode 0: game 12 took 0.09138s, reward: -1.000000
episode 0: game 13 took 0.09142s, reward: -1.000000
episode 0: game 14 took 0.09639s, reward: -1.000000
episode 0: game 15 took 0.09852s, reward: -1.000000
episode 0: game 16 took 0.09984s, reward: -1.000000
episode 0: game 17 took 0.09575s, reward: -1.000000
episode 0: game 18 took 0.09416s, reward: -1.000000
episode 0: game 19 took 0.08674s, reward: -1.000000
episode 0: game 20 took 0.09628s, reward: -1.000000
resetting env. episode reward total was -20.000000. running mean: -20.000000
episode 1: game 0 took 0.09910s, reward: -1.000000
episode 1: game 1 took 0.17056s, reward: -1.000000
episode 1: game 2 took 0.09306s, reward: -1.000000
episode 1: game 3 took 0.09556s, reward: -1.000000
episode 1: game 4 took 0.12520s, reward: 1.000000 !!!!!!!
episode 1: game 5 took 0.17348s, reward: -1.000000
episode 1: game 6 took 0.09415s, reward: -1.000000

```

This example allows the neural network to learn how to play Pong game from the screen inputs, just like human behavior. The neural network will play with a fake AI player and learn to beat it. After training for 15,000 episodes, the neural network can win 20% of the games. The neural network win 35% of the games at 20,000 episode, we can seen the neural network learn faster and faster as it has more winning data to train. If you run it for 30,000 episode, it never loss.

```

render = False
resume = False

```

Setting `render` to `True`, if you want to display the game environment. When you run the code again, you can set `resume` to `True`, the code will load the existing model and train the model basic on it.



## 1.2.6 Understand Reinforcement learning

### Pong Game

To understand Reinforcement Learning, we let computer to learn how to play Pong game from the original screen inputs. Before we start, we highly recommend you to go through a famous blog called [Deep Reinforcement Learning: Pong from Pixels](#) which is a minimalistic implementation of Deep Reinforcement Learning by using python-numpy and OpenAI gym environment.

```
python tutorial_atari_pong.py
```

### Policy Network

In Deep Reinforcement Learning, the Policy Network is the same with Deep Neural Network, it is our player (or “agent”) who output actions to tell what we should do (move UP or DOWN); in Karpathy’s code, he only defined 2 actions, UP and DOWN and using a single sigmoid output; In order to make our tutorial more generic, we defined 3 actions which are UP, DOWN and STOP (do nothing) by using 3 softmax outputs.

```
# observation for training
states_batch_pl = tf.placeholder(tf.float32, shape=[None, D])

network = tl.layers.InputLayer(states_batch_pl, name='input_layer')
network = tl.layers.DenseLayer(network, n_units=H,
                                act = tf.nn.relu, name='relu1')
network = tl.layers.DenseLayer(network, n_units=3,
                                act = tf.identity, name='output_layer')
probs = network.outputs
sampling_prob = tf.nn.softmax(probs)
```

Then when our agent is playing Pong, it calculates the probabilities of different actions, and then draw sample (action) from this uniform distribution. As the actions are represented by 1, 2 and 3, but the softmax outputs should be start from 0, we calculate the label value by minus 1.

```
prob = sess.run(
    sampling_prob,
    feed_dict={states_batch_pl: x}
)
# action. 1: STOP  2: UP  3: DOWN
action = np.random.choice([1,2,3], p=prob.flatten())
...
ys.append(action - 1)
```

### Policy Gradient

Policy gradient methods are end-to-end algorithms that directly learn policy functions mapping states to actions. An approximate policy could be learned directly by maximizing the expected rewards. The parameters of a policy function (e.g. the parameters of a policy network used in the pong example) could be trained and learned under the guidance of the gradient of expected rewards. In other words, we can gradually tune the policy function via updating its parameters, such that it will generate actions from given states towards higher rewards.

An alternative method to policy gradient is Deep Q-Learning (DQN). It is based on Q-Learning that tries to learn a value function (called Q function) mapping states and actions to some value. DQN employs a deep neural network to represent the Q function as a function approximator. The training is done by minimizing temporal-difference errors. A

neurobiologically inspired mechanism called “experience replay” is typically used along with DQN to help improve its stability caused by the use of non-linear function approximator.

You can check the following papers to gain better understandings about Reinforcement Learning.

- [Reinforcement Learning: An Introduction](#). Richard S. Sutton and Andrew G. Barto
- [Deep Reinforcement Learning](#). David Silver, Google DeepMind
- [UCL Course on RL](#)

The most successful applications of Deep Reinforcement Learning in recent years include DQN with experience replay to play Atari games and AlphaGO that for the first time beats world-class professional GO players. AlphaGO used the policy gradient method to train its policy network that is similar to the example of Pong game.

- [Atari - Playing Atari with Deep Reinforcement Learning](#)
- [Atari - Human-level control through deep reinforcement learning](#)
- [AlphaGO - Mastering the game of Go with deep neural networks and tree search](#)

## Dataset iteration

In Reinforcement Learning, we consider a final decision as an episode. In Pong game, a episode is a few dozen games, because the games go up to score of 21 for either player. Then the batch size is how many episode we consider to update the model. In the tutorial, we train a 2-layer policy network with 200 hidden layer units using RMSProp on batches of 10 episodes.

## Loss and update expressions

We create a loss expression to be minimized in training:

```
actions_batch_pl = tf.placeholder(tf.int32, shape=[None])
discount_rewards_batch_pl = tf.placeholder(tf.float32, shape=[None])
loss = tl.rein.cross_entropy_reward_loss(probs, actions_batch_pl,
                                         discount_rewards_batch_pl)

...
...
sess.run(
    train_op,
    feed_dict={
        states_batch_pl: epx,
        actions_batch_pl: epy,
        discount_rewards_batch_pl: disR
    }
)
```

The loss in a batch is relate to all outputs of Policy Network, all actions we made and the corresponding discounted rewards in a batch. We first compute the loss of each action by multiplying the discounted reward and the cross-entropy between its output and its true action. The final loss in a batch is the sum of all loss of the actions.

## What Next?

The tutorial above shows how you can build your own agent, end-to-end. While it has reasonable quality, the default parameters will not give you the best agent model. Here are a few things you can improve.

First of all, instead of conventional MLP model, we can use CNNs to capture the screen information better as [Playing Atari with Deep Reinforcement Learning](#) describe.

Also, the default parameters of the model are not tuned. You can try changing the learning rate, decay, or initializing the weights of your model in a different way.

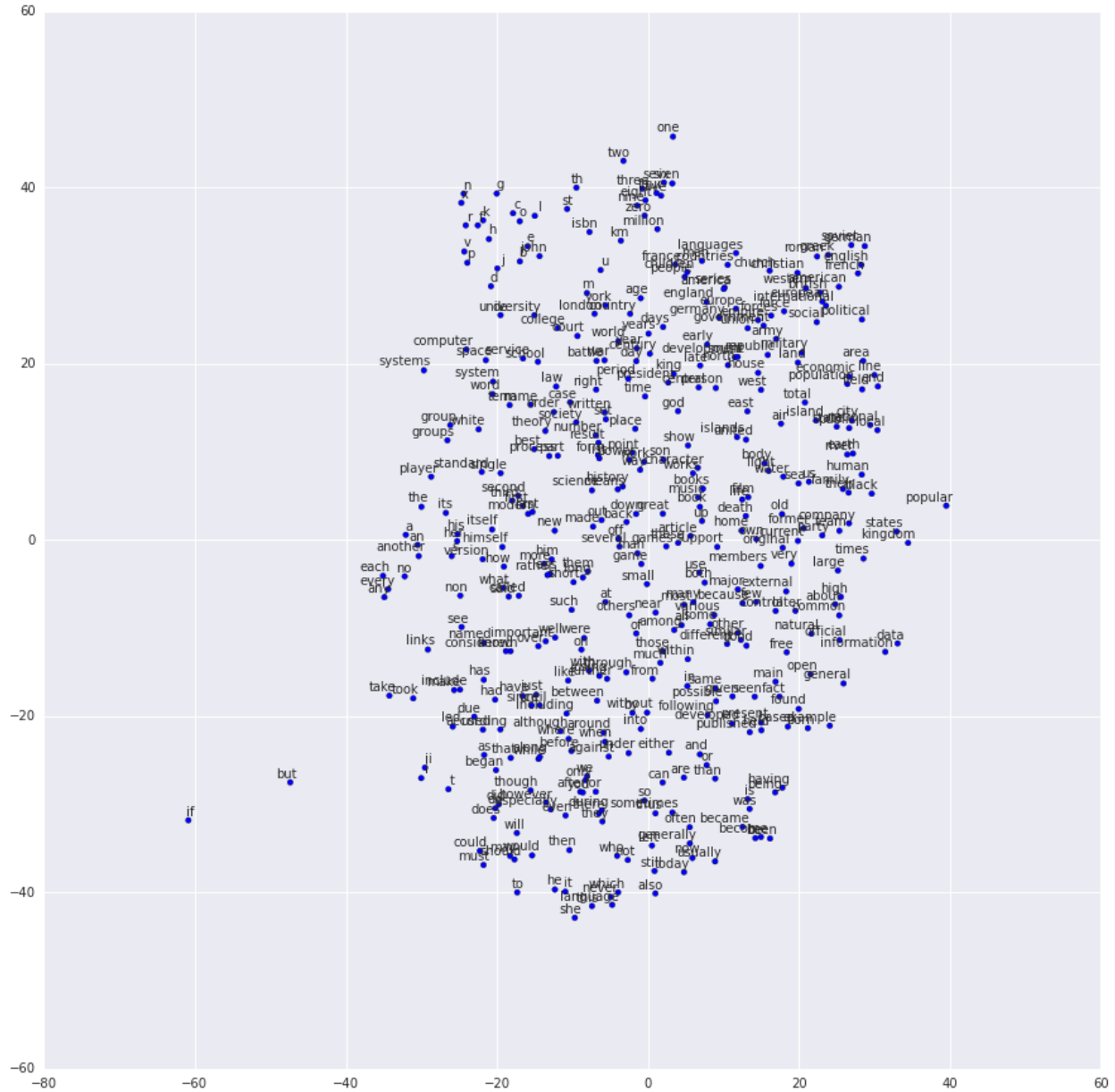
Finally, you can try the model on different tasks (games) and try other reinforcement learning algorithm in [Example](#).

### 1.2.7 Run the Word2Vec example

In this part of the tutorial, we train a matrix for words, where each word can be represented by a unique row vector in the matrix. In the end, similar words will have similar vectors. Then as we plot out the words into a two-dimensional plane, words that are similar end up clustering nearby each other.

```
python tutorial_word2vec_basic.py
```

If everything is set up correctly, you will get an output in the end.



## 1.2.8 Understand Word Embedding

### Word Embedding

We highly recommend you to read Colah's blog [Word Representations](#) to understand why we want to use a vector representation, and how to compute the vectors. (For chinese reader please [click](#). More details about word2vec can be found in [Word2vec Parameter Learning Explained](#).

Bascially, training an embedding matrix is an unsupervised learning. As every word is refected by an unique ID, which is the row index of the embedding matrix, a word can be converted into a vector, it can better represent the meaning. For example, there seems to be a constant male-female difference vector:  $\text{woman} - \text{man} = \text{queen} - \text{king}$ , this means one dimension in the vector represents gender.

The model can be created as follow.

```
# train_inputs is a row vector, a input is an integer id of single word.
# train_labels is a column vector, a label is an integer id of single word.
# valid_dataset is a column vector, a valid set is an integer id of single word.
train_inputs = tf.placeholder(tf.int32, shape=[batch_size])
train_labels = tf.placeholder(tf.int32, shape=[batch_size, 1])
valid_dataset = tf.constant(valid_examples, dtype=tf.int32)

# Look up embeddings for inputs.
emb_net = tl.layers.Word2vecEmbeddingInputlayer(
    inputs = train_inputs,
    train_labels = train_labels,
    vocabulary_size = vocabulary_size,
    embedding_size = embedding_size,
    num_sampled = num_sampled,
    nce_loss_args = {},
    E_init = tf.random_uniform_initializer(minval=-1.0, maxval=1.0),
    E_init_args = {},
    nce_W_init = tf.truncated_normal_initializer(
        stddev=float(1.0/np.sqrt(embedding_size))),
    nce_W_init_args = {},
    nce_b_init = tf.constant_initializer(value=0.0),
    nce_b_init_args = {},
    name = 'word2vec_layer',
)
```

## Dataset iteration and loss

Word2vec uses Negative Sampling and Skip-Gram model for training. Noise-Contrastive Estimation Loss (NCE) can help to reduce the computation of loss. Skip-Gram inverts context and targets, tries to predict each context word from its target word. We use `tl.nlp.generate_skip_gram_batch` to generate training data as follow, see `tutorial_generate_text.py`.

```
# NCE cost expression is provided by Word2vecEmbeddingInputlayer
cost = emb_net.nce_cost
train_params = emb_net.all_params

train_op = tf.train.AdagradOptimizer(learning_rate, initial_accumulator_value=0.1,
    use_locking=False).minimize(cost, var_list=train_params)

data_index = 0
while (step < num_steps):
    batch_inputs, batch_labels, data_index = tl.nlp.generate_skip_gram_batch(
        data=data, batch_size=batch_size, num_skips=num_skips,
        skip_window=skip_window, data_index=data_index)
    feed_dict = {train_inputs : batch_inputs, train_labels : batch_labels}
    _, loss_val = sess.run([train_op, cost], feed_dict=feed_dict)
```

## Restore existing Embedding matrix

In the end of training the embedding matrix, we save the matrix and corresponding dictionaries. Then next time, we can restore the matrix and directories as follow. (see `main_restore_embedding_layer()` in `tutorial_generate_text.py`)



```

vocabulary_size = 50000
embedding_size = 128
model_file_name = "model_word2vec_50k_128"
batch_size = None

print("Load existing embedding matrix and dictionaries")
all_var = tl.files.load_npy_to_any(name=model_file_name+'.npy')
data = all_var['data']; count = all_var['count']
dictionary = all_var['dictionary']
reverse_dictionary = all_var['reverse_dictionary']

tl.nlp.save_vocab(count, name='vocab_'+model_file_name+'.txt')

del all_var, data, count

load_params = tl.files.load_npz(name=model_file_name+'.npz')

x = tf.placeholder(tf.int32, shape=[batch_size])
y_ = tf.placeholder(tf.int32, shape=[batch_size, 1])

emb_net = tl.layers.EmbeddingInputlayer(
    inputs = x,
    vocabulary_size = vocabulary_size,
    embedding_size = embedding_size,
    name='embedding_layer')

tl.layers.initialize_global_variables(sess)

tl.files.assign_params(sess, [load_params[0]], emb_net)

```

## 1.2.9 Run the PTB example

Penn TreeBank (PTB) dataset is used in many LANGUAGE MODELING papers, including “Empirical Evaluation and Combination of Advanced Language Modeling Techniques”, “Recurrent Neural Network Regularization”. It consists of 929k training words, 73k validation words, and 82k test words. It has 10k words in its vocabulary.

The PTB example is trying to show how to train a recurrent neural network on a challenging task of language modeling.

Given a sentence “I am from Imperial College London”, the model can learn to predict “Imperial College London” from “from Imperial College”. In other word, it predict the next word in a text given a history of previous words. In the previous example, `num_steps` (sequence length) is 3.

```
python tutorial_ptb_lstm.py
```

The script provides three settings (small, medium, large), where a larger model has better performance. You can choose different settings in:

```

flags.DEFINE_string(
    "model", "small",
    "A type of model. Possible options are: small, medium, large.")

```

If you choose the small setting, you can see:

```

Epoch: 1 Learning rate: 1.000
0.004 perplexity: 5220.213 speed: 7635 wps
0.104 perplexity: 828.871 speed: 8469 wps

```

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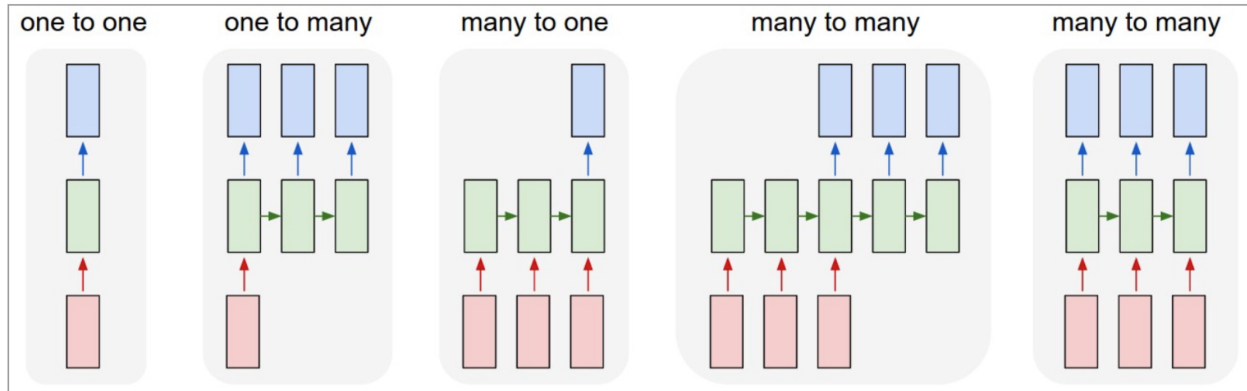
```
0.204 perplexity: 614.071 speed: 8839 wps
0.304 perplexity: 495.485 speed: 8889 wps
0.404 perplexity: 427.381 speed: 8940 wps
0.504 perplexity: 383.063 speed: 8920 wps
0.604 perplexity: 345.135 speed: 8920 wps
0.703 perplexity: 319.263 speed: 8949 wps
0.803 perplexity: 298.774 speed: 8975 wps
0.903 perplexity: 279.817 speed: 8986 wps
Epoch: 1 Train Perplexity: 265.558
Epoch: 1 Valid Perplexity: 178.436
...
Epoch: 13 Learning rate: 0.004
0.004 perplexity: 56.122 speed: 8594 wps
0.104 perplexity: 40.793 speed: 9186 wps
0.204 perplexity: 44.527 speed: 9117 wps
0.304 perplexity: 42.668 speed: 9214 wps
0.404 perplexity: 41.943 speed: 9269 wps
0.504 perplexity: 41.286 speed: 9271 wps
0.604 perplexity: 39.989 speed: 9244 wps
0.703 perplexity: 39.403 speed: 9236 wps
0.803 perplexity: 38.742 speed: 9229 wps
0.903 perplexity: 37.430 speed: 9240 wps
Epoch: 13 Train Perplexity: 36.643
Epoch: 13 Valid Perplexity: 121.475
Test Perplexity: 116.716
```

The PTB example shows that RNN is able to model language, but this example did not do something practically interesting. However, you should read through this example and “Understand LSTM” in order to understand the basics of RNN. After that, you will learn how to generate text, how to achieve language translation, and how to build a question answering system by using RNN.

## 1.2.10 Understand LSTM

### Recurrent Neural Network

We personally think Andrej Karpathy’s blog is the best material to [Understand Recurrent Neural Network](#), after reading that, Colah’s blog can help you to [Understand LSTM Network \[chinese\]](#) which can solve The Problem of Long-Term Dependencies. We will not describe more about the theory of RNN, so please read through these blogs before you go on.



Each rectangle is a vector and arrows represent functions (e.g. matrix multiply). Input vectors are in red, output vectors are in blue and green vectors hold the RNN's state (more on this soon). From left to right: **(1)** Vanilla mode of processing without RNN, from fixed-sized input to fixed-sized output (e.g. image classification). **(2)** Sequence output (e.g. image captioning takes an image and outputs a sentence of words). **(3)** Sequence input (e.g. sentiment analysis where a given sentence is classified as expressing positive or negative sentiment). **(4)** Sequence input and sequence output (e.g. Machine Translation: an RNN reads a sentence in English and then outputs a sentence in French). **(5)** Synced sequence input and output (e.g. video classification where we wish to label each frame of the video). Notice that in every case there are no pre-specified constraints on the lengths of sequences because the recurrent transformation (green) is fixed and can be applied as many times as we like.

Image by Andrej Karpathy

### Synced sequence input and output

The model in PTB example is a typical type of synced sequence input and output, which was described by Karpathy as “(5) Synced sequence input and output (e.g. video classification where we wish to label each frame of the video). Notice that in every case there are no pre-specified constraints on the lengths of sequences because the recurrent transformation (green) can be applied as many times as we like.”

The model is built as follows. Firstly, we transfer the words into word vectors by looking up an embedding matrix. In this tutorial, there is no pre-training on the embedding matrix. Secondly, we stack two LSTMs together using dropout between the embedding layer, LSTM layers, and the output layer for regularization. In the final layer, the model provides a sequence of softmax outputs.

The first LSTM layer outputs `[batch_size, num_steps, hidden_size]` for stacking another LSTM after it. The second LSTM layer outputs `[batch_size*num_steps, hidden_size]` for stacking a DenseLayer after it. Then the DenseLayer computes the softmax outputs of each example `n_examples = batch_size*num_steps`.

To understand the PTB tutorial, you can also read [TensorFlow PTB tutorial](#).

(Note that, TensorLayer supports DynamicRNNLayer after v1.1, so you can set the input/output dropouts, number of RNN layers in one single layer)

```
network = tl.layers.EmbeddingInputlayer(
    inputs = x,
    vocabulary_size = vocab_size,
    embedding_size = hidden_size,
    E_init = tf.random_uniform_initializer(-init_scale, init_scale),
    name = 'embedding_layer')
if is_training:
    network = tl.layers.DropoutLayer(network, keep=keep_prob, name='drop1')
network = tl.layers.RNNLayer(network,
    cell_fn=tf.contrib.rnn.BasicLSTMCell,
```

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```

        cell_init_args={'forget_bias': 0.0},
        n_hidden=hidden_size,
        initializer=tf.random_uniform_initializer(-init_scale, init_scale),
        n_steps=num_steps,
        return_last=False,
        name='basic_lstm_layer1')
lstm1 = network
if is_training:
    network = tl.layers.DropoutLayer(network, keep=keep_prob, name='drop2')
network = tl.layers.RNNLayer(network,
    cell_fn=tf.contrib.rnn.BasicLSTMCell,
    cell_init_args={'forget_bias': 0.0},
    n_hidden=hidden_size,
    initializer=tf.random_uniform_initializer(-init_scale, init_scale),
    n_steps=num_steps,
    return_last=False,
    return_seq_2d=True,
    name='basic_lstm_layer2')
lstm2 = network
if is_training:
    network = tl.layers.DropoutLayer(network, keep=keep_prob, name='drop3')
network = tl.layers.DenseLayer(network,
    n_units=vocab_size,
    W_init=tf.random_uniform_initializer(-init_scale, init_scale),
    b_init=tf.random_uniform_initializer(-init_scale, init_scale),
    act = tf.identity, name='output_layer')

```

## Dataset iteration

The `batch_size` can be seen as the number of concurrent computations we are running. As the following example shows, the first batch learns the sequence information by using items 0 to 9. The second batch learn the sequence information by using items 10 to 19. So it ignores the information from items 9 to 10 !n If only if we set `batch_size = 1``, it will consider all the information from items 0 to 20.

The meaning of `batch_size` here is not the same as the `batch_size` in the MNIST example. In the MNIST example, `batch_size` reflects how many examples we consider in each iteration, while in the PTB example, `batch_size` is the number of concurrent processes (segments) for accelerating the computation.

Some information will be ignored if `batch_size > 1`, however, if your dataset is “long” enough (a text corpus usually has billions of words), the ignored information would not affect the final result.

In the PTB tutorial, we set `batch_size = 20`, so we divide the dataset into 20 segments. At the beginning of each epoch, we initialize (reset) the 20 RNN states for the 20 segments to zero, then go through the 20 segments separately.

An example of generating training data is as follows:

```

train_data = [i for i in range(20)]
for batch in tl.iterate.ptb_iterator(train_data, batch_size=2, num_steps=3):
    x, y = batch
    print(x, '\n', y)

```

```

... [[ 0  1  2] <---x                1st subset/ iteration
...  [10 11 12]]
... [[ 1  2  3] <---y
...  [11 12 13]]

```

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```

...
... [[ 3  4  5] <--- 1st batch input           2nd subset/ iteration
...  [13 14 15]] <--- 2nd batch input
... [[ 4  5  6] <--- 1st batch target
...  [14 15 16]] <--- 2nd batch target
...
... [[ 6  7  8]                               3rd subset/ iteration
...  [16 17 18]]
... [[ 7  8  9]
...  [17 18 19]]

```

**Note:** This example can also be considered as pre-training of the word embedding matrix.

## Loss and update expressions

The cost function is the average cost of each mini-batch:

```

# See tensorlayer.cost.cross_entropy_seq() for more details
def loss_fn(outputs, targets, batch_size, num_steps):
    # Returns the cost function of Cross-entropy of two sequences, implement
    # softmax internally.
    # outputs : 2D tensor [batch_size*num_steps, n_units of output layer]
    # targets : 2D tensor [batch_size, num_steps], need to be reshaped.
    # n_examples = batch_size * num_steps
    # so
    # cost is the average cost of each mini-batch (concurrent process).
    loss = tf.nn.seq2seq.sequence_loss_by_example(
        [outputs],
        [tf.reshape(targets, [-1])],
        [tf.ones([batch_size * num_steps])])
    cost = tf.reduce_sum(loss) / batch_size
    return cost

# Cost for Training
cost = loss_fn(network.outputs, targets, batch_size, num_steps)

```

For updating, truncated backpropagation clips values of gradients by the ratio of the sum of their norms, so as to make the learning process tractable.

```

# Truncated Backpropagation for training
with tf.variable_scope('learning_rate'):
    lr = tf.Variable(0.0, trainable=False)
tvars = tf.trainable_variables()
grads, _ = tf.clip_by_global_norm(tf.gradients(cost, tvars),
                                   max_grad_norm)
optimizer = tf.train.GradientDescentOptimizer(lr)
train_op = optimizer.apply_gradients(zip(grads, tvars))

```

In addition, if the epoch index is greater than max\_epoch, we decrease the learning rate by multiplying lr\_decay.

```

new_lr_decay = lr_decay ** max(i - max_epoch, 0.0)
sess.run(tf.assign(lr, learning_rate * new_lr_decay))

```

At the beginning of each epoch, all states of LSTMs need to be reseted (initialized) to zero states. Then after each iteration, the LSTMs' states is updated, so the new LSTM states (final states) need to be assigned as the initial states of the next iteration:

```
# set all states to zero states at the beginning of each epoch
state1 = tl.layers.initialize_rnn_state(lstm1.initial_state)
state2 = tl.layers.initialize_rnn_state(lstm2.initial_state)
for step, (x, y) in enumerate(tl.iterate.ptb_iterator(train_data,
                                                    batch_size, num_steps)):
    feed_dict = {input_data: x, targets: y,
                 lstm1.initial_state: state1,
                 lstm2.initial_state: state2,
                 }
    # For training, enable dropout
    feed_dict.update( network.all_drop )
    # use the new states as the initial state of next iteration
    _cost, state1, state2, _ = sess.run([cost,
                                         lstm1.final_state,
                                         lstm2.final_state,
                                         train_op],
                                         feed_dict=feed_dict
                                         )
    costs += _cost; iters += num_steps
```

## Predicting

After training the model, when we predict the next output, we no long consider the number of steps (sequence length), i.e. `batch_size`, `num_steps` are set to 1. Then we can output the next word one by one, instead of predicting a sequence of words from a sequence of words.

```
input_data_test = tf.placeholder(tf.int32, [1, 1])
targets_test = tf.placeholder(tf.int32, [1, 1])
...
network_test, lstm1_test, lstm2_test = inference(input_data_test,
                                                is_training=False, num_steps=1, reuse=True)
...
cost_test = loss_fn(network_test.outputs, targets_test, 1, 1)
...
print("Evaluation")
# Testing
# go through the test set step by step, it will take a while.
start_time = time.time()
costs = 0.0; iters = 0
# reset all states at the beginning
state1 = tl.layers.initialize_rnn_state(lstm1_test.initial_state)
state2 = tl.layers.initialize_rnn_state(lstm2_test.initial_state)
for step, (x, y) in enumerate(tl.iterate.ptb_iterator(test_data,
                                                    batch_size=1, num_steps=1)):
    feed_dict = {input_data_test: x, targets_test: y,
                 lstm1_test.initial_state: state1,
                 lstm2_test.initial_state: state2,
                 }
    _cost, state1, state2 = sess.run([cost_test,
                                     lstm1_test.final_state,
                                     lstm2_test.final_state],
                                     feed_dict=feed_dict
                                     )
```

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```

        )
    costs += _cost; iters += 1
test_perplexity = np.exp(costs / iters)
print("Test Perplexity: %.3f took %.2fs" % (test_perplexity, time.time() - start_
→time))

```

## What Next?

Now, you have understood Synced sequence input and output. Let's think about Many to one (Sequence input and one output), so that LSTM is able to predict the next word "English" from "I am from London, I speak ..".

Please read and understand the code of `tutorial_generate_text.py`. It shows you how to restore a pre-trained Embedding matrix and how to learn text generation from a given context.

Karpathy's blog : "(3) Sequence input (e.g. sentiment analysis where a given sentence is classified as expressing positive or negative sentiment). "

## 1.2.11 More Tutorials

In Example page, we provide many examples include Seq2seq, different type of Adversarial Learning, Reinforcement Learning and etc.

## 1.2.12 More info

For more information on what you can do with TensorLayer, just continue reading through `readthedocs`. Finally, the reference lists and explains as follow.

layers (`tensorlayer.layers`),  
activation (`tensorlayer.activation`),  
natural language processing (`tensorlayer.nlp`),  
reinforcement learning (`tensorlayer.rein`),  
cost expressions and regularizers (`tensorlayer.cost`),  
load and save files (`tensorlayer.files`),  
helper functions (`tensorlayer.utils`),  
visualization (`tensorlayer.visualize`),  
iteration functions (`tensorlayer.iterate`),  
preprocessing functions (`tensorlayer.prepro`),  
command line interface (`tensorlayer.prepro`),

## 1.3 Examples

### 1.3.1 Basics

- Multi-layer perceptron (MNIST). Classification task, see `tutorial_mnist_simple.py`.

- Multi-layer perceptron (MNIST). Classification with dropout using iterator, see [method1 \(use placeholder\)](#) and [method2 \(use reuse\)](#).
- Denoising Autoencoder (MNIST). Classification task, see [tutorial\\_mnist\\_autoencoder\\_cnn.py](#).
- Stacked Denoising Autoencoder and Fine-Tuning (MNIST). A MLP classification task, see [tutorial\\_mnist\\_autoencoder\\_cnn.py](#).
- Convolutional Network (MNIST). Classification task, see [tutorial\\_mnist\\_autoencoder\\_cnn.py](#).
- Convolutional Network (CIFAR-10). Classification task, see [tutorial\\_cifar10.py](#) and [tutorial\\_cifar10\\_tfrecord.py](#).
- TensorFlow dataset API for object detection see [here](#).
- Merge TF-Slim into TensorLayer. [tutorial\\_inceptionV3\\_tfslim.py](#).
- Merge Keras into TensorLayer. [tutorial\\_keras.py](#).
- Data augmentation with TFRecord. Effective way to load and pre-process data, see [tutorial\\_tfrecord\\*.py](#) and [tutorial\\_cifar10\\_tfrecord.py](#).
- Data augmentation with Dataset API. Effective way to load and pre-process data, see [tutorial\\_cifar10\\_datasetapi.py](#).
- Data augmentation with TensorLayer. See [tutorial\\_image\\_preprocess.py](#) (for quick test only).
- Float 16 half-precision model, see [tutorial\\_mnist\\_float16.py](#).
- Transparent distributed training. [mnist](#) by [luomai](#).

## 1.3.2 Vision

- Arbitrary Style Transfer in Real-time with Adaptive Instance Normalization, see [examples](#).
- ArcFace: Additive Angular Margin Loss for Deep Face Recognition, see [InsignFace](#).
- BinaryNet. Model compression, see [mnist cifar10](#).
- Ternary Weight Network. Model compression, see [mnist cifar10](#).
- DoReFa-Net. Model compression, see [mnist cifar10](#).
- QuanCNN. Model compression, sees [mnist cifar10](#).
- Wide ResNet (CIFAR) by [ritchieng](#).
- Spatial Transformer Networks by [zsdonghao](#).
- U-Net for brain tumor segmentation by [zsdonghao](#).
- Variational Autoencoder (VAE) for (CelebA) by [yzwxx](#).
- Variational Autoencoder (VAE) for (MNIST) by [BUPTLdy](#).
- Image Captioning - Reimplementation of Google's [im2txt](#) by [zsdonghao](#).

## 1.3.3 Adversarial Learning

- DCGAN (CelebA). Generating images by Deep Convolutional Generative Adversarial Networks by [zsdonghao](#).
- Generative Adversarial Text to Image Synthesis by [zsdonghao](#).
- Unsupervised Image to Image Translation with Generative Adversarial Networks by [zsdonghao](#).



- Improved CycleGAN with resize-convolution by [luoxier](#).
- Super Resolution GAN by [zsdonghao](#).
- BEGAN: Boundary Equilibrium Generative Adversarial Networks by [2wins](#).
- DAGAN: Fast Compressed Sensing MRI Reconstruction by [nebulaV](#).

### 1.3.4 Natural Language Processing

- Recurrent Neural Network (LSTM). Apply multiple LSTM to PTB dataset for language modeling, see [tutorial\\_ptb\\_lstm\\_state\\_is\\_tuple.py](#).
- Word Embedding (Word2vec). Train a word embedding matrix, see [tutorial\\_word2vec\\_basic.py](#).
- Restore Embedding matrix. Restore a pre-train embedding matrix, see [tutorial\\_generate\\_text.py](#).
- Text Generation. Generates new text scripts, using LSTM network, see [tutorial\\_generate\\_text.py](#).
- Chinese Text Anti-Spam by [pakrchen](#).
- Chatbot in 200 lines of code for Seq2Seq.
- FastText Sentence Classification (IMDB), see [tutorial\\_imdb\\_fasttext.py](#) by [tomtung](#).

### 1.3.5 Reinforcement Learning

- Policy Gradient / Network (Atari Ping Pong), see [tutorial\\_atari\\_pong.py](#).
- Deep Q-Network (Frozen lake), see [tutorial\\_frozenlake\\_dqn.py](#).
- Q-Table learning algorithm (Frozen lake), see [tutorial\\_frozenlake\\_q\\_table.py](#).
- Asynchronous Policy Gradient using TensorDB (Atari Ping Pong) by [nebulaV](#).
- AC for discrete action space (Cartpole), see [tutorial\\_cartpole\\_ac.py](#).
- A3C for continuous action space (Bipedal Walker), see [tutorial\\_bipedalwalker\\_a3c\\*.py](#).
- DAGGER for (Gym Torcs) by [zsdonghao](#).
- TRPO for continuous and discrete action space by [jjkke88](#).

### 1.3.6 Pretrained Models

- VGG 16 (ImageNet). Classification task, see [tl.models.VGG16](#) or [tutorial\\_vgg16.py](#).
- VGG 19 (ImageNet). Classification task, see [tutorial\\_vgg19.py](#).
- InceptionV3 (ImageNet). Classification task, see [tutorial\\_inceptionV3\\_tfslim.py](#).
- SqueezeNet (ImageNet). Model compression, see [tl.models.SqueezeNetV1](#) or [tutorial\\_squeezenet.py](#).
- MobileNet (ImageNet). Model compression, see [tl.models.MobileNetV1](#) or [tutorial\\_mobilenet.py](#).
- More CNN implementations of [TF-Slim](#) can be connected to TensorLayer via SlimNetsLayer.
- All pretrained models in [pretrained-models](#).

### 1.3.7 Miscellaneous

- TensorDB by [fangde](#) see [tl\\_paper](#).
- A simple web service - [TensorFlask](#) by [JoelKronander](#).

## 1.4 Contributing

TensorLayer is a major ongoing research project in Data Science Institute, Imperial College London. The goal of the project is to develop a compositional language while complex learning systems can be build through composition of neural network modules.

Numerous contributors come from various horizons such as: Tsinghua University, Carnegie Mellon University, University of Technology of Compiègne, Google, Microsoft, Bloomberg and etc.

There are many functions need to be contributed such as Maxout, Neural Turing Machine, Attention, TensorLayer Mobile and etc.

You can easily open a Pull Request (PR) on [GitHub](#), every little step counts and will be credited. As an open-source project, we highly welcome and value contributions!

**If you are interested in working with us, please contact us at:** [tensorlayer@gmail.com](mailto:tensorlayer@gmail.com).

### 1.4.1 Project Maintainers

The TensorLayer project was started by [Hao Dong](#) at Imperial College London in June 2016.

It is actively developed and maintained by the following people (*in alphabetical order*):

- **Akara Supratak** ([@akaraspt](#)) - <https://akaraspt.github.io>
- **Fangde Liu** ([@fangde](#)) - <http://fangde.github.io/>
- **Guo Li** ([@lgarithm](#)) - <https://lgarithm.github.io>
- **Hao Dong** ([@zsdonghao](#)) - <https://zsdonghao.github.io>
- **Jonathan Dekhtiar** ([@DEKHTIARJonathan](#)) - <https://www.jonathandekhtiar.eu>
- **Luo Mai** ([@luomai](#)) - <http://www.doc.ic.ac.uk/~lm111/>
- **Simiao Yu** ([@nebulaV](#)) - <https://nebulav.github.io>

Numerous other contributors can be found in the [Github Contribution Graph](#).

### 1.4.2 What to contribute

#### Your method and example

If you have a new method or example in term of Deep learning and Reinforcement learning, you are welcome to contribute.

- Provide your layer or example, so everyone can use it.
- Explain how it would work, and link to a scientific paper if applicable.
- Keep the scope as narrow as possible, to make it easier to implement.

## Report bugs

Report bugs at the [GitHub](#), we normally will fix it in 5 hours. If you are reporting a bug, please include:

- your TensorLayer, TensorFlow and Python version.
- steps to reproduce the bug, ideally reduced to a few Python commands.
- the results you obtain, and the results you expected instead.

If you are unsure whether the behavior you experience is a bug, or if you are unsure whether it is related to TensorLayer or TensorFlow, please just ask on [our mailing list](#) first.

## Fix bugs

Look through the GitHub issues for bug reports. Anything tagged with “bug” is open to whoever wants to implement it. If you discover a bug in TensorLayer you can fix yourself, by all means feel free to just implement a fix and not report it first.

## Write documentation

Whenever you find something not explained well, misleading, glossed over or just wrong, please update it! The *Edit on GitHub* link on the top right of every documentation page and the *[source]* link for every documented entity in the API reference will help you to quickly locate the origin of any text.

### 1.4.3 How to contribute

#### Edit on GitHub

As a very easy way of just fixing issues in the documentation, use the *Edit on GitHub* link on the top right of a documentation page or the *[source]* link of an entity in the API reference to open the corresponding source file in GitHub, then click the *Edit this file* link to edit the file in your browser and send us a Pull Request. All you need for this is a free GitHub account.

For any more substantial changes, please follow the steps below to setup TensorLayer for development.

#### Documentation

The documentation is generated with [Sphinx](#). To build it locally, run the following commands:

```
pip install Sphinx
sphinx-quickstart

cd docs
make html
```

If you want to re-generate the whole docs, run the following commands:

```
cd docs
make clean
make html
```

To write the docs, we recommend you to install [Local RTD VM](#).

Afterwards, open `docs/_build/html/index.html` to view the documentation as it would appear on [readthedocs](#). If you changed a lot and seem to get misleading error messages or warnings, run `make clean html` to force Sphinx to recreate all files from scratch.

When writing docstrings, follow existing documentation as much as possible to ensure consistency throughout the library. For additional information on the syntax and conventions used, please refer to the following documents:

- [reStructuredText Primer](#)
- [Sphinx reST markup constructs](#)
- [A Guide to NumPy/SciPy Documentation](#)

## Testing

TensorLayer has a code coverage of 100%, which has proven very helpful in the past, but also creates some duties:

- Whenever you change any code, you should test whether it breaks existing features by just running the test scripts.
- Every bug you fix indicates a missing test case, so a proposed bug fix should come with a new test that fails without your fix.

## Sending Pull Requests

When you're satisfied with your addition, the tests pass and the documentation looks good without any markup errors, commit your changes to a new branch, push that branch to your fork and send us a Pull Request via GitHub's web interface.

All these steps are nicely explained on GitHub: <https://guides.github.com/introduction/flow/>

When filing your Pull Request, please include a description of what it does, to help us reviewing it. If it is fixing an open issue, say, issue #123, add *Fixes #123*, *Resolves #123* or *Closes #123* to the description text, so GitHub will close it when your request is merged.

# 1.5 Get Involved in Research

## 1.5.1 Data Science Institute, Imperial College London

Data science is therefore by nature at the core of all modern transdisciplinary scientific activities, as it involves the whole life cycle of data, from acquisition and exploration to analysis and communication of the results. Data science is not only concerned with the tools and methods to obtain, manage and analyse data: it is also about extracting value from data and translating it from asset to product.

Launched on 1st April 2014, the Data Science Institute at Imperial College London aims to enhance Imperial's excellence in data-driven research across its faculties by fulfilling the following objectives.

The Data Science Institute is housed in purpose built facilities in the heart of the Imperial College campus in South Kensington. Such a central location provides excellent access to collaborators across the College and across London.

- To act as a focal point for coordinating data science research at Imperial College by facilitating access to funding, engaging with global partners, and stimulating cross-disciplinary collaboration.
- To develop data management and analysis technologies and services for supporting data driven research in the College.

- To promote the training and education of the new generation of data scientist by developing and coordinating new degree courses, and conducting public outreach programmes on data science.
- To advise College on data strategy and policy by providing world-class data science expertise.
- To enable the translation of data science innovation by close collaboration with industry and supporting commercialization.

If you are interested in working with us, please check our [vacancies](#) and other ways to [get involved](#) , or feel free to [contact us](#).

## 1.6 FAQ

### 1.6.1 How to effectively learn TensorLayer

No matter what stage you are in, we recommend you to spend just 10 minutes to read the source code of TensorLayer and the [Understand layer / Your layer](#) in this website, you will find the abstract methods are very simple for everyone. Reading the source codes helps you to better understand TensorFlow and allows you to implement your own methods easily. For discussion, we recommend [Gitter](#), [Help Wanted Issues](#), [QQ group](#) and [Wechat group](#).

#### Beginner

For people who new to deep learning, the contributors provided a number of tutorials in this website, these tutorials will guide you to understand autoencoder, convolutional neural network, recurrent neural network, word embedding and deep reinforcement learning and etc. If your already understand the basic of deep learning, we recommend you to skip the tutorials and read the example codes on [Github](#) , then implement an example from scratch.

#### Engineer

For people from industry, the contributors provided mass format-consistent examples covering computer vision, natural language processing and reinforcement learning. Besides, there are also many TensorFlow users already implemented product-level examples including image captioning, semantic/instance segmentation, machine translation, chatbot and etc, which can be found online. It is worth noting that a wrapper especially for computer vision [Tf-Slim](#) can be connected with TensorLayer seamlessly. Therefore, you may able to find the examples that can be used in your project.

#### Researcher

For people from academic, TensorLayer was originally developed by PhD students who facing issues with other libraries on implement novel algorithm. Installing TensorLayer in editable mode is recommended, so you can extend your methods in TensorLayer. For researches related to image such as image captioning, visual QA and etc, you may find it is very helpful to use the existing [Tf-Slim pre-trained models](#) with TensorLayer (a specially layer for connecting Tf-Slim is provided).

### 1.6.2 Exclude some layers from training

You may need to get the list of variables you want to update, TensorLayer provides two ways to get the variables list.

The first way is to use the `all_params` of a network, by default, it will store the variables in order. You can print the variables information via `tl.layers.print_all_variables(train_only=True)` or `network.print_params(details=False)`. To choose which variables to update, you can do as below.

```
train_params = network.all_params[3:]
```

The second way is to get the variables by a given name. For example, if you want to get all variables which the layer name contain dense, you can do as below.

```
train_params = tl.layers.get_variables_with_name('dense', train_only=True, ↵
↵printable=True)
```

After you get the variable list, you can define your optimizer like that so as to update only a part of the variables.

```
train_op = tf.train.AdamOptimizer(0.001).minimize(cost, var_list= train_params)
```

### 1.6.3 Logging

TensorLayer adopts the [Python logging module](#) to log running information. The logging module would print logs to the console in default. If you want to configure the logging module, you shall follow its [manual](#).

### 1.6.4 Visualization

#### Cannot Save Image

If you run the script via SSH control, sometime you may find the following error.

```
_tkinter.TclError: no display name and no $DISPLAY environment variable
```

If happen, run `sudo apt-get install python3-tk` or `import matplotlib` and `matplotlib.use('Agg')` before `import tensorlayer as tl`. Alternatively, add the following code into the top of `visualize.py` or in your own code.

```
import matplotlib
matplotlib.use('Agg')
import matplotlib.pyplot as plt
```

### 1.6.5 Install Master Version

To use all new features of TensorLayer, you need to install the master version from Github. Before that, you need to make sure you already installed git.

```
[stable version] pip install tensorlayer
[master version] pip install git+https://github.com/tensorlayer/tensorlayer.git
```

### 1.6.6 Editable Mode

- 1. Download the TensorLayer folder from Github.
- 2. Before editing the TensorLayer .py file.
  - If your script and TensorLayer folder are in the same folder, when you edit the .py inside TensorLayer folder, your script can access the new features.
  - If your script and TensorLayer folder are not in the same folder, you need to run the following command in the folder contains `setup.py` before you edit .py inside TensorLayer folder.

```
pip install -e .
```

### 1.6.7 Load Model

Note that, the `tl.files.load_npz()` can only able to load the npz model saved by `tl.files.save_npz()`. If you have a model want to load into your TensorLayer network, you can first assign your parameters into a list in order, then use `tl.files.assign_params()` to load the parameters into your TensorLayer model.





If you are looking for information on a specific function, class or method, this part of the documentation is for you.

## 2.1 API - Activations

To make TensorLayer simple, we minimize the number of activation functions as much as we can. So we encourage you to use TensorFlow's function. TensorFlow provides `tf.nn.relu`, `tf.nn.relu6`, `tf.nn.elu`, `tf.nn.softplus`, `tf.nn.softsign` and so on. More TensorFlow official activation functions can be found [here](#). For parametric activation, please read the layer APIs.

The shortcut of `tensorlayer.activation` is `tensorlayer.act`.

### 2.1.1 Your activation

Customizes activation function in TensorLayer is very easy. The following example implements an activation that multiplies its input by 2. For more complex activation, TensorFlow API will be required.

```
def double_activation(x):
    return x * 2
```

A file containing various activation functions.

<code>leaky_relu(x[, alpha, name])</code>	<code>leaky_relu</code> can be used through its shortcut: <code>tl.act.lrelu()</code> .
<code>leaky_relu6(x[, alpha, name])</code>	<code>leaky_relu6()</code> can be used through its shortcut: <code>tl.act.lrelu6()</code> .
<code>leaky_twice_relu6(x[, alpha_low, ...])</code>	<code>leaky_twice_relu6()</code> can be used through its shortcut: <code>:func:`tl.act.lrelu6()</code> .
<code>ramp(x[, v_min, v_max, name])</code>	Ramp activation function.
<code>swish(x[, name])</code>	Swish function.

Continued on next page

Table 1 – continued from previous page

<code>sign(x)</code>	Sign function.
<code>hard_tanh(x[, name])</code>	Hard tanh activation function.
<code>pixel_wise_softmax(x[, name])</code>	Return the softmax outputs of images, every pixels have multiple label, the sum of a pixel is 1.

### 2.1.2 Ramp

`tensorlayer.activation.ramp(x, v_min=0, v_max=1, name=None)`

Ramp activation function.

#### Parameters

- **x** (*Tensor*) – input.
- **v\_min** (*float*) – cap input to v\_min as a lower bound.
- **v\_max** (*float*) – cap input to v\_max as a upper bound.
- **name** (*str*) – The function name (optional).

**Returns** A *Tensor* in the same type as **x**.

**Return type** *Tensor*

### 2.1.3 Leaky ReLU

`tensorlayer.activation.leaky_relu(x, alpha=0.2, name='leaky_relu')`

`leaky_relu` can be used through its shortcut: `tl.act.lrelu()`.

**Warning: THIS FUNCTION IS DEPRECATED:** It will be removed after after 2018-09-30.  
*Instructions for updating:* This API is deprecated. Please use as `tf.nn.leaky_relu`.

This function is a modified version of ReLU, introducing a nonzero gradient for negative input. Introduced by the paper: [Rectifier Nonlinearities Improve Neural Network Acoustic Models](#) [A. L. Maas et al., 2013]

**The function return the following results:**

- When  $x < 0$ :  $f(x) = \text{alpha\_low} * x$ .
- When  $x \geq 0$ :  $f(x) = x$ .

#### Parameters

- **x** (*Tensor*) – Support input type float, double, int32, int64, uint8, int16, or int8.
- **alpha** (*float*) – Slope.
- **name** (*str*) – The function name (optional).

#### Examples

```
>>> import tensorlayer as tl
>>> net = tl.layers.DenseLayer(net, 100, act=lambda x : tl.act.lrelu(x, 0.2),
↪ name='dense')
```

**Returns** A `Tensor` in the same type as `x`.

**Return type** `Tensor`

## References

- Rectifier Nonlinearities Improve Neural Network Acoustic Models [A. L. Maas et al., 2013]

### 2.1.4 Leaky ReLU6

`tensorlayer.activation.leaky_relu6(x, alpha=0.2, name='leaky_relu6')`  
`leaky_relu6()` can be used through its shortcut: `tl.act.lrelu6()`.

This activation function is a modified version `leaky_relu()` introduced by the following paper: Rectifier Nonlinearities Improve Neural Network Acoustic Models [A. L. Maas et al., 2013]

This activation function also follows the behaviour of the activation function `tf.nn.relu6()` introduced by the following paper: Convolutional Deep Belief Networks on CIFAR-10 [A. Krizhevsky, 2010]

**The function return the following results:**

- When  $x < 0$ :  $f(x) = \text{alpha\_low} * x$ .
- When  $x$  in  $[0, 6]$ :  $f(x) = x$ .
- When  $x > 6$ :  $f(x) = 6$ .

#### Parameters

- **x** (*Tensor*) – Support input type `float`, `double`, `int32`, `int64`, `uint8`, `int16`, or `int8`.
- **alpha** (*float*) – Slope.
- **name** (*str*) – The function name (optional).

## Examples

```
>>> import tensorlayer as tl
>>> net = tl.layers.DenseLayer(net, 100, act=lambda x : tl.act.leaky_relu6(x, 0.
↪2), name='dense')
```

**Returns** A `Tensor` in the same type as `x`.

**Return type** `Tensor`

## References

- Rectifier Nonlinearities Improve Neural Network Acoustic Models [A. L. Maas et al., 2013]
- Convolutional Deep Belief Networks on CIFAR-10 [A. Krizhevsky, 2010]

## 2.1.5 Twice Leaky ReLU6

```
tensorlayer.activation.leaky_twice_relu6(x, alpha_low=0.2, alpha_high=0.2,
                                         name='leaky_relu6')
```

`leaky_twice_relu6()` can be used through its shortcut: `:func:`tl.act.ltrelu6()`.

This activation function is a modified version `leaky_relu()` introduced by the following paper: [Rectifier Nonlinearities Improve Neural Network Acoustic Models](#) [A. L. Maas et al., 2013]

This activation function also follows the behaviour of the activation function `tf.nn.relu6()` introduced by the following paper: [Convolutional Deep Belief Networks on CIFAR-10](#) [A. Krizhevsky, 2010]

This function push further the logic by adding *leaky* behaviour both below zero and above six.

**The function return the following results:**

- When  $x < 0$ :  $f(x) = \text{alpha\_low} * x$ .
- When  $x$  in  $[0, 6]$ :  $f(x) = x$ .
- When  $x > 6$ :  $f(x) = 6 + (\text{alpha\_high} * (x-6))$ .

### Parameters

- **x** (*Tensor*) – Support input type float, double, int32, int64, uint8, int16, or int8.
- **alpha\_low** (*float*) – Slope for  $x < 0$ :  $f(x) = \text{alpha\_low} * x$ .
- **alpha\_high** (*float*) – Slope for  $x > 6$ :  $f(x) = 6 + (\text{alpha\_high} * (x-6))$ .
- **name** (*str*) – The function name (optional).

### Examples

```
>>> import tensorlayer as tl
>>> net = tl.layers.DenseLayer(net, 100, act=lambda x : tl.act.leaky_twice_
↪relu6(x, 0.2, 0.2), name='dense')
```

**Returns** A Tensor in the same type as x.

**Return type** Tensor

### References

- [Rectifier Nonlinearities Improve Neural Network Acoustic Models](#) [A. L. Maas et al., 2013]
- [Convolutional Deep Belief Networks on CIFAR-10](#) [A. Krizhevsky, 2010]

## 2.1.6 Swish

```
tensorlayer.activation.swish(x, name='swish')
```

Swish function.

See [Swish: a Self-Gated Activation Function](#).

### Parameters

- **x** (*Tensor*) – input.
- **name** (*str*) – function name (optional).

**Returns** A *Tensor* in the same type as **x**.

**Return type** *Tensor*

### 2.1.7 Sign

`tensorlayer.activation.sign(x)`  
Sign function.

Clip and binarize tensor using the straight through estimator (STE) for the gradient, usually be used for quantizing values in *Binarized Neural Networks*: <https://arxiv.org/abs/1602.02830>.

**Parameters** **x** (*Tensor*) – input.

#### Examples

```
>>> net = tl.layers.DenseLayer(net, 100, act=lambda x : tl.act.lrelu(x, 0.2),
↳ name='dense')
```

**Returns** A *Tensor* in the same type as **x**.

**Return type** *Tensor*

#### References

- *Rectifier Nonlinearities Improve Neural Network Acoustic Models*, Maas et al. (2013) [http://web.stanford.edu/~awni/papers/relu\\_hybrid\\_icml2013\\_final.pdf](http://web.stanford.edu/~awni/papers/relu_hybrid_icml2013_final.pdf)
- *BinaryNet: Training Deep Neural Networks with Weights and Activations Constrained to +1 or -1*, Courbariaux et al. (2016) <https://arxiv.org/abs/1602.02830>

### 2.1.8 Hard Tanh

`tensorlayer.activation.hard_tanh(x, name='htanh')`  
Hard tanh activation function.

Which is a ramp function with low bound of -1 and upper bound of 1, shortcut is *htanh*.

#### Parameters

- **x** (*Tensor*) – input.
- **name** (*str*) – The function name (optional).

**Returns** A *Tensor* in the same type as **x**.

**Return type** *Tensor*

### 2.1.9 Pixel-wise softmax

`tensorlayer.activation.pixel_wise_softmax(x, name='pixel_wise_softmax')`

Return the softmax outputs of images, every pixels have multiple label, the sum of a pixel is 1.

**Warning: THIS FUNCTION IS DEPRECATED:** It will be removed after after 2018-06-30.  
*Instructions for updating:* This API will be deprecated soon as `tf.nn.softmax` can do the same thing.

Usually be used for image segmentation.

#### Parameters

- **x** (*Tensor*) –  
**input.**
  - For 2d image, 4D tensor (batch\_size, height, weight, channel), where channel  $\geq 2$ .
  - For 3d image, 5D tensor (batch\_size, depth, height, weight, channel), where channel  $\geq 2$ .
- **name** (*str*) – function name (optional)

**Returns** A `Tensor` in the same type as `x`.

**Return type** `Tensor`

#### Examples

```
>>> outputs = pixel_wise_softmax(network.outputs)
>>> dice_loss = 1 - dice_coe(outputs, y_, epsilon=1e-5)
```

#### References

- `tf.reverse`

### 2.1.10 Parametric activation

See `tensorlayer.layers`.

## 2.2 API - Array Operations

A file containing functions related to array manipulation.

---

<code>alphas(shape, alpha_value[, name])</code>	Creates a tensor with all elements set to <i>alpha_value</i> .
<code>alphas_like(tensor, alpha_value[, name, ...])</code>	Creates a tensor with all elements set to <i>alpha_value</i> .

---

## 2.2.1 Tensorflow Tensor Operations

### tl.alphas

`tensorlayer.array_ops.alphas` (*shape*, *alpha\_value*, *name=None*)

Creates a tensor with all elements set to *alpha\_value*. This operation returns a tensor of type *dtype* with shape *shape* and all elements set to *alpha*.

#### Parameters

- **shape** (A list of integers, a tuple of integers, or a 1-D *Tensor* of type *int32*.) – The shape of the desired tensor
- **alpha\_value** (*float32*, *float64*, *int8*, *uint8*, *int16*, *uint16*, *int32*, *int64*) – The value used to fill the resulting *Tensor*.
- **name** (*str*) – A name for the operation (optional).

#### Returns

**Return type** A *Tensor* with all elements set to *alpha*.

### Examples

```
>>> tl.alphas([2, 3], tf.int32) # [[alpha, alpha, alpha], [alpha, alpha, alpha]]
```

### tl.alphas\_like

`tensorlayer.array_ops.alphas_like` (*tensor*, *alpha\_value*, *name=None*, *optimize=True*)

Creates a tensor with all elements set to *alpha\_value*. Given a single tensor (*tensor*), this operation returns a tensor of the same type and shape as *tensor* with all elements set to *alpha\_value*.

#### Parameters

- **tensor** (*tf.Tensor*) – The Tensorflow Tensor that will be used as a template.
- **alpha\_value** (*float32*, *float64*, *int8*, *uint8*, *int16*, *uint16*, *int32*, *int64*) – The value used to fill the resulting *Tensor*.
- **name** (*str*) – A name for the operation (optional).
- **optimize** (*bool*) – if true, attempt to statically determine the shape of ‘tensor’ and encode it as a constant.

#### Returns

**Return type** A *Tensor* with all elements set to *alpha\_value*.

### Examples

```
>>> tensor = tf.constant([[1, 2, 3], [4, 5, 6]])
>>> tl.alphas_like(tensor, 0.5) # [[0.5, 0.5, 0.5], [0.5, 0.5, 0.5]]
```

## 2.3 API - Cost

To make TensorLayer simple, we minimize the number of cost functions as much as we can. So we encourage you to use TensorFlow's function. For example, you can implement L1, L2 and sum regularization by `tf.nn.l2_loss`, `tf.contrib.layers.l1_regularizer`, `tf.contrib.layers.l2_regularizer` and `tf.contrib.layers.sum_regularizer`, see [TensorFlow API](#).

### 2.3.1 Your cost function

TensorLayer provides a simple way to create you own cost function. Take a MLP below for example.

```
network = InputLayer(x, name='input')
network = DropoutLayer(network, keep=0.8, name='drop1')
network = DenseLayer(network, n_units=800, act=tf.nn.relu, name='relu1')
network = DropoutLayer(network, keep=0.5, name='drop2')
network = DenseLayer(network, n_units=800, act=tf.nn.relu, name='relu2')
network = DropoutLayer(network, keep=0.5, name='drop3')
network = DenseLayer(network, n_units=10, act=tf.identity, name='output')
```

The network parameters will be `[W1, b1, W2, b2, W_out, b_out]`, then you can apply L2 regularization on the weights matrix of first two layer as follow.

```
cost = tl.cost.cross_entropy(y, y_)
cost = cost + tf.contrib.layers.l2_regularizer(0.001)(network.all_params[0])
        + tf.contrib.layers.l2_regularizer(0.001)(network.all_params[2])
```

Besides, TensorLayer provides a easy way to get all variables by a given name, so you can also apply L2 regularization on some weights as follow.

```
l2 = 0
for w in tl.layers.get_variables_with_name('W_conv2d', train_only=True,
    ↪printable=False):
    l2 += tf.contrib.layers.l2_regularizer(1e-4)(w)
cost = tl.cost.cross_entropy(y, y_) + l2
```

### Regularization of Weights

After initializing the variables, the informations of network parameters can be observed by using `network.print_params()`.

```
tl.layers.initialize_global_variables(sess)
network.print_params()
```

```
param 0: (784, 800) (mean: -0.000000, median: 0.000004 std: 0.035524)
param 1: (800,) (mean: 0.000000, median: 0.000000 std: 0.000000)
param 2: (800, 800) (mean: 0.000029, median: 0.000031 std: 0.035378)
param 3: (800,) (mean: 0.000000, median: 0.000000 std: 0.000000)
param 4: (800, 10) (mean: 0.000673, median: 0.000763 std: 0.049373)
param 5: (10,) (mean: 0.000000, median: 0.000000 std: 0.000000)
num of params: 1276810
```

The output of `network` is `network.outputs`, then the cross entropy can be defined as follow. Besides, to regularize the weights, the `network.all_params` contains all parameters of the network. In this case, `network`.



`all_params = [W1, b1, W2, b2, Wout, bout]` according to param 0, 1 ... 5 shown by `network.print_params()`. Then max-norm regularization on W1 and W2 can be performed as follow.

```
max_norm = 0
for w in tl.layers.get_variables_with_name('W', train_only=True, printable=False):
    max_norm += tl.cost.maxnorm_regularizer(1)(w)
cost = tl.cost.cross_entropy(y, y_) + max_norm
```

In addition, all TensorFlow's regularizers like `tf.contrib.layers.l2_regularizer` can be used with TensorLayer.

## Regularization of Activation outputs

Instance method `network.print_layers()` prints all outputs of different layers in order. To achieve regularization on activation output, you can use `network.all_layers` which contains all outputs of different layers. If you want to apply L1 penalty on the activations of first hidden layer, just simply add `tf.contrib.layers.l2_regularizer(lambda_l1)(network.all_layers[1])` to the cost function.

```
network.print_layers()
```

```
layer 0: Tensor("dropout/mul_1:0", shape=(?, 784), dtype=float32)
layer 1: Tensor("Relu:0", shape=(?, 800), dtype=float32)
layer 2: Tensor("dropout_1/mul_1:0", shape=(?, 800), dtype=float32)
layer 3: Tensor("Relu_1:0", shape=(?, 800), dtype=float32)
layer 4: Tensor("dropout_2/mul_1:0", shape=(?, 800), dtype=float32)
layer 5: Tensor("add_2:0", shape=(?, 10), dtype=float32)
```

<code>cross_entropy(output, target[, name])</code>	Softmax cross-entropy operation, returns the TensorFlow expression of cross-entropy for two distributions, it implements softmax internally.
<code>sigmoid_cross_entropy(output, target[, name])</code>	Sigmoid cross-entropy operation, see <code>tf.nn.sigmoid_cross_entropy_with_logits</code> .
<code>binary_cross_entropy(output, target[, ...])</code>	Binary cross entropy operation.
<code>mean_squared_error(output, target[, ...])</code>	Return the TensorFlow expression of mean-square-error (L2) of two batch of data.
<code>normalized_mean_square_error(output, target)</code>	Return the TensorFlow expression of normalized mean-square-error of two distributions.
<code>absolute_difference_error(output, target[, ...])</code>	Return the TensorFlow expression of absolute difference error (L1) of two batch of data.
<code>dice_coe(output, target[, loss_type, axis, ...])</code>	Soft dice (Sørensen or Jaccard) coefficient for comparing the similarity of two batch of data, usually be used for binary image segmentation i.e.
<code>dice_hard_coe(output, target[, threshold, ...])</code>	Non-differentiable Sørensen–Dice coefficient for comparing the similarity of two batch of data, usually be used for binary image segmentation i.e.
<code>iou_coe(output, target[, threshold, axis, ...])</code>	Non-differentiable Intersection over Union (IoU) for comparing the similarity of two batch of data, usually be used for evaluating binary image segmentation.
<code>cross_entropy_seq(logits, target_seqs[, ...])</code>	Returns the expression of cross-entropy of two sequences, implement softmax internally.
<code>cross_entropy_seq_with_mask(logits, ..., [...])</code>	Returns the expression of cross-entropy of two sequences, implement softmax internally.

Continued on next page

Table 3 – continued from previous page

<code>cosine_similarity(v1, v2)</code>	Cosine similarity [-1, 1].
<code>li_regularizer(scale[, scope])</code>	Li regularization removes the neurons of previous layer.
<code>lo_regularizer(scale)</code>	Lo regularization removes the neurons of current layer.
<code>maxnorm_regularizer([scale])</code>	Max-norm regularization returns a function that can be used to apply max-norm regularization to weights.
<code>maxnorm_o_regularizer(scale)</code>	Max-norm output regularization removes the neurons of current layer.
<code>maxnorm_i_regularizer(scale)</code>	Max-norm input regularization removes the neurons of previous layer.

## 2.3.2 Softmax cross entropy

`tensorlayer.cost.cross_entropy(output, target, name=None)`

Softmax cross-entropy operation, returns the TensorFlow expression of cross-entropy for two distributions, it implements softmax internally. See `tf.nn.sparse_softmax_cross_entropy_with_logits`.

### Parameters

- **output** (*Tensor*) – A batch of distribution with shape: [batch\_size, num of classes].
- **target** (*Tensor*) – A batch of index with shape: [batch\_size, ].
- **name** (*string*) – Name of this loss.

### Examples

```
>>> ce = tl.cost.cross_entropy(y_logits, y_target_logits, 'my_loss')
```

### References

- About cross-entropy: [https://en.wikipedia.org/wiki/Cross\\_entropy](https://en.wikipedia.org/wiki/Cross_entropy).
- The code is borrowed from: [https://en.wikipedia.org/wiki/Cross\\_entropy](https://en.wikipedia.org/wiki/Cross_entropy).

## 2.3.3 Sigmoid cross entropy

`tensorlayer.cost.sigmoid_cross_entropy(output, target, name=None)`

Sigmoid cross-entropy operation, see `tf.nn.sigmoid_cross_entropy_with_logits`.

### Parameters

- **output** (*Tensor*) – A batch of distribution with shape: [batch\_size, num of classes].
- **target** (*Tensor*) – A batch of index with shape: [batch\_size, ].
- **name** (*string*) – Name of this loss.

## 2.3.4 Binary cross entropy

`tensorlayer.cost.binary_cross_entropy(output, target, epsilon=1e-08, name='bce_loss')`

Binary cross entropy operation.

**Parameters**

- **output** (*Tensor*) – Tensor with type of *float32* or *float64*.
- **target** (*Tensor*) – The target distribution, format the same with *output*.
- **epsilon** (*float*) – A small value to avoid output to be zero.
- **name** (*str*) – An optional name to attach to this function.

**References**

- [ericjang-DRAW](#)

**2.3.5 Mean squared error (L2)**

```
tensorlayer.cost.mean_squared_error(output, target, is_mean=False,
                                     name='mean_squared_error')
```

Return the TensorFlow expression of mean-square-error (L2) of two batch of data.

**Parameters**

- **output** (*Tensor*) – 2D, 3D or 4D tensor i.e. [batch\_size, n\_feature], [batch\_size, height, width] or [batch\_size, height, width, channel].
- **target** (*Tensor*) – The target distribution, format the same with *output*.
- **is\_mean** (*boolean*) –

Whether compute the mean or sum for each example.

- If True, use `tf.reduce_mean` to compute the loss between one target and predict data.
- If False, use `tf.reduce_sum` (default).
- **name** (*str*) – An optional name to attach to this function.

**References**

- [Wiki Mean Squared Error](#)

**2.3.6 Normalized mean square error**

```
tensorlayer.cost.normalized_mean_square_error(output, target,
                                                name='normalized_mean_squared_error_loss')
```

Return the TensorFlow expression of normalized mean-square-error of two distributions.

**Parameters**

- **output** (*Tensor*) – 2D, 3D or 4D tensor i.e. [batch\_size, n\_feature], [batch\_size, height, width] or [batch\_size, height, width, channel].
- **target** (*Tensor*) – The target distribution, format the same with *output*.
- **name** (*str*) – An optional name to attach to this function.

### 2.3.7 Absolute difference error (L1)

`tensorlayer.cost.absolute_difference_error` (*output*, *target*, *is\_mean=False*,  
*name='absolute\_difference\_error\_loss'*)

Return the TensorFlow expression of absolute difference error (L1) of two batch of data.

#### Parameters

- **output** (*Tensor*) – 2D, 3D or 4D tensor i.e. [batch\_size, n\_feature], [batch\_size, height, width] or [batch\_size, height, width, channel].
- **target** (*Tensor*) – The target distribution, format the same with *output*.
- **is\_mean** (*boolean*) –

Whether compute the mean or sum for each example.

- If True, use `tf.reduce_mean` to compute the loss between one target and predict data.
- If False, use `tf.reduce_sum` (default).
- **name** (*str*) – An optional name to attach to this function.

### 2.3.8 Dice coefficient

`tensorlayer.cost.dice_coe` (*output*, *target*, *loss\_type='jaccard'*, *axis=(1, 2, 3)*, *smooth=1e-05*)

Soft dice (Sørensen or Jaccard) coefficient for comparing the similarity of two batch of data, usually be used for binary image segmentation i.e. labels are binary. The coefficient between 0 to 1, 1 means totally match.

#### Parameters

- **output** (*Tensor*) – A distribution with shape: [batch\_size, ...], (any dimensions).
- **target** (*Tensor*) – The target distribution, format the same with *output*.
- **loss\_type** (*str*) – jaccard or sorensen, default is jaccard.
- **axis** (*tuple of int*) – All dimensions are reduced, default [1, 2, 3].
- **smooth** (*float*) –

This small value will be added to the numerator and denominator.

- If both output and target are empty, it makes sure dice is 1.
- If either output or target are empty (all pixels are background),  $\text{dice} = \frac{\text{smooth}}{(\text{small\_value} + \text{smooth})}$ , then if smooth is very small, dice close to 0 (even the image values lower than the threshold), so in this case, higher smooth can have a higher dice.

#### Examples

```
>>> outputs = tl.act.pixel_wise_softmax(network.outputs)
>>> dice_loss = 1 - tl.cost.dice_coe(outputs, y_)
```

#### References

- [Wiki-Dice](#)

### 2.3.9 Hard Dice coefficient

`tensorlayer.cost.dice_hard_coe` (*output*, *target*, *threshold=0.5*, *axis=(1, 2, 3)*, *smooth=1e-05*)

Non-differentiable Sørensen–Dice coefficient for comparing the similarity of two batch of data, usually be used for binary image segmentation i.e. labels are binary. The coefficient between 0 to 1, 1 if totally match.

#### Parameters

- **output** (*tensor*) – A distribution with shape: [batch\_size, ...], (any dimensions).
- **target** (*tensor*) – The target distribution, format the same with *output*.
- **threshold** (*float*) – The threshold value to be true.
- **axis** (*tuple of integer*) – All dimensions are reduced, default (1, 2, 3).
- **smooth** (*float*) – This small value will be added to the numerator and denominator, see `dice_coe`.

#### References

- [Wiki-Dice](#)

### 2.3.10 IOU coefficient

`tensorlayer.cost.iou_coe` (*output*, *target*, *threshold=0.5*, *axis=(1, 2, 3)*, *smooth=1e-05*)

Non-differentiable Intersection over Union (IoU) for comparing the similarity of two batch of data, usually be used for evaluating binary image segmentation. The coefficient between 0 to 1, and 1 means totally match.

#### Parameters

- **output** (*tensor*) – A batch of distribution with shape: [batch\_size, ...], (any dimensions).
- **target** (*tensor*) – The target distribution, format the same with *output*.
- **threshold** (*float*) – The threshold value to be true.
- **axis** (*tuple of integer*) – All dimensions are reduced, default (1, 2, 3).
- **smooth** (*float*) – This small value will be added to the numerator and denominator, see `dice_coe`.

#### Notes

- IoU cannot be used as training loss, people usually use dice coefficient for training, IoU and hard-dice for evaluating.

### 2.3.11 Cross entropy for sequence

`tensorlayer.cost.cross_entropy_seq` (*logits*, *target\_seqs*, *batch\_size=None*)

Returns the expression of cross-entropy of two sequences, implement softmax internally. Normally be used for fixed length RNN outputs, see [PTB example](#).

#### Parameters

- **logits** (*Tensor*) – 2D tensor with shape of [batch\_size \* n\_steps, n\_classes].

- **target\_seqs** (*Tensor*) – The target sequence, 2D tensor  $[batch\_size, n\_steps]$ , if the number of step is dynamic, please use `tl.cost.cross_entropy_seq_with_mask` instead.
- **batch\_size** (*None or int.*) –

Whether to divide the cost by batch size.

- If integer, the return cost will be divided by *batch\_size*.
- If None (default), the return cost will not be divided by anything.

## Examples

```
>>> see `PTB example <https://github.com/tensorlayer/tensorlayer/blob/master/
↪example/tutorial_ptb_lstm_state_is_tuple.py>`__ for more details
>>> input_data = tf.placeholder(tf.int32, [batch_size, n_steps])
>>> targets = tf.placeholder(tf.int32, [batch_size, n_steps])
>>> # build the network
>>> print(net.outputs)
(batch_size * n_steps, n_classes)
>>> cost = tl.cost.cross_entropy_seq(network.outputs, targets)
```

## 2.3.12 Cross entropy with mask for sequence

`tensorlayer.cost.cross_entropy_seq_with_mask` (*logits*, *target\_seqs*, *input\_mask*, *return\_details=False*, *name=None*)

Returns the expression of cross-entropy of two sequences, implement softmax internally. Normally be used for Dynamic RNN with Synced sequence input and output.

### Parameters

- **logits** (*Tensor*) – 2D tensor with shape of  $[batch\_size * ?, n\_classes]$ , ? means dynamic IDs for each example. - Can be get from *DynamicRNNLayer* by setting *return\_seq\_2d* to *True*.
- **target\_seqs** (*Tensor*) – int of tensor, like word ID.  $[batch\_size, ?]$ , ? means dynamic IDs for each example.
- **input\_mask** (*Tensor*) – The mask to compute loss, it has the same size with *target\_seqs*, normally 0 or 1.
- **return\_details** (*boolean*) –

Whether to return detailed losses.

- If False (default), only returns the loss.
- If True, returns the loss, losses, weights and targets (see source code).

## Examples

```
>>> batch_size = 64
>>> vocab_size = 10000
>>> embedding_size = 256
>>> input_seqs = tf.placeholder(dtype=tf.int64, shape=[batch_size, None], name=
↪"input")
```

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```

>>> target_seqs = tf.placeholder(dtype=tf.int64, shape=[batch_size, None], name=
↳"target")
>>> input_mask = tf.placeholder(dtype=tf.int64, shape=[batch_size, None], name=
↳"mask")
>>> net = tl.layers.EmbeddingInputlayer(
...     inputs = input_seqs,
...     vocabulary_size = vocab_size,
...     embedding_size = embedding_size,
...     name = 'seq_embedding')
>>> net = tl.layers.DynamicRNNLayer(net,
...     cell_fn = tf.contrib.rnn.BasicLSTMCell,
...     n_hidden = embedding_size,
...     dropout = (0.7 if is_train else None),
...     sequence_length = tl.layers.retrieve_seq_length_op2(input_seqs),
...     return_seq_2d = True,
...     name = 'dynamicrnn')
>>> print(net.outputs)
(?, 256)
>>> net = tl.layers.DenseLayer(net, n_units=vocab_size, name="output")
>>> print(net.outputs)
(?, 10000)
>>> loss = tl.cost.cross_entropy_seq_with_mask(net.outputs, target_seqs, input_
↳mask)

```

### 2.3.13 Cosine similarity

`tensorlayer.cost.cosine_similarity(v1, v2)`

Cosine similarity [-1, 1].

**Parameters** `v2` (`v1,`) – Tensor with the same shape [batch\_size, n\_feature].

#### References

- [Wiki](#).

### 2.3.14 Regularization functions

For `tf.nn.l2_loss`, `tf.contrib.layers.l1_regularizer`, `tf.contrib.layers.l2_regularizer` and `tf.contrib.layers.sum_regularizer`, see [TensorFlow API](#).

#### Maxnorm

`tensorlayer.cost.maxnorm_regularizer(scale=1.0)`

Max-norm regularization returns a function that can be used to apply max-norm regularization to weights.

More about max-norm, see [wiki-max norm](#). The implementation follows [TensorFlow contrib](#).

**Parameters** `scale` (`float`) – A scalar multiplier *Tensor*. 0.0 disables the regularizer.

#### Returns

**Return type** A function with signature `mn(weights, name=None)` that apply Lo regularization.

**Raises** `ValueError` : If scale is outside of the range [0.0, 1.0] or if scale is not a float.

## Special

`tensorlayer.cost.li_regularizer(scale, scope=None)`

Li regularization removes the neurons of previous layer. The *i* represents *inputs*. Returns a function that can be used to apply group li regularization to weights. The implementation follows [TensorFlow contrib](#).

### Parameters

- **scale** (*float*) – A scalar multiplier *Tensor*. 0.0 disables the regularizer.
- **scope** (*str*) – An optional scope name for this function.

### Returns

**Return type** A function with signature `li(weights, name=None)` that apply Li regularization.

**Raises** `ValueError` : if scale is outside of the range [0.0, 1.0] or if scale is not a float.

`tensorlayer.cost.lo_regularizer(scale)`

Lo regularization removes the neurons of current layer. The *o* represents *outputs*. Returns a function that can be used to apply group lo regularization to weights. The implementation follows [TensorFlow contrib](#).

**Parameters** **scale** (*float*) – A scalar multiplier *Tensor*. 0.0 disables the regularizer.

### Returns

**Return type** A function with signature `lo(weights, name=None)` that apply Lo regularization.

**Raises** `ValueError` : If scale is outside of the range [0.0, 1.0] or if scale is not a float.

`tensorlayer.cost.maxnorm_o_regularizer(scale)`

Max-norm output regularization removes the neurons of current layer. Returns a function that can be used to apply max-norm regularization to each column of weight matrix. The implementation follows [TensorFlow contrib](#).

**Parameters** **scale** (*float*) – A scalar multiplier *Tensor*. 0.0 disables the regularizer.

### Returns

**Return type** A function with signature `mn_o(weights, name=None)` that apply Lo regularization.

**Raises** `ValueError` : If scale is outside of the range [0.0, 1.0] or if scale is not a float.

`tensorlayer.cost.maxnorm_i_regularizer(scale)`

Max-norm input regularization removes the neurons of previous layer. Returns a function that can be used to apply max-norm regularization to each row of weight matrix. The implementation follows [TensorFlow contrib](#).

**Parameters** **scale** (*float*) – A scalar multiplier *Tensor*. 0.0 disables the regularizer.

### Returns

**Return type** A function with signature `mn_i(weights, name=None)` that apply Lo regularization.

**Raises** `ValueError` : If scale is outside of the range [0.0, 1.0] or if scale is not a float.

## 2.4 API - Data Pre-Processing

---

<code>affine_rotation_matrix([angle])</code>	Create an affine transform matrix for image rotation.
<code>affine_horizontal_flip_matrix([prob])</code>	Create an affine transformation matrix for image horizontal flipping.

---

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Table 4 – continued from previous page

<code>affine_vertical_flip_matrix([prob])</code>	Create an affine transformation for image vertical flipping.
<code>affine_shift_matrix([wrg, hrg, w, h])</code>	Create an affine transform matrix for image shifting.
<code>affine_shear_matrix([x_shear, y_shear])</code>	Create affine transform matrix for image shearing.
<code>affine_zoom_matrix([zoom_range])</code>	Create an affine transform matrix for zooming/scaling an image's height and width.
<code>affine_respective_zoom_matrix([w_range, h_range])</code>	Get affine transform matrix for zooming/scaling that height and width are changed independently.
<code>transform_matrix_offset_center(matrix, x, y)</code>	Convert the matrix from Cartesian coordinates (the origin in the middle of image) to Image coordinates (the origin on the top-left of image).
<code>affine_transform(x, transform_matrix[, ...])</code>	Return transformed images by given an affine matrix in Scipy format (x is height).
<code>affine_transform_cv2(x, transform_matrix[, ...])</code>	Return transformed images by given an affine matrix in OpenCV format (x is width).
<code>affine_transform_keypoints(coords_list, ...)</code>	Transform keypoint coordinates according to a given affine transform matrix.
<code>projective_transform_by_points(x, src, dst)</code>	Projective transform by given coordinates, usually 4 coordinates.
<code>rotation(x[, rg, is_random, row_index, ...])</code>	Rotate an image randomly or non-randomly.
<code>rotation_multi(x[, rg, is_random, ...])</code>	Rotate multiple images with the same arguments, randomly or non-randomly.
<code>crop(x, wrg, hrg[, is_random, row_index, ...])</code>	Randomly or centrally crop an image.
<code>crop_multi(x, wrg, hrg[, is_random, ...])</code>	Randomly or centrally crop multiple images.
<code>flip_axis(x[, axis, is_random])</code>	Flip the axis of an image, such as flip left and right, up and down, randomly or non-randomly.
<code>flip_axis_multi(x, axis[, is_random])</code>	Flip the axes of multiple images together, such as flip left and right, up and down, randomly or non-randomly.
<code>shift(x[, wrg, hrg, is_random, row_index, ...])</code>	Shift an image randomly or non-randomly.
<code>shift_multi(x[, wrg, hrg, is_random, ...])</code>	Shift images with the same arguments, randomly or non-randomly.
<code>shear(x[, intensity, is_random, row_index, ...])</code>	Shear an image randomly or non-randomly.
<code>shear_multi(x[, intensity, is_random, ...])</code>	Shear images with the same arguments, randomly or non-randomly.
<code>shear2(x[, shear, is_random, row_index, ...])</code>	Shear an image randomly or non-randomly.
<code>shear_multi2(x[, shear, is_random, ...])</code>	Shear images with the same arguments, randomly or non-randomly.
<code>swirl(x[, center, strength, radius, ...])</code>	Swirl an image randomly or non-randomly, see <a href="#">scikit-image swirl API</a> and <a href="#">example</a> .
<code>swirl_multi(x[, center, strength, radius, ...])</code>	Swirl multiple images with the same arguments, randomly or non-randomly.
<code>elastic_transform(x, alpha, sigma[, mode, ...])</code>	Elastic transformation for image as described in <a href="#">[Simard2003]</a> .
<code>elastic_transform_multi(x, alpha, sigma[, ...])</code>	Elastic transformation for images as described in <a href="#">[Simard2003]</a> .
<code>zoom(x[, zoom_range, row_index, col_index, ...])</code>	Zooming/Scaling a single image that height and width are changed together.
<code>respective_zoom(x[, h_range, w_range, ...])</code>	Zooming/Scaling a single image that height and width are changed independently.
<code>zoom_multi(x[, zoom_range, is_random, ...])</code>	Zoom in and out of images with the same arguments, randomly or non-randomly.

Continued on next page

Table 4 – continued from previous page

<code>brightness(x[, gamma, gain, is_random])</code>	Change the brightness of a single image, randomly or non-randomly.
<code>brightness_multi(x[, gamma, gain, is_random])</code>	Change the brightness of multiply images, randomly or non-randomly.
<code>illumination(x[, gamma, contrast, ...])</code>	Perform illumination augmentation for a single image, randomly or non-randomly.
<code>rgb_to_hsv(rgb)</code>	Input RGB image [0~255] return HSV image [0~1].
<code>hsv_to_rgb(hsv)</code>	Input HSV image [0~1] return RGB image [0~255].
<code>adjust_hue(im[, hout, is_offset, is_clip, ...])</code>	Adjust hue of an RGB image.
<code>imresize(x[, size, interp, mode])</code>	Resize an image by given output size and method.
<code>pixel_value_scale(im[, val, clip, is_random])</code>	Scales each value in the pixels of the image.
<code>samplewise_norm(x[, rescale, ...])</code>	Normalize an image by rescale, samplewise centering and samplewise centering in order.
<code>featurewise_norm(x[, mean, std, epsilon])</code>	Normalize every pixels by the same given mean and std, which are usually compute from all examples.
<code>channel_shift(x, intensity[, is_random, ...])</code>	Shift the channels of an image, randomly or non-randomly, see <a href="#">numpy.rollaxis</a> .
<code>channel_shift_multi(x, intensity[, ...])</code>	Shift the channels of images with the same arguments, randomly or non-randomly, see <a href="#">numpy.rollaxis</a> .
<code>drop(x[, keep])</code>	Randomly set some pixels to zero by a given keeping probability.
<code>array_to_img(x[, dim_ordering, scale])</code>	Converts a numpy array to PIL image object (uint8 format).
<code>find_contours(x[, level, fully_connected, ...])</code>	Find iso-valued contours in a 2D array for a given level value, returns list of (n, 2)-ndarrays see <a href="#">skimage.measure.find_contours</a> .
<code>pt2map([list_points, size, val])</code>	Inputs a list of points, return a 2D image.
<code>binary_dilation(x[, radius])</code>	Return fast binary morphological dilation of an image.
<code>dilation(x[, radius])</code>	Return greyscale morphological dilation of an image, see <a href="#">skimage.morphology.dilation</a> .
<code>binary_erosion(x[, radius])</code>	Return binary morphological erosion of an image, see <a href="#">skimage.morphology.binary_erosion</a> .
<code>erosion(x[, radius])</code>	Return greyscale morphological erosion of an image, see <a href="#">skimage.morphology.erosion</a> .
<code>obj_box_coord_rescale([coord, shape])</code>	Scale down one coordinates from pixel unit to the ratio of image size i.e.
<code>obj_box_coords_rescale([coords, shape])</code>	Scale down a list of coordinates from pixel unit to the ratio of image size i.e.
<code>obj_box_coord_scale_to_pixelunit(coord[, shape])</code>	Convert one coordinate [x, y, w (or x2), h (or y2)] in ratio format to image coordinate format.
<code>obj_box_coord_centroid_to_upleft_butright(coord)</code>	Convert one coordinate [x_center, y_center, w, h] to [x1, y1, x2, y2] in up-left and botton-right format.
<code>obj_box_coord_upleft_butright_to_centroid(coord)</code>	Convert one coordinate [x1, y1, x2, y2] to [x_center, y_center, w, h].
<code>obj_box_coord_centroid_to_upleft(coord)</code>	Convert one coordinate [x_center, y_center, w, h] to [x, y, w, h].
<code>obj_box_coord_upleft_to_centroid(coord)</code>	Convert one coordinate [x, y, w, h] to [x_center, y_center, w, h].
<code>parse_darknet_ann_str_to_list(annotations)</code>	Input string format of class, x, y, w, h, return list of list format.

Continued on next page

Table 4 – continued from previous page

<code>parse_darknet_ann_list_to_cls_box(annotation_list)</code>	Parse darknet annotation format into two lists for class and bounding box.
<code>obj_box_horizontal_flip(im[, coords, ...])</code>	Left-right flip the image and coordinates for object detection.
<code>obj_box_imresize(im[, coords, size, interp, ...])</code>	Resize an image, and compute the new bounding box coordinates.
<code>obj_box_crop(im[, classes, coords, wrg, ...])</code>	Randomly or centrally crop an image, and compute the new bounding box coordinates.
<code>obj_box_shift(im[, classes, coords, wrg, ...])</code>	Shift an image randomly or non-randomly, and compute the new bounding box coordinates.
<code>obj_box_zoom(im[, classes, coords, ...])</code>	Zoom in and out of a single image, randomly or non-randomly, and compute the new bounding box coordinates.
<code>keypoint_random_crop(image, annos[, mask, size])</code>	Randomly crop an image and corresponding keypoints without influence scales, given by <code>keypoint_random_resize_shortestedge</code> .
<code>keypoint_resize_random_crop(image, annos[, ...])</code>	Reszie the image to make either its width or height equals to the given sizes.
<code>keypoint_random_rotate(image, annos[, mask, rg])</code>	Rotate an image and corresponding keypoints.
<code>keypoint_random_flip(image, annos[, mask, ...])</code>	Flip an image and corresponding keypoints.
<code>keypoint_random_resize(image, annos[, mask, ...])</code>	Randomly resize an image and corresponding keypoints.
<code>keypoint_random_resize_shortestedge(image, annos)</code>	Randomly resize an image and corresponding keypoints based on shorter edgeself.
<code>pad_sequences(sequences[, maxlen, dtype, ...])</code>	Pads each sequence to the same length: the length of the longest sequence.
<code>remove_pad_sequences(sequences[, pad_id])</code>	Remove padding.
<code>process_sequences(sequences[, end_id, ...])</code>	Set all tokens(ids) after END token to the padding value, and then shorten (option) it to the maximum sequence length in this batch.
<code>sequences_add_start_id(sequences[, ...])</code>	Add special start token(id) in the beginning of each sequence.
<code>sequences_add_end_id(sequences[, end_id])</code>	Add special end token(id) in the end of each sequence.
<code>sequences_add_end_id_after_pad(sequences[, ...])</code>	Add special end token(id) in the end of each sequence.
<code>sequences_get_mask(sequences[, pad_val])</code>	Return mask for sequences.

## 2.4.1 Affine Transform

### Python can be FAST

Image augmentation is a critical step in deep learning. Though TensorFlow has provided `tf.image`, image augmentation often remains as a key bottleneck. `tf.image` has three limitations:

- Real-world visual tasks such as object detection, segmentation, and pose estimation must cope with image meta-data (e.g., coordinates). These data are beyond `tf.image` which processes images as tensors.
- `tf.image` operators breaks the pure Python programing experience (i.e., users have to use `tf.py_func` in order to call image functions written in Python); however, frequent uses of `tf.py_func` slow down TensorFlow, making users hard to balance flexibility and performance.

- `tf.image` API is inflexible. Image operations are performed in an order. They are hard to jointly optimize. More importantly, sequential image operations can significantly reduces the quality of images, thus affecting training accuracy.

TensorLayer addresses these limitations by providing a high-performance image augmentation API in Python. This API bases on affine transformation and `cv2.wrapAffine`. It allows you to combine multiple image processing functions into a single matrix operation. This combined operation is executed by the fast `cv2` library, offering 78x performance improvement (observed in [openpose-plus](#) for example). The following example illustrates the rationale behind this tremendous speed up.

## Example

The source code of complete examples can be found [here](#). The following is a typical Python program that applies rotation, shifting, flipping, zooming and shearing to an image,

```
image = tl.vis.read_image('tiger.jpeg')

xx = tl.prepro.rotation(image, rg=-20, is_random=False)
xx = tl.prepro.flip_axis(xx, axis=1, is_random=False)
xx = tl.prepro.shear2(xx, shear=(0., -0.2), is_random=False)
xx = tl.prepro.zoom(xx, zoom_range=1/0.8)
xx = tl.prepro.shift(xx, wrg=-0.1, hrg=0, is_random=False)

tl.vis.save_image(xx, '_result_slow.png')
```

However, by leveraging affine transformation, image operations can be combined into one:

```
# 1. Create required affine transformation matrices
M_rotate = tl.prepro.affine_rotation_matrix(angle=20)
M_flip = tl.prepro.affine_horizontal_flip_matrix(prob=1)
M_shift = tl.prepro.affine_shift_matrix(wrg=0.1, hrg=0, h=h, w=w)
M_shear = tl.prepro.affine_shear_matrix(x_shear=0.2, y_shear=0)
M_zoom = tl.prepro.affine_zoom_matrix(zoom_range=0.8)

# 2. Combine matrices
# NOTE: operations are applied in a reversed order (i.e., rotation is performed first)
M_combined = M_shift.dot(M_zoom).dot(M_shear).dot(M_flip).dot(M_rotate)

# 3. Convert the matrix from Cartesian coordinates (the origin in the middle of image)
# to image coordinates (the origin on the top-left of image)
transform_matrix = tl.prepro.transform_matrix_offset_center(M_combined, x=w, y=h)

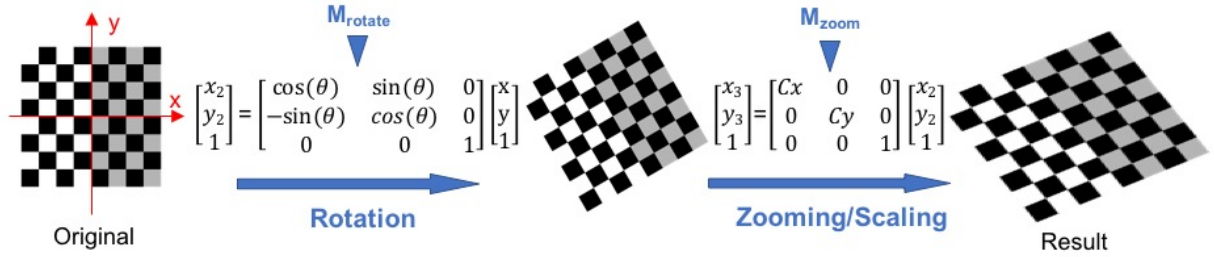
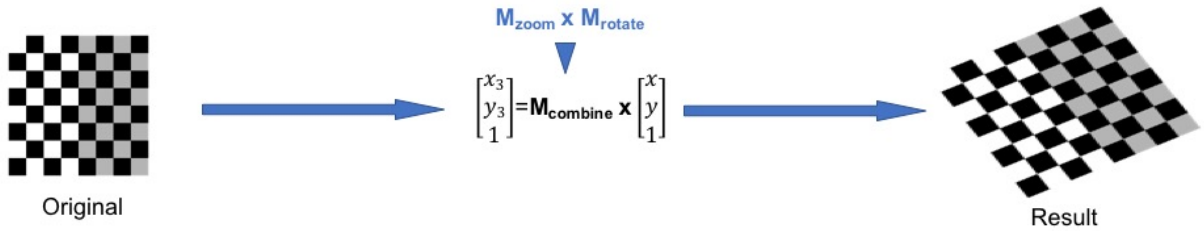
# 4. Transform the image using a single operation
result = tl.prepro.affine_transform_cv2(image, transform_matrix) # 76 times faster

tl.vis.save_image(result, '_result_fast.png')
```

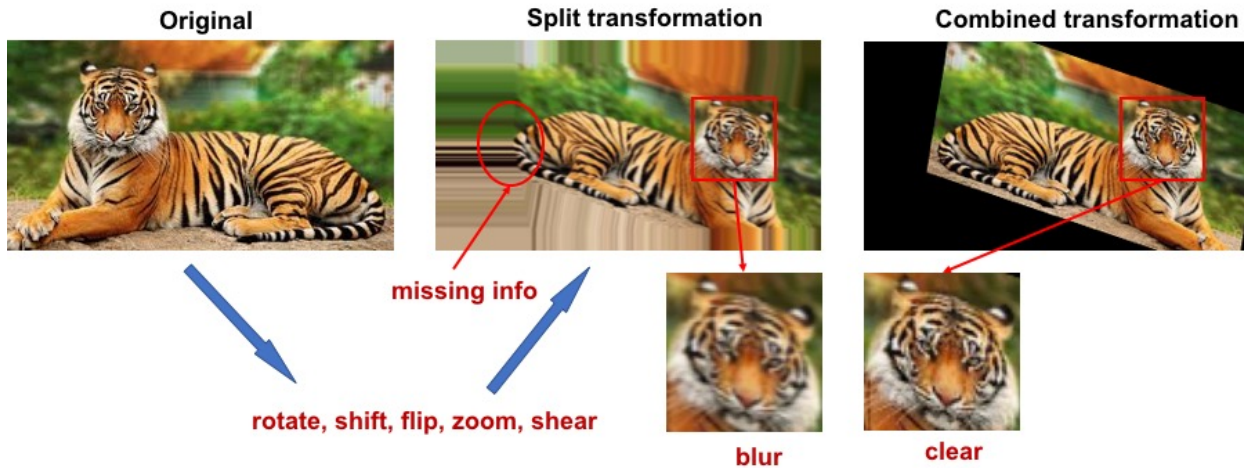
The following figure illustrates the rationale behind combined affine transformation.

**Split transformation**

Cartesian coordinate

**Combined transformation**

Using combined affine transformation has two key benefits. First, it allows you to leverage a pure Python API to achieve orders of magnitudes of speed up in image augmentation, and thus prevent data pre-processing from becoming a bottleneck in training. Second, performing sequential image transformation requires multiple image interpolations. This produces low-quality input images. In contrast, a combined transformation performs the interpolation only once, and thus preserve the content in an image. The following figure illustrates these two benefits:



The major reason for combined affine transformation being fast is because it has lower computational complexity. Assume we have  $k$  affine transformations  $T_1, \dots, T_k$ , where  $T_i$  can be represented by  $3 \times 3$  matrixes. The sequential transformation can be represented as  $y = T_k (\dots T_1 (x))$ , and the time complexity is  $O(k \cdot N)$  where  $N$  is the cost of applying one transformation to image  $x$ .  $N$  is linear to the size of  $x$ . For the combined transformation  $y = (T_k \dots T_1) (x)$  the time complexity is  $O(27(k-1) + N) = \max\{O(27k), O(N)\} = O(N)$  (assuming  $27k \ll N$ ) where  $27 = 3^3$  is the cost for combining two transformations.

### Get rotation matrix

`tensorlayer.prepro.affine_rotation_matrix (angle=(-20, 20))`

Create an affine transform matrix for image rotation. NOTE: In OpenCV, x is width and y is height.

**Parameters** `angle` (*int/float or tuple of two int/float*) –

Degree to rotate, usually -180 ~ 180.

- int/float, a fixed angle.
- tuple of 2 floats/ints, randomly sample a value as the angle between these 2 values.

**Returns** An affine transform matrix.

**Return type** `numpy.array`

### Get horizontal flipping matrix

`tensorlayer.prepro.affine_horizontal_flip_matrix (prob=0.5)`

Create an affine transformation matrix for image horizontal flipping. NOTE: In OpenCV, x is width and y is height.

**Parameters** `prob` (*float*) – Probability to flip the image. 1.0 means always flip.

**Returns** An affine transform matrix.

**Return type** `numpy.array`

### Get vertical flipping matrix

`tensorlayer.prepro.affine_vertical_flip_matrix (prob=0.5)`

Create an affine transformation for image vertical flipping. NOTE: In OpenCV, x is width and y is height.

**Parameters** `prob` (*float*) – Probability to flip the image. 1.0 means always flip.

**Returns** An affine transform matrix.

**Return type** `numpy.array`

### Get shifting matrix

`tensorlayer.prepro.affine_shift_matrix (wrg=(-0.1, 0.1), hrg=(-0.1, 0.1), w=200, h=200)`

Create an affine transform matrix for image shifting. NOTE: In OpenCV, x is width and y is height.

**Parameters**

- `wrg` (*float or tuple of floats*) –

Range to shift on width axis, -1 ~ 1.

- float, a fixed distance.
- tuple of 2 floats, randomly sample a value as the distance between these 2 values.

- `hrg` (*float or tuple of floats*) –

Range to shift on height axis, -1 ~ 1.

- float, a fixed distance.
- tuple of 2 floats, randomly sample a value as the distance between these 2 values.



- $h(w,)$  – The width and height of the image.

**Returns** An affine transform matrix.

**Return type** numpy.array

### Get shearing matrix

`tensorlayer.prepro.affine_shear_matrix(x_shear=(-0.1, 0.1), y_shear=(-0.1, 0.1))`

Create affine transform matrix for image shearing. NOTE: In OpenCV, x is width and y is height.

**Parameters** **shear** (*tuple of two floats*) – Percentage of shears for width and height directions.

**Returns** An affine transform matrix.

**Return type** numpy.array

### Get zooming matrix

`tensorlayer.prepro.affine_zoom_matrix(zoom_range=(0.8, 1.1))`

Create an affine transform matrix for zooming/scaling an image's height and width. OpenCV format, x is width.

**Parameters**

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **zoom\_range** (*float or tuple of 2 floats*) –  
**The zooming/scaling ratio, greater than 1 means larger.**
  - float, a fixed ratio.
  - tuple of 2 floats, randomly sample a value as the ratio between these 2 values.

**Returns** An affine transform matrix.

**Return type** numpy.array

### Get respective zooming matrix

`tensorlayer.prepro.affine_respective_zoom_matrix(w_range=0.8, h_range=1.1)`

Get affine transform matrix for zooming/scaling that height and width are changed independently. OpenCV format, x is width.

**Parameters**

- **w\_range** (*float or tuple of 2 floats*) –  
**The zooming/scaling ratio of width, greater than 1 means larger.**
  - float, a fixed ratio.
  - tuple of 2 floats, randomly sample a value as the ratio between 2 values.
- **h\_range** (*float or tuple of 2 floats*) –  
**The zooming/scaling ratio of height, greater than 1 means larger.**
  - float, a fixed ratio.
  - tuple of 2 floats, randomly sample a value as the ratio between 2 values.

**Returns** An affine transform matrix.

**Return type** numpy.array

## Cartesian to image coordinates

tensorlayer.prepro.**transform\_matrix\_offset\_center**(*matrix*, *x*, *y*)

Convert the matrix from Cartesian coordinates (the origin in the middle of image) to Image coordinates (the origin on the top-left of image).

### Parameters

- **matrix** (*numpy.array*) – Transform matrix.
- **and y** (*x*) – Size of image.

**Returns** The transform matrix.

**Return type** numpy.array

## Examples

- See `tl.prepro.rotation`, `tl.prepro.shear`, `tl.prepro.zoom`.

## Apply image transform

tensorlayer.prepro.**affine\_transform\_cv2**(*x*, *transform\_matrix*, *flags=None*, *border\_mode='constant'*)

Return transformed images by given an affine matrix in OpenCV format (*x* is width). (Powered by OpenCV2, faster than `tl.prepro.affine_transform`)

### Parameters

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **transform\_matrix** (*numpy.array*) – A transform matrix, OpenCV format.
- **border\_mode** (*str*) –
  - *constant*, pad the image with a constant value (i.e. black or 0)
  - *replicate*, the row or column at the very edge of the original is replicated to the extra border.

## Examples

```
>>> M_shear = tl.prepro.affine_shear_matrix(intensity=0.2, is_random=False)
>>> M_zoom = tl.prepro.affine_zoom_matrix(zoom_range=0.8)
>>> M_combined = M_shear.dot(M_zoom)
>>> result = tl.prepro.affine_transform_cv2(image, M_combined)
```



## Apply keypoint transform

`tensorlayer.prepro.affine_transform_keypoints` (*coords\_list*, *transform\_matrix*)

Transform keypoint coordinates according to a given affine transform matrix. OpenCV format, x is width.

Note that, for pose estimation task, flipping requires maintaining the left and right body information. We should not flip the left and right body, so please use `tl.prepro.keypoint_random_flip`.

### Parameters

- **coords\_list** (*list of list of tuple/list*) – The coordinates e.g., the keypoint coordinates of every person in an image.
- **transform\_matrix** (*numpy.array*) – Transform matrix, OpenCV format.

### Examples

```
>>> # 1. get all affine transform matrices
>>> M_rotate = tl.prepro.affine_rotation_matrix(angle=20)
>>> M_flip = tl.prepro.affine_horizontal_flip_matrix(prob=1)
>>> # 2. combine all affine transform matrices to one matrix
>>> M_combined = dot(M_flip).dot(M_rotate)
>>> # 3. transfrom the matrix from Cartesian coordinate (the origin in the middle_
    ↪ of image)
>>> # to Image coordinate (the origin on the top-left of image)
>>> transform_matrix = tl.prepro.transform_matrix_offset_center(M_combined, x=w,
    ↪ y=h)
>>> # 4. then we can transfrom the image once for all transformations
>>> result = tl.prepro.affine_transform_cv2(image, transform_matrix) # 76 times_
    ↪ faster
>>> # 5. transform keypoint coordinates
>>> coords = [[(50, 100), (100, 100), (100, 50), (200, 200)], [(250, 50), (200,
    ↪ 50), (200, 100)]]
>>> coords_result = tl.prepro.affine_transform_keypoints(coords, transform_matrix)
```

## 2.4.2 Images

### Projective transform by points

`tensorlayer.prepro.projective_transform_by_points` (*x*, *src*, *dst*, *map\_args=None*,  
*output\_shape=None*, *order=1*,  
*mode='constant'*, *cval=0.0*,  
*clip=True*, *preserve\_range=False*)

Projective transform by given coordinates, usually 4 coordinates.

see [scikit-image](#).

### Parameters

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **src** (*list or numpy*) – The original coordinates, usually 4 coordinates of (width, height).
- **dst** (*list or numpy*) – The coordinates after transformation, the number of coordinates is the same with src.
- **map\_args** (*dictionary or None*) – Keyword arguments passed to inverse map.

- **output\_shape** (*tuple of 2 int*) – Shape of the output image generated. By default the shape of the input image is preserved. Note that, even for multi-band images, only rows and columns need to be specified.
- **order** (*int*) –  
**The order of interpolation. The order has to be in the range 0-5:**
  - 0 Nearest-neighbor
  - 1 Bi-linear (default)
  - 2 Bi-quadratic
  - 3 Bi-cubic
  - 4 Bi-quartic
  - 5 Bi-quintic
- **mode** (*str*) – One of *constant* (default), *edge*, *symmetric*, *reflect* or *wrap*. Points outside the boundaries of the input are filled according to the given mode. Modes match the behaviour of `numpy.pad`.
- **cval** (*float*) – Used in conjunction with mode *constant*, the value outside the image boundaries.
- **clip** (*boolean*) – Whether to clip the output to the range of values of the input image. This is enabled by default, since higher order interpolation may produce values outside the given input range.
- **preserve\_range** (*boolean*) – Whether to keep the original range of values. Otherwise, the input image is converted according to the conventions of `img_as_float`.

**Returns** A processed image.

**Return type** `numpy.array`

## Examples

Assume `X` is an image from CIFAR-10, i.e. `shape == (32, 32, 3)`

```
>>> src = [[0,0],[0,32],[32,0],[32,32]] # [w, h]
>>> dst = [[10,10],[0,32],[32,0],[32,32]]
>>> x = tl.prepro.projective_transform_by_points(X, src, dst)
```

## References

- [scikit-image : geometric transformations](#)
- [scikit-image : examples](#)

## Rotation

`tensorlayer.prepro.rotation` (*x*, *rg=20*, *is\_random=False*, *row\_index=0*, *col\_index=1*, *channel\_index=2*, *fill\_mode='nearest'*, *cval=0.0*, *order=1*)

Rotate an image randomly or non-randomly.

**Parameters**

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **rg** (*int or float*) – Degree to rotate, usually 0 ~ 180.
- **is\_random** (*boolean*) – If True, randomly rotate. Default is False
- **col\_index and channel\_index** (*row\_index*) – Index of row, col and channel, default (0, 1, 2), for theano (1, 2, 0).
- **fill\_mode** (*str*) – Method to fill missing pixel, default *nearest*, more options *constant*, *reflect* or *wrap*, see [scipy ndimage affine\\_transform](#)
- **cval** (*float*) – Value used for points outside the boundaries of the input if mode='constant'. Default is 0.0
- **order** (*int*) – The order of interpolation. The order has to be in the range 0-5. See [tl.prepro.affine\\_transform](#) and [scipy ndimage affine\\_transform](#)

**Returns** A processed image.

**Return type** `numpy.array`

### Examples

```
>>> x --> [row, col, 1]
>>> x = tl.prepro.rotation(x, rg=40, is_random=False)
>>> tl.vis.save_image(x, 'im.png')
```

`tensorlayer.prepro.rotation_multi(x, rg=20, is_random=False, row_index=0, col_index=1, channel_index=2, fill_mode='nearest', cval=0.0, order=1)`

Rotate multiple images with the same arguments, randomly or non-randomly. Usually be used for image segmentation which `x=[X, Y]`. X and Y should be matched.

#### Parameters

- **x** (*list of numpy.array*) – List of images with dimension of [n\_images, row, col, channel] (default).
- **others** (*args*) – See `tl.prepro.rotation`.

**Returns** A list of processed images.

**Return type** `numpy.array`

### Examples

```
>>> x, y --> [row, col, 1] greyscale
>>> x, y = tl.prepro.rotation_multi([x, y], rg=90, is_random=False)
```

## Crop

`tensorlayer.prepro.crop(x, wrg, hrg, is_random=False, row_index=0, col_index=1)`

Randomly or centrally crop an image.

#### Parameters

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **wrg** (*int*) – Size of width.

- **hrg** (*int*) – Size of height.
- **is\_random** (*boolean*,) – If True, randomly crop, else central crop. Default is False.
- **row\_index** (*int*) – index of row.
- **col\_index** (*int*) – index of column.

**Returns** A processed image.

**Return type** `numpy.array`

`tensorlayer.prepro.crop_multi(x, wrg, hrg, is_random=False, row_index=0, col_index=1)`

Randomly or centrally crop multiple images.

**Parameters**

- **x** (*list of numpy.array*) – List of images with dimension of [n\_images, row, col, channel] (default).
- **others** (*args*) – See `tl.prepro.crop`.

**Returns** A list of processed images.

**Return type** `numpy.array`

## Flip

`tensorlayer.prepro.flip_axis(x, axis=1, is_random=False)`

Flip the axis of an image, such as flip left and right, up and down, randomly or non-randomly,

**Parameters**

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **axis** (*int*) –

**Which axis to flip.**

- 0, flip up and down
- 1, flip left and right
- 2, flip channel

- **is\_random** (*boolean*) – If True, randomly flip. Default is False.

**Returns** A processed image.

**Return type** `numpy.array`

`tensorlayer.prepro.flip_axis_multi(x, axis, is_random=False)`

Flip the axes of multiple images together, such as flip left and right, up and down, randomly or non-randomly,

**Parameters**

- **x** (*list of numpy.array*) – List of images with dimension of [n\_images, row, col, channel] (default).
- **others** (*args*) – See `tl.prepro.flip_axis`.

**Returns** A list of processed images.

**Return type** `numpy.array`

## Shift

`tensorlayer.prepro.shift(x, wrg=0.1, hrg=0.1, is_random=False, row_index=0, col_index=1, channel_index=2, fill_mode='nearest', cval=0.0, order=1)`

Shift an image randomly or non-randomly.

### Parameters

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **wrg** (*float*) – Percentage of shift in axis x, usually -0.25 ~ 0.25.
- **hrg** (*float*) – Percentage of shift in axis y, usually -0.25 ~ 0.25.
- **is\_random** (*boolean*) – If True, randomly shift. Default is False.
- **col\_index and channel\_index** (*row\_index*) – Index of row, col and channel, default (0, 1, 2), for theano (1, 2, 0).
- **fill\_mode** (*str*) – Method to fill missing pixel, default *nearest*, more options *constant*, *reflect* or *wrap*, see [scipy ndimage affine\\_transform](#)
- **cval** (*float*) – Value used for points outside the boundaries of the input if mode='constant'. Default is 0.0.
- **order** (*int*) – The order of interpolation. The order has to be in the range 0-5. See `tl.prepro.affine_transform` and [scipy ndimage affine\\_transform](#)

**Returns** A processed image.

**Return type** `numpy.array`

`tensorlayer.prepro.shift_multi(x, wrg=0.1, hrg=0.1, is_random=False, row_index=0, col_index=1, channel_index=2, fill_mode='nearest', cval=0.0, order=1)`

Shift images with the same arguments, randomly or non-randomly. Usually be used for image segmentation which `x=[X, Y]`, X and Y should be matched.

### Parameters

- **x** (*list of numpy.array*) – List of images with dimension of [n\_images, row, col, channel] (default).
- **others** (*args*) – See `tl.prepro.shift`.

**Returns** A list of processed images.

**Return type** `numpy.array`

## Shear

`tensorlayer.prepro.shear(x, intensity=0.1, is_random=False, row_index=0, col_index=1, channel_index=2, fill_mode='nearest', cval=0.0, order=1)`

Shear an image randomly or non-randomly.

### Parameters

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **intensity** (*float*) – Percentage of shear, usually -0.5 ~ 0.5 (`is_random==True`), 0 ~ 0.5 (`is_random==False`), you can have a quick try by `shear(X, 1)`.
- **is\_random** (*boolean*) – If True, randomly shear. Default is False.

- **col\_index and channel\_index** (*row\_index*) – Index of row, col and channel, default (0, 1, 2), for theano (1, 2, 0).
- **fill\_mode** (*str*) – Method to fill missing pixel, default *nearest*, more options *constant*, *reflect* or *wrap*, see and [scipy ndimage affine\\_transform](#)
- **cval** (*float*) – Value used for points outside the boundaries of the input if mode='constant'. Default is 0.0.
- **order** (*int*) – The order of interpolation. The order has to be in the range 0-5. See `tl.prepro.affine_transform` and [scipy ndimage affine\\_transform](#)

**Returns** A processed image.

**Return type** `numpy.array`

## References

- [Affine transformation](#)

`tensorlayer.prepro.shear_multi` (*x*, *intensity=0.1*, *is\_random=False*, *row\_index=0*, *col\_index=1*, *channel\_index=2*, *fill\_mode='nearest'*, *cval=0.0*, *order=1*)

Shear images with the same arguments, randomly or non-randomly. Usually be used for image segmentation which  $x=[X, Y]$ ,  $X$  and  $Y$  should be matched.

### Parameters

- **x** (*list of numpy.array*) – List of images with dimension of [n\_images, row, col, channel] (default).
- **others** (*args*) – See `tl.prepro.shear`.

**Returns** A list of processed images.

**Return type** `numpy.array`

## Shear V2

`tensorlayer.prepro.shear2` (*x*, *shear=(0.1, 0.1)*, *is\_random=False*, *row\_index=0*, *col\_index=1*, *channel\_index=2*, *fill\_mode='nearest'*, *cval=0.0*, *order=1*)

Shear an image randomly or non-randomly.

### Parameters

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **shear** (*tuple of two floats*) – Percentage of shear for height and width direction (0, 1).
- **is\_random** (*boolean*) – If True, randomly shear. Default is False.
- **col\_index and channel\_index** (*row\_index*) – Index of row, col and channel, default (0, 1, 2), for theano (1, 2, 0).
- **fill\_mode** (*str*) – Method to fill missing pixel, default *nearest*, more options *constant*, *reflect* or *wrap*, see [scipy ndimage affine\\_transform](#)
- **cval** (*float*) – Value used for points outside the boundaries of the input if mode='constant'. Default is 0.0.
- **order** (*int*) – The order of interpolation. The order has to be in the range 0-5. See `tl.prepro.affine_transform` and [scipy ndimage affine\\_transform](#)

**Returns** A processed image.

**Return type** `numpy.array`

## References

- [Affine transformation](#)

```
tensorlayer.prepro.shear_multi2(x, shear=(0.1, 0.1), is_random=False, row_index=0,
                                col_index=1, channel_index=2, fill_mode='nearest', cval=0.0,
                                order=1)
```

Shear images with the same arguments, randomly or non-randomly. Usually be used for image segmentation which  $x=[X, Y]$ ,  $X$  and  $Y$  should be matched.

### Parameters

- **x** (*list of numpy.array*) – List of images with dimension of [n\_images, row, col, channel] (default).
- **others** (*args*) – See `tl.prepro.shear2`.

**Returns** A list of processed images.

**Return type** `numpy.array`

## Swirl

```
tensorlayer.prepro.swirl(x, center=None, strength=1, radius=100, rotation=0,
                          output_shape=None, order=1, mode='constant', cval=0, clip=True,
                          preserve_range=False, is_random=False)
```

Swirl an image randomly or non-randomly, see [scikit-image swirl API](#) and [example](#).

### Parameters

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **center** (*tuple or 2 int or None*) – Center coordinate of transformation (optional).
- **strength** (*float*) – The amount of swirling applied.
- **radius** (*float*) – The extent of the swirl in pixels. The effect dies out rapidly beyond radius.
- **rotation** (*float*) – Additional rotation applied to the image, usually [0, 360], relates to center.
- **output\_shape** (*tuple of 2 int or None*) – Shape of the output image generated (height, width). By default the shape of the input image is preserved.
- **order** (*int, optional*) – The order of the spline interpolation, default is 1. The order has to be in the range 0-5. See `skimage.transform.warp` for detail.
- **mode** (*str*) – One of *constant* (default), *edge*, *symmetric reflect* and *wrap*. Points outside the boundaries of the input are filled according to the given mode, with *constant* used as the default. Modes match the behaviour of `numpy.pad`.
- **cval** (*float*) – Used in conjunction with mode *constant*, the value outside the image boundaries.

- **clip** (*boolean*) – Whether to clip the output to the range of values of the input image. This is enabled by default, since higher order interpolation may produce values outside the given input range.
- **preserve\_range** (*boolean*) – Whether to keep the original range of values. Otherwise, the input image is converted according to the conventions of `img_as_float`.
- **is\_random** (*boolean*,) –

If True, random swirl. Default is False.

- random center = [(0 ~ x.shape[0]), (0 ~ x.shape[1])]
- random strength = [0, strength]
- random radius = [1e-10, radius]
- random rotation = [-rotation, rotation]

**Returns** A processed image.

**Return type** `numpy.array`

## Examples

```
>>> x --> [row, col, 1] greyscale
>>> x = tl.prepro.swirl(x, strength=4, radius=100)
```

```
tensorlayer.prepro.swirl_multi(x, center=None, strength=1, radius=100, rotation=0, out-
                               put_shape=None, order=1, mode='constant', cval=0,
                               clip=True, preserve_range=False, is_random=False)
```

Swirl multiple images with the same arguments, randomly or non-randomly. Usually be used for image segmentation which `x=[X, Y]`, X and Y should be matched.

### Parameters

- **x** (*list of numpy.array*) – List of images with dimension of [n\_images, row, col, channel] (default).
- **others** (*args*) – See `tl.prepro.swirl`.

**Returns** A list of processed images.

**Return type** `numpy.array`

## Elastic transform

```
tensorlayer.prepro.elastic_transform(x, alpha, sigma, mode='constant', cval=0,
                                     is_random=False)
```

Elastic transformation for image as described in [\[Simard2003\]](#).

### Parameters

- **x** (*numpy.array*) – A greyscale image.
- **alpha** (*float*) – Alpha value for elastic transformation.
- **sigma** (*float or sequence of float*) – The smaller the sigma, the more transformation. Standard deviation for Gaussian kernel. The standard deviations of the Gaussian filter are given for each axis as a sequence, or as a single number, in which case it is equal for all axes.



- **mode** (*str*) – See `scipy.ndimage.filters.gaussian_filter`. Default is *constant*.
- **cval** (*float*,) – Used in conjunction with *mode* of *constant*, the value outside the image boundaries.
- **is\_random** (*boolean*) – Default is False.

**Returns** A processed image.

**Return type** `numpy.array`

## Examples

```
>>> x = tl.prepro.elastic_transform(x, alpha=x.shape[1]*3, sigma=x.shape[1]*0.07)
```

## References

- [Github](#).
- [Kaggle](#)

`tensorlayer.prepro.elastic_transform_multi(x, alpha, sigma, mode='constant', cval=0, is_random=False)`

Elastic transformation for images as described in [Simard2003].

### Parameters

- **x** (*list of numpy.array*) – List of greyscale images.
- **others** (*args*) – See `tl.prepro.elastic_transform`.

**Returns** A list of processed images.

**Return type** `numpy.array`

## Zoom

`tensorlayer.prepro.zoom(x, zoom_range=(0.9, 1.1), row_index=0, col_index=1, channel_index=2, fill_mode='nearest', cval=0.0, order=1)`

Zooming/Scaling a single image that height and width are changed together.

### Parameters

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **zoom\_range** (*float or tuple of 2 floats*) –  
**The zooming/scaling ratio, greater than 1 means larger.**
  - float, a fixed ratio.
  - tuple of 2 floats, randomly sample a value as the ratio between 2 values.
- **col\_index and channel\_index** (*row\_index*) – Index of row, col and channel, default (0, 1, 2), for theano (1, 2, 0).
- **fill\_mode** (*str*) – Method to fill missing pixel, default *nearest*, more options *constant*, *reflect* or *wrap*, see `scipy ndimage affine_transform`

- **cval** (*float*) – Value used for points outside the boundaries of the input if mode='constant'. Default is 0.0.
- **order** (*int*) – The order of interpolation. The order has to be in the range 0-5. See `tl.prepro.affine_transform` and [scipy ndimage affine\\_transform](#)

**Returns** A processed image.

**Return type** `numpy.array`

```
tensorlayer.prepro.zoom_multi(x, zoom_range=(0.9, 1.1), is_random=False, row_index=0,  
                              col_index=1, channel_index=2, fill_mode='nearest', cval=0.0,  
                              order=1)
```

Zoom in and out of images with the same arguments, randomly or non-randomly. Usually be used for image segmentation which `x=[X, Y]`, X and Y should be matched.

#### Parameters

- **x** (*list of numpy.array*) – List of images with dimension of [n\_images, row, col, channel] (default).
- **others** (*args*) – See `tl.prepro.zoom`.

**Returns** A list of processed images.

**Return type** `numpy.array`

## Respective Zoom

```
tensorlayer.prepro.respective_zoom(x, h_range=(0.9, 1.1), w_range=(0.9, 1.1), row_index=0,  
                                   col_index=1, channel_index=2, fill_mode='nearest',  
                                   cval=0.0, order=1)
```

Zooming/Scaling a single image that height and width are changed independently.

#### Parameters

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **h\_range** (*float or tuple of 2 floats*) –  
**The zooming/scaling ratio of height, greater than 1 means larger.**
  - float, a fixed ratio.
  - tuple of 2 floats, randomly sample a value as the ratio between 2 values.
- **w\_range** (*float or tuple of 2 floats*) –  
**The zooming/scaling ratio of width, greater than 1 means larger.**
  - float, a fixed ratio.
  - tuple of 2 floats, randomly sample a value as the ratio between 2 values.
- **col\_index and channel\_index** (*row\_index*) – Index of row, col and channel, default (0, 1, 2), for theano (1, 2, 0).
- **fill\_mode** (*str*) – Method to fill missing pixel, default *nearest*, more options *constant*, *reflect* or *wrap*, see [scipy ndimage affine\\_transform](#)
- **cval** (*float*) – Value used for points outside the boundaries of the input if mode='constant'. Default is 0.0.
- **order** (*int*) – The order of interpolation. The order has to be in the range 0-5. See `tl.prepro.affine_transform` and [scipy ndimage affine\\_transform](#)

**Returns** A processed image.

**Return type** numpy.array

## Brightness

`tensorlayer.prepro.brightness(x, gamma=1, gain=1, is_random=False)`

Change the brightness of a single image, randomly or non-randomly.

### Parameters

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **gamma** (*float*) –  
Non negative real number. Default value is 1.  
– Small than 1 means brighter.  
– If *is\_random* is True, gamma in a range of (1-gamma, 1+gamma).
- **gain** (*float*) – The constant multiplier. Default value is 1.
- **is\_random** (*boolean*) – If True, randomly change brightness. Default is False.

**Returns** A processed image.

**Return type** numpy.array

## References

- [skimage.exposure.adjust\\_gamma](#)
- [chinese blog](#)

`tensorlayer.prepro.brightness_multi(x, gamma=1, gain=1, is_random=False)`

Change the brightness of multiply images, randomly or non-randomly. Usually be used for image segmentation which x=[X, Y], X and Y should be matched.

### Parameters

- **x** (*list of numpyarray*) – List of images with dimension of [n\_images, row, col, channel] (default).
- **others** (*args*) – See `tl.prepro.brightness`.

**Returns** A list of processed images.

**Return type** numpy.array

## Brightness, contrast and saturation

`tensorlayer.prepro.illumination(x, gamma=1.0, contrast=1.0, saturation=1.0, is_random=False)`

Perform illumination augmentation for a single image, randomly or non-randomly.

### Parameters

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **gamma** (*float*) –

**Change brightness (the same with `tl.prepro.brightness`)**

- if `is_random=False`, one float number, small than one means brighter, greater than one means darker.
- if `is_random=True`, tuple of two float numbers, (min, max).

- **contrast** (*float*) –

**Change contrast.**

- if `is_random=False`, one float number, small than one means blur.
- if `is_random=True`, tuple of two float numbers, (min, max).

- **saturation** (*float*) –

**Change saturation.**

- if `is_random=False`, one float number, small than one means unsaturation.
- if `is_random=True`, tuple of two float numbers, (min, max).

- **is\_random** (*boolean*) – If True, randomly change illumination. Default is False.

**Returns** A processed image.

**Return type** `numpy.array`

## Examples

Random

```
>>> x = tl.prepro.illumination(x, gamma=(0.5, 5.0), contrast=(0.3, 1.0),  
↪ saturation=(0.7, 1.0), is_random=True)
```

Non-random

```
>>> x = tl.prepro.illumination(x, 0.5, 0.6, 0.8, is_random=False)
```

## RGB to HSV

`tensorlayer.prepro.rgb_to_hsv(rgb)`

Input RGB image [0~255] return HSV image [0~1].

**Parameters** `rgb` (*numpy.array*) – An image with values between 0 and 255.

**Returns** A processed image.

**Return type** `numpy.array`

## HSV to RGB

`tensorlayer.prepro.hsv_to_rgb(hsv)`

Input HSV image [0~1] return RGB image [0~255].

**Parameters** `hsv` (*numpy.array*) – An image with values between 0.0 and 1.0

**Returns** A processed image.

**Return type** `numpy.array`

## Adjust Hue

`tensorlayer.prepro.adjust_hue(im, hout=0.66, is_offset=True, is_clip=True, is_random=False)`  
Adjust hue of an RGB image.

This is a convenience method that converts an RGB image to float representation, converts it to HSV, add an offset to the hue channel, converts back to RGB and then back to the original data type. For TF, see [tf.image.adjust\\_hue](#) and [tf.image.random\\_hue](#).

### Parameters

- **im** (*numpy.array*) – An image with values between 0 and 255.
- **hout** (*float*) –

The scale value for adjusting hue.

- If `is_offset` is False, set all hue values to this value. 0 is red; 0.33 is green; 0.66 is blue.
- If `is_offset` is True, add this value as the offset to the hue channel.

- **is\_offset** (*boolean*) – Whether `hout` is added on HSV as offset or not. Default is True.
- **is\_clip** (*boolean*) – If HSV value smaller than 0, set to 0. Default is True.
- **is\_random** (*boolean*) – If True, randomly change hue. Default is False.

**Returns** A processed image.

**Return type** `numpy.array`

## Examples

Random, add a random value between -0.2 and 0.2 as the offset to every hue values.

```
>>> im_hue = tl.prepro.adjust_hue(image, hout=0.2, is_offset=True, is_
↳ random=False)
```

Non-random, make all hue to green.

```
>>> im_green = tl.prepro.adjust_hue(image, hout=0.66, is_offset=False, is_
↳ random=False)
```

## References

- [tf.image.random\\_hue](#).
- [tf.image.adjust\\_hue](#).
- [StackOverflow: Changing image hue with python PIL](#).

## Resize

`tensorlayer.prepro.imresize(x, size=None, interp='bicubic', mode=None)`  
Resize an image by given output size and method.

Warning, this function will rescale the value to [0, 255].

### Parameters

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **size** (*list of 2 int or None*) – For height and width.
- **interp** (*str*) – Interpolation method for re-sizing (*nearest*, *lanczos*, *bilinear*, *bicubic* (default) or *cubic*).
- **mode** (*str*) – The PIL image mode (*P*, *L*, etc.) to convert arr before resizing.

**Returns** A processed image.

**Return type** `numpy.array`

## References

- [scipy.misc.imresize](#)

## Pixel value scale

`tensorlayer.prepro.pixel_value_scale(im, val=0.9, clip=None, is_random=False)`

Scales each value in the pixels of the image.

### Parameters

- **im** (*numpy.array*) – An image.
- **val** (*float*) –

The scale value for changing pixel value.

- If `is_random=False`, multiply this value with all pixels.
- If `is_random=True`, multiply a value between [1-val, 1+val] with all pixels.

- **clip** (*tuple of 2 numbers*) – The minimum and maximum value.
- **is\_random** (*boolean*) – If True, see val.

**Returns** A processed image.

**Return type** `numpy.array`

## Examples

Random

```
>>> im = pixel_value_scale(im, 0.1, [0, 255], is_random=True)
```

Non-random

```
>>> im = pixel_value_scale(im, 0.9, [0, 255], is_random=False)
```

## Normalization

`tensorlayer.prepro.samplewise_norm(x, rescale=None, samplewise_center=False, samplewise_std_normalization=False, channel_index=2, epsilon=1e-07)`

Normalize an image by rescale, samplewise centering and samplewise centering in order.

**Parameters**

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **rescale** (*float*) – Rescaling factor. If None or 0, no rescaling is applied, otherwise we multiply the data by the value provided (before applying any other transformation)
- **samplewise\_center** (*boolean*) – If True, set each sample mean to 0.
- **samplewise\_std\_normalization** (*boolean*) – If True, divide each input by its std.
- **epsilon** (*float*) – A small position value for dividing standard deviation.

**Returns** A processed image.

**Return type** `numpy.array`

**Examples**

```
>>> x = samplewise_norm(x, samplewise_center=True, samplewise_std_
↪normalization=True)
>>> print(x.shape, np.mean(x), np.std(x))
(160, 176, 1), 0.0, 1.0
```

**Notes**

When `samplewise_center` and `samplewise_std_normalization` are True. - For greyscale image, every pixels are subtracted and divided by the mean and std of whole image. - For RGB image, every pixels are subtracted and divided by the mean and std of this pixel i.e. the mean and std of a pixel is 0 and 1.

`tensorlayer.prepro.featurewise_norm(x, mean=None, std=None, epsilon=1e-07)`

Normalize every pixels by the same given mean and std, which are usually compute from all examples.

**Parameters**

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **mean** (*float*) – Value for subtraction.
- **std** (*float*) – Value for division.
- **epsilon** (*float*) – A small position value for dividing standard deviation.

**Returns** A processed image.

**Return type** `numpy.array`

**Channel shift**

`tensorlayer.prepro.channel_shift(x, intensity, is_random=False, channel_index=2)`

Shift the channels of an image, randomly or non-randomly, see [numpy.rollaxis](#).

**Parameters**

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **intensity** (*float*) – Intensity of shifting.
- **is\_random** (*boolean*) – If True, randomly shift. Default is False.

- **channel\_index** (*int*) – Index of channel. Default is 2.

**Returns** A processed image.

**Return type** `numpy.array`

`tensorlayer.prepro.channel_shift_multi` (*x, intensity, is\_random=False, channel\_index=2*)

Shift the channels of images with the same arguments, randomly or non-randomly, see [numpy.rollaxis](#). Usually be used for image segmentation which `x=[X, Y]`, X and Y should be matched.

**Parameters**

- **x** (*list of numpy.array*) – List of images with dimension of [n\_images, row, col, channel] (default).
- **others** (*args*) – See `tl.prepro.channel_shift`.

**Returns** A list of processed images.

**Return type** `numpy.array`

## Noise

`tensorlayer.prepro.drop` (*x, keep=0.5*)

Randomly set some pixels to zero by a given keeping probability.

**Parameters**

- **x** (*numpy.array*) – An image with dimension of [row, col, channel] or [row, col].
- **keep** (*float*) – The keeping probability (0, 1), the lower more values will be set to zero.

**Returns** A processed image.

**Return type** `numpy.array`

## Numpy and PIL

`tensorlayer.prepro.array_to_img` (*x, dim\_ordering=(0, 1, 2), scale=True*)

Converts a numpy array to PIL image object (uint8 format).

**Parameters**

- **x** (*numpy.array*) – An image with dimension of 3 and channels of 1 or 3.
- **dim\_ordering** (*tuple of 3 int*) – Index of row, col and channel, default (0, 1, 2), for theano (1, 2, 0).
- **scale** (*boolean*) – If True, converts image to [0, 255] from any range of value like [-1, 2]. Default is True.

**Returns** An image.

**Return type** `PIL.image`

## References

[PIL Image.fromarray](#)



## Find contours

`tensorlayer.prepro.find_contours(x, level=0.8, fully_connected='low', positive_orientation='low')`

Find iso-valued contours in a 2D array for a given level value, returns list of (n, 2)-ndarrays see [skimage.measure.find\\_contours](#).

### Parameters

- **x** (*2D ndarray of double.*) – Input data in which to find contours.
- **level** (*float*) – Value along which to find contours in the array.
- **fully\_connected** (*str*) – Either *low* or *high*. Indicates whether array elements below the given level value are to be considered fully-connected (and hence elements above the value will only be face connected), or vice-versa. (See notes below for details.)
- **positive\_orientation** (*str*) – Either *low* or *high*. Indicates whether the output contours will produce positively-oriented polygons around islands of low- or high-valued elements. If *low* then contours will wind counter-clockwise around elements below the iso-value. Alternately, this means that low-valued elements are always on the left of the contour.

**Returns** Each contour is an ndarray of shape (n, 2), consisting of n (row, column) coordinates along the contour.

**Return type** list of (n,2)-ndarrays

## Points to Image

`tensorlayer.prepro.pt2map(list_points=None, size=(100, 100), val=1)`

Inputs a list of points, return a 2D image.

### Parameters

- **list\_points** (*list of 2 int*) – [[x, y], [x, y]..] for point coordinates.
- **size** (*tuple of 2 int*) – (w, h) for output size.
- **val** (*float or int*) – For the contour value.

**Returns** An image.

**Return type** numpy.array

## Binary dilation

`tensorlayer.prepro.binary_dilation(x, radius=3)`

Return fast binary morphological dilation of an image. see [skimage.morphology.binary\\_dilation](#).

### Parameters

- **x** (*2D array*) – A binary image.
- **radius** (*int*) – For the radius of mask.

**Returns** A processed binary image.

**Return type** numpy.array

## Greyscale dilation

`tensorlayer.prepro.dilation(x, radius=3)`

Return greyscale morphological dilation of an image, see [skimage.morphology.dilation](#).

### Parameters

- **x** (*2D array*) – An greyscale image.
- **radius** (*int*) – For the radius of mask.

**Returns** A processed greyscale image.

**Return type** `numpy.array`

## Binary erosion

`tensorlayer.prepro.binary_erosion(x, radius=3)`

Return binary morphological erosion of an image, see [skimage.morphology.binary\\_erosion](#).

### Parameters

- **x** (*2D array*) – A binary image.
- **radius** (*int*) – For the radius of mask.

**Returns** A processed binary image.

**Return type** `numpy.array`

## Greyscale erosion

`tensorlayer.prepro.erosion(x, radius=3)`

Return greyscale morphological erosion of an image, see [skimage.morphology.erosion](#).

### Parameters

- **x** (*2D array*) – A greyscale image.
- **radius** (*int*) – For the radius of mask.

**Returns** A processed greyscale image.

**Return type** `numpy.array`

## 2.4.3 Object detection

### Tutorial for Image Aug

Hi, here is an example for image augmentation on VOC dataset.

```
import tensorlayer as tl

## download VOC 2012 dataset
imgs_file_list, _, _, classes, _, _, \
    _, objs_info_list, _ = tl.files.load_voc_dataset(dataset="2012")

## parse annotation and convert it into list format
ann_list = []
```

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```

for info in objs_info_list:
    ann = tl.prepro.parse_darknet_ann_str_to_list(info)
    c, b = tl.prepro.parse_darknet_ann_list_to_cls_box(ann)
    ann_list.append([c, b])

# read and save one image
idx = 2 # you can select your own image
image = tl.vis.read_image(imgs_file_list[idx])
tl.vis.draw_boxes_and_labels_to_image(image, ann_list[idx][0],
    ann_list[idx][1], [], classes, True, save_name='_im_original.png')

# left right flip
im_flip, coords = tl.prepro.obj_box_horizontal_flip(image,
    ann_list[idx][1], is_rescale=True, is_center=True, is_random=False)
tl.vis.draw_boxes_and_labels_to_image(im_flip, ann_list[idx][0],
    coords, [], classes, True, save_name='_im_flip.png')

# resize
im_resize, coords = tl.prepro.obj_box_imresize(image,
    coords=ann_list[idx][1], size=[300, 200], is_rescale=True)
tl.vis.draw_boxes_and_labels_to_image(im_resize, ann_list[idx][0],
    coords, [], classes, True, save_name='_im_resize.png')

# crop
im_crop, clas, coords = tl.prepro.obj_box_crop(image, ann_list[idx][0],
    ann_list[idx][1], wrg=200, hrg=200,
    is_rescale=True, is_center=True, is_random=False)
tl.vis.draw_boxes_and_labels_to_image(im_crop, clas, coords, [],
    classes, True, save_name='_im_crop.png')

# shift
im_shfit, clas, coords = tl.prepro.obj_box_shift(image, ann_list[idx][0],
    ann_list[idx][1], wrg=0.1, hrg=0.1,
    is_rescale=True, is_center=True, is_random=False)
tl.vis.draw_boxes_and_labels_to_image(im_shfit, clas, coords, [],
    classes, True, save_name='_im_shift.png')

# zoom
im_zoom, clas, coords = tl.prepro.obj_box_zoom(image, ann_list[idx][0],
    ann_list[idx][1], zoom_range=(1.3, 0.7),
    is_rescale=True, is_center=True, is_random=False)
tl.vis.draw_boxes_and_labels_to_image(im_zoom, clas, coords, [],
    classes, True, save_name='_im_zoom.png')

```

In practice, you may want to use threading method to process a batch of images as follows.

```

import tensorlayer as tl
import random

batch_size = 64
im_size = [416, 416]
n_data = len(imgs_file_list)
jitter = 0.2
def _data_pre_aug_fn(data):
    im, ann = data
    clas, coords = ann
    ## change image brightness, contrast and saturation randomly

```

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```

im = tl.prepro.illumination(im, gamma=(0.5, 1.5),
                           contrast=(0.5, 1.5), saturation=(0.5, 1.5), is_random=True)
## flip randomly
im, coords = tl.prepro.obj_box_horizontal_flip(im, coords,
        is_rescale=True, is_center=True, is_random=True)
## randomly resize and crop image, it can have same effect as random zoom
tmp0 = random.randint(1, int(im_size[0]*jitter))
tmp1 = random.randint(1, int(im_size[1]*jitter))
im, coords = tl.prepro.obj_box_imresize(im, coords,
        [im_size[0]+tmp0, im_size[1]+tmp1], is_rescale=True,
        interp='bicubic')
im, clas, coords = tl.prepro.obj_box_crop(im, clas, coords,
        wrg=im_size[1], hrg=im_size[0], is_rescale=True,
        is_center=True, is_random=True)
## rescale value from [0, 255] to [-1, 1] (optional)
im = im / 127.5 - 1
return im, [clas, coords]

# randomly read a batch of image and the corresponding annotations
idxs = tl.utils.get_random_int(min=0, max=n_data-1, number=batch_size)
b_im_path = [imgs_file_list[i] for i in idxs]
b_images = tl.prepro.threading_data(b_im_path, fn=tl.vis.read_image)
b_ann = [ann_list[i] for i in idxs]

# threading process
data = tl.prepro.threading_data([_ for _ in zip(b_images, b_ann)],
        _data_pre_aug_fn)
b_images2 = [d[0] for d in data]
b_ann = [d[1] for d in data]

# save all images
for i in range(len(b_images)):
    tl.vis.draw_boxes_and_labels_to_image(b_images[i],
        ann_list[idxs[i]][0], ann_list[idxs[i]][1], [],
        classes, True, save_name='_bbox_vis_%d_original.png' % i)
    tl.vis.draw_boxes_and_labels_to_image((b_images2[i]+1)*127.5,
        b_ann[i][0], b_ann[i][1], [], classes, True,
        save_name='_bbox_vis_%d.png' % i)

```

## Image Aug with TF Dataset API

- Example code for VOC [here](#).

## Coordinate pixel unit to percentage

tensorlayer.prepro.**obj\_box\_coord\_rescale** (coord=None, shape=None)

Scale down one coordinates from pixel unit to the ratio of image size i.e. in the range of [0, 1]. It is the reverse process of obj\_box\_coord\_scale\_to\_pixelunit.

### Parameters

- **coords** (list of 4 int or None) – One coordinates of one image e.g. [x, y, w, h].
- **shape** (list of 2 int or None) – For [height, width].

**Returns** New bounding box.

**Return type** list of 4 numbers

### Examples

```
>>> coord = tl.prepro.obj_box_coord_rescale(coord=[30, 40, 50, 50], shape=[100, 100])
[0.3, 0.4, 0.5, 0.5]
```

## Coordinates pixel unit to percentage

`tensorlayer.prepro.obj_box_coords_rescale` (*coords=None, shape=None*)

Scale down a list of coordinates from pixel unit to the ratio of image size i.e. in the range of [0, 1].

### Parameters

- **coords** (*list of list of 4 ints or None*) – For coordinates of more than one images e.g. `[[x, y, w, h], [x, y, w, h], ...]`.
- **shape** (*list of 2 int or None*) – height, width].

**Returns** A list of new bounding boxes.

**Return type** list of list of 4 numbers

### Examples

```
>>> coords = obj_box_coords_rescale(coords=[[30, 40, 50, 50], [10, 10, 20, 20]], shape=[100, 100])
>>> print(coords)
[[0.3, 0.4, 0.5, 0.5], [0.1, 0.1, 0.2, 0.2]]
>>> coords = obj_box_coords_rescale(coords=[[30, 40, 50, 50]], shape=[50, 100])
>>> print(coords)
[[0.3, 0.8, 0.5, 1.0]]
>>> coords = obj_box_coords_rescale(coords=[[30, 40, 50, 50]], shape=[100, 200])
>>> print(coords)
[[0.15, 0.4, 0.25, 0.5]]
```

**Returns** New coordinates.

**Return type** list of 4 numbers

## Coordinate percentage to pixel unit

`tensorlayer.prepro.obj_box_coord_scale_to_pixelunit` (*coord, shape=None*)

Convert one coordinate `[x, y, w (or x2), h (or y2)]` in ratio format to image coordinate format. It is the reverse process of `obj_box_coord_rescale`.

### Parameters

- **coord** (*list of 4 float*) – One coordinate of one image `[x, y, w (or x2), h (or y2)]` in ratio format, i.e value range [0~1].
- **shape** (*tuple of 2 or None*) – For [height, width].

**Returns** New bounding box.

**Return type** list of 4 numbers

### Examples

```
>>> x, y, x2, y2 = tl.prepro.obj_box_coord_scale_to_pixelunit([0.2, 0.3, 0.5, 0.
↪7], shape=(100, 200, 3))
[40, 30, 100, 70]
```

### Coordinate [x\_center, y\_center, w, h] to up-left button-right

`tensorlayer.prepro.obj_box_coord_centroid_to_upleft_butright` (*coord*,  
*to\_int=False*)  
Convert one coordinate [x\_center, y\_center, w, h] to [x1, y1, x2, y2] in up-left and bottom-right format.

#### Parameters

- **coord** (*list of 4 int/float*) – One coordinate.
- **to\_int** (*boolean*) – Whether to convert output as integer.

**Returns** New bounding box.

**Return type** list of 4 numbers

### Examples

```
>>> coord = obj_box_coord_centroid_to_upleft_butright([30, 40, 20, 20])
[20, 30, 40, 50]
```

### Coordinate up-left button-right to [x\_center, y\_center, w, h]

`tensorlayer.prepro.obj_box_coord_upleft_butright_to_centroid` (*coord*)  
Convert one coordinate [x1, y1, x2, y2] to [x\_center, y\_center, w, h]. It is the reverse process of `obj_box_coord_centroid_to_upleft_butright`.

**Parameters** **coord** (*list of 4 int/float*) – One coordinate.

**Returns** New bounding box.

**Return type** list of 4 numbers

### Coordinate [x\_center, y\_center, w, h] to up-left-width-high

`tensorlayer.prepro.obj_box_coord_centroid_to_upleft` (*coord*)  
Convert one coordinate [x\_center, y\_center, w, h] to [x, y, w, h]. It is the reverse process of `obj_box_coord_upleft_to_centroid`.

**Parameters** **coord** (*list of 4 int/float*) – One coordinate.

**Returns** New bounding box.

**Return type** list of 4 numbers

### Coordinate up-left-width-high to [x\_center, y\_center, w, h]

`tensorlayer.prepro.obj_box_coord_upleft_to_centroid(coord)`

Convert one coordinate [x, y, w, h] to [x\_center, y\_center, w, h]. It is the reverse process of `obj_box_coord_centroid_to_upleft`.

**Parameters** `coord` (*list of 4 int/float*) – One coordinate.

**Returns** New bounding box.

**Return type** list of 4 numbers

### Darknet format string to list

`tensorlayer.prepro.parse_darknet_ann_str_to_list(annotations)`

Input string format of class, x, y, w, h, return list of list format.

**Parameters** `annotations` (*str*) – The annotations in darknet format “class, x, y, w, h ...” separated by “\n”.

**Returns** List of bounding box.

**Return type** list of list of 4 numbers

### Darknet format split class and coordinate

`tensorlayer.prepro.parse_darknet_ann_list_to_cls_box(annotations)`

Parse darknet annotation format into two lists for class and bounding box.

Input list of [[class, x, y, w, h], ...], return two list of [class ...] and [[x, y, w, h], ...].

**Parameters** `annotations` (*list of list*) – A list of class and bounding boxes of images e.g. [[class, x, y, w, h], ...]

**Returns**

- *list of int* – List of class labels.
- *list of list of 4 numbers* – List of bounding box.

### Image Aug - Flip

`tensorlayer.prepro.obj_box_horizontal_flip(im, coords=None, is_rescale=False, is_center=False, is_random=False)`

Left-right flip the image and coordinates for object detection.

**Parameters**

- `im` (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- `coords` (*list of list of 4 int/float or None*) – Coordinates [[x, y, w, h], [x, y, w, h], ...].
- `is_rescale` (*boolean*) – Set to True, if the input coordinates are rescaled to [0, 1]. Default is False.
- `is_center` (*boolean*) – Set to True, if the x and y of coordinates are the centroid (i.e. darknet format). Default is False.
- `is_random` (*boolean*) – If True, randomly flip. Default is False.

### Returns

- *numpy.array* – A processed image
- *list of list of 4 numbers* – A list of new bounding boxes.

### Examples

```
>>> im = np.zeros([80, 100])      # as an image with shape width=100, height=80
>>> im, coords = obj_box_left_right_flip(im, coords=[[0.2, 0.4, 0.3, 0.3], [0.1, 0.5, 0.2, 0.3]], is_rescale=True, is_center=True, is_random=False)
>>> print(coords)
[[0.8, 0.4, 0.3, 0.3], [0.9, 0.5, 0.2, 0.3]]
>>> im, coords = obj_box_left_right_flip(im, coords=[[0.2, 0.4, 0.3, 0.3]], is_rescale=True, is_center=False, is_random=False)
>>> print(coords)
[[0.5, 0.4, 0.3, 0.3]]
>>> im, coords = obj_box_left_right_flip(im, coords=[[20, 40, 30, 30]], is_rescale=False, is_center=True, is_random=False)
>>> print(coords)
[[80, 40, 30, 30]]
>>> im, coords = obj_box_left_right_flip(im, coords=[[20, 40, 30, 30]], is_rescale=False, is_center=False, is_random=False)
>>> print(coords)
[[50, 40, 30, 30]]
```

### Image Aug - Resize

`tensorlayer.prepro.obj_box_imresize(im, coords=None, size=None, interp='bicubic', mode=None, is_rescale=False)`

Resize an image, and compute the new bounding box coordinates.

### Parameters

- **im** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **coords** (*list of list of 4 int/float or None*) – Coordinates [[x, y, w, h], [x, y, w, h], ...]
- **interp and mode** (*size*) – See `tl.prepro.imresize`.
- **is\_rescale** (*boolean*) – Set to True, if the input coordinates are rescaled to [0, 1], then return the original coordinates. Default is False.

### Returns

- *numpy.array* – A processed image
- *list of list of 4 numbers* – A list of new bounding boxes.

### Examples

```
>>> im = np.zeros([80, 100, 3])    # as an image with shape width=100, height=80
>>> _, coords = obj_box_imresize(im, coords=[[20, 40, 30, 30], [10, 20, 20, 20]], size=[160, 200], is_rescale=False)
>>> print(coords)
```

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```

[[40, 80, 60, 60], [20, 40, 40, 40]]
>>> _, coords = obj_box_imresize(im, coords=[[20, 40, 30, 30]], size=[40, 100],
↳is_rescale=False)
>>> print(coords)
[[20, 20, 30, 15]]
>>> _, coords = obj_box_imresize(im, coords=[[20, 40, 30, 30]], size=[60, 150],
↳is_rescale=False)
>>> print(coords)
[[30, 30, 45, 22]]
>>> im2, coords = obj_box_imresize(im, coords=[[0.2, 0.4, 0.3, 0.3]], size=[160,
↳200], is_rescale=True)
>>> print(coords, im2.shape)
[[0.2, 0.4, 0.3, 0.3]] (160, 200, 3)

```

## Image Aug - Crop

`tensorlayer.prepro.obj_box_crop(im, classes=None, coords=None, wrg=100, hrg=100, is_rescale=False, is_center=False, is_random=False, thresh_wh=0.02, thresh_wh2=12.0)`

Randomly or centrally crop an image, and compute the new bounding box coordinates. Objects outside the cropped image will be removed.

### Parameters

- **im** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **classes** (*list of int or None*) – Class IDs.
- **coords** (*list of list of 4 int/float or None*) – Coordinates [[x, y, w, h], [x, y, w, h], ...]
- **hrg** and **is\_random** (*wrg*) – See `tl.prepro.crop`.
- **is\_rescale** (*boolean*) – Set to True, if the input coordinates are rescaled to [0, 1]. Default is False.
- **is\_center** (*boolean, default False*) – Set to True, if the x and y of coordinates are the centroid (i.e. darknet format). Default is False.
- **thresh\_wh** (*float*) – Threshold, remove the box if its ratio of width(height) to image size less than the threshold.
- **thresh\_wh2** (*float*) – Threshold, remove the box if its ratio of width to height or vice verse higher than the threshold.

### Returns

- *numpy.array* – A processed image
- *list of int* – A list of classes
- *list of list of 4 numbers* – A list of new bounding boxes.

## Image Aug - Shift

```
tensorlayer.prepro.obj_box_shift(im, classes=None, coords=None, wrg=0.1, hrg=0.1,
                                row_index=0, col_index=1, channel_index=2,
                                fill_mode='nearest', cval=0.0, order=1, is_rescale=False,
                                is_center=False, is_random=False, thresh_wh=0.02,
                                thresh_wh2=12.0)
```

Shift an image randomly or non-randomly, and compute the new bounding box coordinates. Objects outside the cropped image will be removed.

### Parameters

- **im** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **classes** (*list of int or None*) – Class IDs.
- **coords** (*list of list of 4 int/float or None*) – Coordinates [[x, y, w, h], [x, y, w, h], ...]
- **hrg row\_index col\_index channel\_index is\_random fill\_mode cval and order** (*wrg,*) –
- **is\_rescale** (*boolean*) – Set to True, if the input coordinates are rescaled to [0, 1]. Default is False.
- **is\_center** (*boolean*) – Set to True, if the x and y of coordinates are the centroid (i.e. darknet format). Default is False.
- **thresh\_wh** (*float*) – Threshold, remove the box if its ratio of width(height) to image size less than the threshold.
- **thresh\_wh2** (*float*) – Threshold, remove the box if its ratio of width to height or vice versa higher than the threshold.

### Returns

- *numpy.array* – A processed image
- *list of int* – A list of classes
- *list of list of 4 numbers* – A list of new bounding boxes.

## Image Aug - Zoom

```
tensorlayer.prepro.obj_box_zoom(im, classes=None, coords=None, zoom_range=(0.9,
1.1), row_index=0, col_index=1, channel_index=2,
                                fill_mode='nearest', cval=0.0, order=1, is_rescale=False,
                                is_center=False, is_random=False, thresh_wh=0.02,
                                thresh_wh2=12.0)
```

Zoom in and out of a single image, randomly or non-randomly, and compute the new bounding box coordinates. Objects outside the cropped image will be removed.

### Parameters

- **im** (*numpy.array*) – An image with dimension of [row, col, channel] (default).
- **classes** (*list of int or None*) – Class IDs.
- **coords** (*list of list of 4 int/float or None*) – Coordinates [[x, y, w, h], [x, y, w, h], ...].
- **row\_index col\_index channel\_index is\_random fill\_mode cval and order** (*zoom\_range*) –

- **is\_rescale** (*boolean*) – Set to True, if the input coordinates are rescaled to [0, 1]. Default is False.
- **is\_center** (*boolean*) – Set to True, if the x and y of coordinates are the centroid. (i.e. darknet format). Default is False.
- **thresh\_wh** (*float*) – Threshold, remove the box if its ratio of width(height) to image size less than the threshold.
- **thresh\_wh2** (*float*) – Threshold, remove the box if its ratio of width to height or vice versa higher than the threshold.

#### Returns

- *numpy.array* – A processed image
- *list of int* – A list of classes
- *list of list of 4 numbers* – A list of new bounding boxes.

## 2.4.4 Keypoints

### Image Aug - Crop

`tensorlayer.prepro.keypoint_random_crop(image, annos, mask=None, size=(368, 368))`

Randomly crop an image and corresponding keypoints without influence scales, given by `keypoint_random_resize_shortestedge`.

#### Parameters

- **image** (*3 channel image*) – The given image for augmentation.
- **annos** (*list of list of floats*) – The keypoints annotation of people.
- **mask** (*single channel image or None*) – The mask if available.
- **size** (*tuple of int*) – The size of returned image.

#### Returns

**Return type** preprocessed image, annotation, mask

### Image Aug - Resize then Crop

`tensorlayer.prepro.keypoint_resize_random_crop(image, annos, mask=None, size=(368, 368))`

Reszie the image to make either its width or height equals to the given sizes. Then randomly crop image without influence scales. Resize the image match with the minimum size before cropping, this API will change the zoom scale of object.

#### Parameters

- **image** (*3 channel image*) – The given image for augmentation.
- **annos** (*list of list of floats*) – The keypoints annotation of people.
- **mask** (*single channel image or None*) – The mask if available.
- **size** (*tuple of int*) – The size (height, width) of returned image.

#### Returns

**Return type** preprocessed image, annos, mask

## Image Aug - Rotate

`tensorlayer.prepro.keypoint_random_rotate` (*image*, *annos*, *mask=None*, *rg=15.0*)

Rotate an image and corresponding keypoints.

### Parameters

- **image** (*3 channel image*) – The given image for augmentation.
- **annos** (*list of list of floats*) – The keypoints annotation of people.
- **mask** (*single channel image or None*) – The mask if available.
- **rg** (*int or float*) – Degree to rotate, usually 0 ~ 180.

### Returns

**Return type** preprocessed image, annos, mask

## Image Aug - Flip

`tensorlayer.prepro.keypoint_random_flip` (*image*, *annos*, *mask=None*, *prob=0.5*, *flip\_list=(0, 1, 5, 6, 7, 2, 3, 4, 11, 12, 13, 8, 9, 10, 15, 14, 17, 16, 18)*)

Flip an image and corresponding keypoints.

### Parameters

- **image** (*3 channel image*) – The given image for augmentation.
- **annos** (*list of list of floats*) – The keypoints annotation of people.
- **mask** (*single channel image or None*) – The mask if available.
- **prob** (*float, 0 to 1*) – The probability to flip the image, if 1, always flip the image.
- **flip\_list** (*tuple of int*) – Denotes how the keypoints number be changed after flipping which is required for pose estimation task. The left and right body should be maintained rather than switch. (Default COCO format). Set to an empty tuple if you don't need to maintain left and right information.

### Returns

**Return type** preprocessed image, annos, mask

## Image Aug - Resize

`tensorlayer.prepro.keypoint_random_resize` (*image*, *annos*, *mask=None*, *zoom\_range=(0.8, 1.2)*)

Randomly resize an image and corresponding keypoints. The height and width of image will be changed independently, so the scale will be changed.

### Parameters

- **image** (*3 channel image*) – The given image for augmentation.
- **annos** (*list of list of floats*) – The keypoints annotation of people.
- **mask** (*single channel image or None*) – The mask if available.
- **zoom\_range** (*tuple of two floats*) – The minimum and maximum factor to zoom in or out, e.g (0.5, 1) means zoom out 1~2 times.

**Returns****Return type** preprocessed image, annos, mask**Image Aug - Resize Shortest Edge**

```

tensorlayer.prepro.keypoint_random_resize_shortestedge (image, annos, mask=None,
                                                         min_size=(368, 368),
                                                         zoom_range=(0.8,
                                                         1.2), pad_val=(0, 0,
                                                         <sphinx.ext.autodoc.importer._MockObject
                                                         object>))

```

Randomly resize an image and corresponding keypoints based on shorter edgeself. If the resized image is smaller than *min\_size*, uses padding to make shape matchs *min\_size*. The height and width of image will be changed together, the scale would not be changed.

**Parameters**

- **image** (*3 channel image*) – The given image for augmentation.
- **annos** (*list of list of floats*) – The keypoints annotation of people.
- **mask** (*single channel image or None*) – The mask if available.
- **min\_size** (*tuple of two int*) – The minimum size of height and width.
- **zoom\_range** (*tuple of two floats*) – The minimum and maximum factor to zoom in or out, e.g (0.5, 1) means zoom out 1~2 times.
- **pad\_val** (*int/float, or tuple of int or random function*) – The three padding values for RGB channels respectively.

**Returns****Return type** preprocessed image, annos, mask**2.4.5 Sequence**

More related functions can be found in `tensorlayer.nlp`.

**Padding**

```

tensorlayer.prepro.pad_sequences (sequences, maxlen=None, dtype='int32', padding='post',
                                  truncating='pre', value=0.0)

```

Pads each sequence to the same length: the length of the longest sequence. If *maxlen* is provided, any sequence longer than *maxlen* is truncated to *maxlen*. Truncation happens off either the beginning (default) or the end of the sequence. Supports post-padding and pre-padding (default).

**Parameters**

- **sequences** (*list of list of int*) – All sequences where each row is a sequence.
- **maxlen** (*int*) – Maximum length.
- **dtype** (*numpy.dtype or str*) – Data type to cast the resulting sequence.
- **padding** (*str*) – Either 'pre' or 'post', pad either before or after each sequence.
- **truncating** (*str*) – Either 'pre' or 'post', remove values from sequences larger than *maxlen* either in the beginning or in the end of the sequence

- **value** (*float*) – Value to pad the sequences to the desired value.

**Returns** **x** – With dimensions (number\_of\_sequences, maxlen)

**Return type** numpy.array

### Examples

```
>>> sequences = [[1,1,1,1,1],[2,2,2],[3,3]]
>>> sequences = pad_sequences(sequences, maxlen=None, dtype='int32',
...                           padding='post', truncating='pre', value=0.)
[[1 1 1 1 1]
 [2 2 2 0 0]
 [3 3 0 0 0]]
```

### Remove Padding

tensorlayer.prepro.**remove\_pad\_sequences** (*sequences, pad\_id=0*)

Remove padding.

#### Parameters

- **sequences** (*list of list of int*) – All sequences where each row is a sequence.
- **pad\_id** (*int*) – The pad ID.

**Returns** The processed sequences.

**Return type** list of list of int

### Examples

```
>>> sequences = [[2,3,4,0,0], [5,1,2,3,4,0,0,0], [4,5,0,2,4,0,0,0]]
>>> print(remove_pad_sequences(sequences, pad_id=0))
[[2, 3, 4], [5, 1, 2, 3, 4], [4, 5, 0, 2, 4]]
```

### Process

tensorlayer.prepro.**process\_sequences** (*sequences, end\_id=0, pad\_val=0, is\_shorten=True, re-  
main\_end\_id=False*)

Set all tokens(ids) after END token to the padding value, and then shorten (option) it to the maximum sequence length in this batch.

#### Parameters

- **sequences** (*list of list of int*) – All sequences where each row is a sequence.
- **end\_id** (*int*) – The special token for END.
- **pad\_val** (*int*) – Replace the *end\_id* and the IDs after *end\_id* to this value.
- **is\_shorten** (*boolean*) – Shorten the sequences. Default is True.
- **remain\_end\_id** (*boolean*) – Keep an *end\_id* in the end. Default is False.

**Returns** The processed sequences.

**Return type** list of list of int

## Examples

```
>>> sentences_ids = [[4, 3, 5, 3, 2, 2, 2, 2], <-- end_id is 2
...                 [5, 3, 9, 4, 9, 2, 2, 3]] <-- end_id is 2
>>> sentences_ids = preprocess_sequences(sentences_ids, end_id=vocab.end_id, pad_
↳ val=0, is_shorten=True)
[[4, 3, 5, 3, 0], [5, 3, 9, 4, 9]]
```

## Add Start ID

`tensorlayer.prepro.sequences_add_start_id(sequences, start_id=0, remove_last=False)`  
Add special start token(id) in the beginning of each sequence.

### Parameters

- **sequences** (*list of list of int*) – All sequences where each row is a sequence.
- **start\_id** (*int*) – The start ID.
- **remove\_last** (*boolean*) – Remove the last value of each sequences. Usually be used for removing the end ID.

**Returns** The processed sequences.

**Return type** list of list of int

## Examples

```
>>> sentences_ids = [[4,3,5,3,2,2,2,2], [5,3,9,4,9,2,2,3]]
>>> sentences_ids = sequences_add_start_id(sentences_ids, start_id=2)
[[2, 4, 3, 5, 3, 2, 2, 2, 2], [2, 5, 3, 9, 4, 9, 2, 2, 3]]
>>> sentences_ids = sequences_add_start_id(sentences_ids, start_id=2, remove_
↳ last=True)
[[2, 4, 3, 5, 3, 2, 2, 2], [2, 5, 3, 9, 4, 9, 2, 2]]
```

For Seq2seq

```
>>> input = [a, b, c]
>>> target = [x, y, z]
>>> decode_seq = [start_id, a, b] <-- sequences_add_start_id(input, start_id,
↳ True)
```

## Add End ID

`tensorlayer.prepro.sequences_add_end_id(sequences, end_id=888)`  
Add special end token(id) in the end of each sequence.

### Parameters

- **sequences** (*list of list of int*) – All sequences where each row is a sequence.
- **end\_id** (*int*) – The end ID.

**Returns** The processed sequences.

**Return type** list of list of int

## Examples

```
>>> sequences = [[1,2,3],[4,5,6,7]]
>>> print(sequences_add_end_id(sequences, end_id=999))
[[1, 2, 3, 999], [4, 5, 6, 999]]
```

## Add End ID after pad

tensorlayer.prepro.**sequences\_add\_end\_id\_after\_pad**(sequences, end\_id=888, pad\_id=0)  
Add special end token(id) in the end of each sequence.

### Parameters

- **sequences** (*list of list of int*) – All sequences where each row is a sequence.
- **end\_id** (*int*) – The end ID.
- **pad\_id** (*int*) – The pad ID.

**Returns** The processed sequences.

**Return type** list of list of int

## Examples

```
>>> sequences = [[1,2,0,0], [1,2,3,0], [1,2,3,4]]
>>> print(sequences_add_end_id_after_pad(sequences, end_id=99, pad_id=0))
[[1, 2, 99, 0], [1, 2, 3, 99], [1, 2, 3, 4]]
```

## Get Mask

tensorlayer.prepro.**sequences\_get\_mask**(sequences, pad\_val=0)  
Return mask for sequences.

### Parameters

- **sequences** (*list of list of int*) – All sequences where each row is a sequence.
- **pad\_val** (*int*) – The pad value.

**Returns** The mask.

**Return type** list of list of int

## Examples

```
>>> sentences_ids = [[4, 0, 5, 3, 0, 0],
...                 [5, 3, 9, 4, 9, 0]]
>>> mask = sequences_get_mask(sentences_ids, pad_val=0)
[[1 1 1 1 0 0]
 [1 1 1 1 1 0]]
```



## 2.5 API - Distributed Training

(Alpha release - usage might change later)

Helper API to run a distributed training. Check these [examples](#).

---

<code>Trainer(training_dataset, ..., batch_size, ...)</code>	Trainer for neural networks in a distributed environment.
--	---

---

### 2.5.1 Distributed training

#### Trainer

```
tensorlayer.distributed.Trainer(training_dataset,    build_training_func,    optimizer,    op-
                                timizer_args,    batch_size=32,    prefetch_size=None,
                                checkpoint_dir=None,    scaling_learning_rate=True,
                                log_step_size=1,    validation_dataset=None,
                                build_validation_func=None, max_iteration=inf)
```

Trainer for neural networks in a distributed environment.

TensorLayer Trainer is a high-level training interface built on top of TensorFlow MonitoredSession and [Horovod](#). It transparently scales the training of a TensorLayer model from a single GPU to multiple GPUs that be placed on different machines in a single cluster.

To run the trainer, you will need to install Horovod on your machine. Check the installation script at [tensorlayer/scripts/download\\_and\\_install\\_openmpi3\\_ubuntu.sh](#)

The minimal inputs to the Trainer include (1) a training dataset defined using the TensorFlow DataSet API, and (2) a model build function given the inputs of the training dataset, and returns the neural network to train, the loss function to minimize, and the names of the tensor to log during training, and (3) an optimizer and its arguments.

The default parameter choices of Trainer is inspired by the Facebook paper: [Accurate, Large Minibatch SGD: Training ImageNet in 1 Hour](#)

#### Parameters

- **training\_dataset** (class TensorFlow DataSet) – The training dataset which zips samples and labels. The trainer automatically shards the training dataset based on the number of GPUs.
- **build\_training\_func** (*function*) – A function that builds the training operator. It takes the training dataset as an input, and returns the neural network, the loss function and a dictionary that maps string tags to tensors to log during training.
- **optimizer** (class TensorFlow Optimizer) – The loss function optimizer. The trainer automatically linearly scale the learning rate based on the number of GPUs.
- **optimizer\_args** (*dict*) – The optimizer argument dictionary. It must contain a *learning\_rate* field in type of float. Note that the learning rate is linearly scaled according to the number of GPU by default. You can disable it using the option *scaling\_learning\_rate*
- **batch\_size** (*int*) – The training mini-batch size (i.e., number of samples per batch).
- **prefetch\_size** (*int or None*) – The dataset prefetch buffer size. Set this parameter to overlap the GPU training and data preparation if the data preparation is heavy.

- **checkpoint\_dir** (*None or str*) – The path to the TensorFlow model checkpoint. Note that only one trainer master would checkpoints its model. If *None*, checkpoint is disabled.
- **log\_step\_size** (*int*) – The trainer logs training information every *N* mini-batches (i.e., step size).
- **validation\_dataset** (*None or class TensorFlow DataSet*) – The optional validation dataset that zips samples and labels. Note that only the trainer master needs to the validation often.
- **build\_validation\_func** (*None or function*) – The function that builds the validation operator. It returns the validation neural network (which share the weights of the training network) and a custom number of validation metrics.
- **scaling\_learning\_rate** (*Boolean*) – Linearly scale the learning rate by the number of GPUs. Default is *True*. This *linear scaling rule* is generally effective and is highly recommended by the practioners. Check [Accurate, Large Minibatch SGD: Training ImageNet in 1 Hour](#)
- **max\_iteration** (*int*) – The maximum iteration (i.e., mini-batch) to train. The default is *math.inf*. You can set it to a small number to end the training earlier. This is usually set for testing purpose.

tensorlayer.distributed.**training\_network**

class TensorLayer Layer – The training model.

tensorlayer.distributed.**session**

class TensorFlow MonitoredTrainingSession – The training session tha the Trainer wraps.

tensorlayer.distributed.**global\_step**

*int* – The number of training mini-batch by far.

tensorlayer.distributed.**validation\_metrics**

*list of tuples* – The validation metrics that zips the validation metric property and the average value.

## Examples

See [tutorial\\_mnist\\_distributed\\_trainer.py](#).

## 2.6 API - Files

A collections of helper functions to work with dataset. Load benchmark dataset, save and restore model, save and load variables.

TensorLayer provides rich layer implementations trailed for various benchmarks and domain-specific problems. In addition, we also support transparent access to native TensorFlow parameters. For example, we provide not only layers for local response normalization, but also layers that allow user to apply `tf.nn.lrn` on `network.outputs`. More functions can be found in [TensorFlow API](#).

<code>load_mnist_dataset([shape, path])</code>	Load the original mnist.
<code>load_fashion_mnist_dataset([shape, path])</code>	Load the fashion mnist.
<code>load_cifar10_dataset([shape, path, plotable])</code>	Load CIFAR-10 dataset.
<code>load_cropped_svhn([path, include_extra])</code>	Load Cropped SVHN.
<code>load_ptb_dataset([path])</code>	Load Penn TreeBank (PTB) dataset.

Continued on next page

Table 6 – continued from previous page

<code>load_matt_mahoney_text8_dataset([path])</code>	Load Matt Mahoney’s dataset.
<code>load_imdb_dataset([path, nb_words, ...])</code>	Load IMDB dataset.
<code>load_nietzsche_dataset([path])</code>	Load Nietzsche dataset.
<code>load_wmt_en_fr_dataset([path])</code>	Load WMT’15 English-to-French translation dataset.
<code>load_flickr25k_dataset([tag, path, ...])</code>	Load Flickr25K dataset.
<code>load_flickr1M_dataset([tag, size, path, ...])</code>	Load Flickr1M dataset.
<code>load_cyclegan_dataset([filename, path])</code>	Load images from CycleGAN’s database, see <a href="#">this link</a> .
<code>load_celebA_dataset([path])</code>	Load CelebA dataset
<code>load_voc_dataset([path, dataset, ...])</code>	Pascal VOC 2007/2012 Dataset.
<code>load_mpii_pose_dataset([path, is_16_pos_only])</code>	Load MPII Human Pose Dataset.
<code>download_file_from_google_drive(ID, destination)</code>	Download file from Google Drive.
<code>save_npz([save_list, name, sess])</code>	Input parameters and the file name, save parameters into .npz file.
<code>load_npz([path, name])</code>	Load the parameters of a Model saved by <code>tl.files.save_npz()</code> .
<code>assign_params(sess, params, network)</code>	Assign the given parameters to the TensorLayer network.
<code>load_and_assign_npz([sess, name, network])</code>	Load model from npz and assign to a network.
<code>save_npz_dict([save_list, name, sess])</code>	Input parameters and the file name, save parameters as a dictionary into .npz file.
<code>load_and_assign_npz_dict([name, sess])</code>	Restore the parameters saved by <code>tl.files.save_npz_dict()</code> .
<code>save_ckpt([sess, mode_name, save_dir, ...])</code>	Save parameters into <i>ckpt</i> file.
<code>load_ckpt([sess, mode_name, save_dir, ...])</code>	Load parameters from <i>ckpt</i> file.

## 2.6.1 Load dataset functions

### MNIST

`tensorlayer.files.load_mnist_dataset(shape=(-1, 784), path='data')`

Load the original mnist.

Automatically download MNIST dataset and return the training, validation and test set with 50000, 10000 and 10000 digit images respectively.

#### Parameters

- **shape** (*tuple*) – The shape of digit images (the default is (-1, 784), alternatively (-1, 28, 28, 1)).
- **path** (*str*) – The path that the data is downloaded to.

**Returns** **X\_train, y\_train, X\_val, y\_val, X\_test, y\_test** – Return splitted training/validation/test set respectively.

**Return type** tuple

### Examples

```
>>> X_train, y_train, X_val, y_val, X_test, y_test = tl.files.load_mnist_
↳dataset(shape=(-1, 784), path='datasets')
>>> X_train, y_train, X_val, y_val, X_test, y_test = tl.files.load_mnist_
↳dataset(shape=(-1, 28, 28, 1))
```

## Fashion-MNIST

`tensorlayer.files.load_fashion_mnist_dataset(shape=(-1, 784), path='data')`

Load the fashion mnist.

Automatically download fashion-MNIST dataset and return the training, validation and test set with 50000, 10000 and 10000 fashion images respectively, [examples](#).

### Parameters

- **shape** (*tuple*) – The shape of digit images (the default is (-1, 784), alternatively (-1, 28, 28, 1)).
- **path** (*str*) – The path that the data is downloaded to.

**Returns** `X_train, y_train, X_val, y_val, X_test, y_test` – Return splitted training/validation/test set respectively.

**Return type** tuple

## Examples

```
>>> X_train, y_train, X_val, y_val, X_test, y_test = tl.files.load_fashion_mnist_
↳dataset(shape=(-1, 784), path='datasets')
>>> X_train, y_train, X_val, y_val, X_test, y_test = tl.files.load_fashion_mnist_
↳dataset(shape=(-1, 28, 28, 1))
```

## CIFAR-10

`tensorlayer.files.load_cifar10_dataset(shape=(-1, 32, 32, 3), path='data', plotable=False)`

Load CIFAR-10 dataset.

It consists of 60000 32x32 colour images in 10 classes, with 6000 images per class. There are 50000 training images and 10000 test images.

The dataset is divided into five training batches and one test batch, each with 10000 images. The test batch contains exactly 1000 randomly-selected images from each class. The training batches contain the remaining images in random order, but some training batches may contain more images from one class than another. Between them, the training batches contain exactly 5000 images from each class.

### Parameters

- **shape** (*tupe*) – The shape of digit images e.g. (-1, 3, 32, 32) and (-1, 32, 32, 3).
- **path** (*str*) – The path that the data is downloaded to, defaults is `data/cifar10/`.
- **plotable** (*boolean*) – Whether to plot some image examples, False as default.

## Examples

```
>>> X_train, y_train, X_test, y_test = tl.files.load_cifar10_dataset(shape=(-1, 32, 32, 3))
```

## References

- [CIFAR website](#)
- [Data download link](#)
- <https://teratail.com/questions/28932>

## SVHN

`tensorlayer.files.load_cropped_svhn(path='data', include_extra=True)`  
Load Cropped SVHN.

The Cropped Street View House Numbers (SVHN) Dataset contains 32x32x3 RGB images. Digit '1' has label 1, '9' has label 9 and '0' has label 0 (the original dataset uses 10 to represent '0'), see [ufldl website](#).

### Parameters

- **path** (*str*) – The path that the data is downloaded to.
- **include\_extra** (*boolean*) – If True (default), add extra images to the training set.

**Returns** `X_train, y_train, X_test, y_test` – Return splitted training/test set respectively.

**Return type** tuple

## Examples

```
>>> X_train, y_train, X_test, y_test = tl.files.load_cropped_svhn(include_extra=False)
>>> tl.vis.save_images(X_train[0:100], [10, 10], 'svhn.png')
```

## Penn TreeBank (PTB)

`tensorlayer.files.load_ptb_dataset(path='data')`  
Load Penn TreeBank (PTB) dataset.

It is used in many LANGUAGE MODELING papers, including “Empirical Evaluation and Combination of Advanced Language Modeling Techniques”, “Recurrent Neural Network Regularization”. It consists of 929k training words, 73k validation words, and 82k test words. It has 10k words in its vocabulary.

**Parameters** **path** (*str*) – The path that the data is downloaded to, defaults is `data/ptb/`.

### Returns

- **train\_data, valid\_data, test\_data** (*list of int*) – The training, validating and testing data in integer format.
- **vocab\_size** (*int*) – The vocabulary size.

## Examples

```
>>> train_data, valid_data, test_data, vocab_size = tl.files.load_ptb_dataset()
```

## References

- tensorflow.models.rnn.ptb import reader
- [Manual download](#)

## Notes

- If you want to get the raw data, see the source code.

## Matt Mahoney's text8

```
tensorlayer.files.load_matt_mahoney_text8_dataset(path='data')
```

Load Matt Mahoney's dataset.

Download a text file from Matt Mahoney's website if not present, and make sure it's the right size. Extract the first file enclosed in a zip file as a list of words. This dataset can be used for Word Embedding.

**Parameters** `path` (*str*) – The path that the data is downloaded to, defaults is `data/mm_test8/`.

**Returns** The raw text data e.g. `[... 'their', 'families', 'who', 'were', 'expelled', 'from', 'jerusalem', ...]`

**Return type** list of str

## Examples

```
>>> words = tl.files.load_matt_mahoney_text8_dataset()
>>> print('Data size', len(words))
```

## IMBD

```
tensorlayer.files.load_imdb_dataset(path='data', nb_words=None, skip_top=0,
                                     maxlen=None, test_split=0.2, seed=113, start_char=1,
                                     oov_char=2, index_from=3)
```

Load IMDB dataset.

### Parameters

- **path** (*str*) – The path that the data is downloaded to, defaults is `data/imdb/`.
- **nb\_words** (*int*) – Number of words to get.
- **skip\_top** (*int*) – Top most frequent words to ignore (they will appear as `oov_char` value in the sequence data).
- **maxlen** (*int*) – Maximum sequence length. Any longer sequence will be truncated.
- **seed** (*int*) – Seed for reproducible data shuffling.

- **start\_char** (*int*) – The start of a sequence will be marked with this character. Set to 1 because 0 is usually the padding character.
- **oov\_char** (*int*) – Words that were cut out because of the num\_words or skip\_top limit will be replaced with this character.
- **index\_from** (*int*) – Index actual words with this index and higher.

## Examples

```
>>> X_train, y_train, X_test, y_test = tl.files.load_imdb_dataset(
...                                     nb_words=20000, test_split=0.2)
>>> print('X_train.shape', X_train.shape)
(20000,) [[1, 62, 74, ... 1033, 507, 27], [1, 60, 33, ... 13, 1053, 7]..]
>>> print('y_train.shape', y_train.shape)
(20000,) [1 0 0 ..., 1 0 1]
```

## References

- Modified from keras.

## Nietzsche

tensorlayer.files.**load\_nietzsche\_dataset** (*path='data'*)

Load Nietzsche dataset.

**Parameters** *path* (*str*) – The path that the data is downloaded to, defaults is data/nietzsche/.

**Returns** The content.

**Return type** str

## Examples

```
>>> see tutorial_generate_text.py
>>> words = tl.files.load_nietzsche_dataset()
>>> words = basic_clean_str(words)
>>> words = words.split()
```

## English-to-French translation data from the WMT'15 Website

tensorlayer.files.**load\_wmt\_en\_fr\_dataset** (*path='data'*)

Load WMT'15 English-to-French translation dataset.

It will download the data from the WMT'15 Website (10^9-French-English corpus), and the 2013 news test from the same site as development set. Returns the directories of training data and test data.

**Parameters** *path* (*str*) – The path that the data is downloaded to, defaults is data/wmt\_en\_fr/.

## References

- Code modified from `/tensorflow/models/rnn/translation/data_utils.py`

## Notes

Usually, it will take a long time to download this dataset.

## Flickr25k

```
tensorlayer.files.load_flickr25k_dataset(tag='sky', path='data', n_threads=50, printable=False)
```

Load Flickr25K dataset.

Returns a list of images by a given tag from Flickr25k dataset, it will download Flickr25k from [the official website](#) at the first time you use it.

### Parameters

- **tag** (*str or None*) –

**What images to return.**

- If you want to get images with tag, use string like ‘dog’, ‘red’, see [Flickr Search](#).
- If you want to get all images, set to None.

- **path** (*str*) – The path that the data is downloaded to, defaults is `data/flickr25k/`.
- **n\_threads** (*int*) – The number of thread to read image.
- **printable** (*boolean*) – Whether to print information when reading images, default is False.

## Examples

Get images with tag of sky

```
>>> images = tl.files.load_flickr25k_dataset(tag='sky')
```

Get all images

```
>>> images = tl.files.load_flickr25k_dataset(tag=None, n_threads=100,
↳printable=True)
```

## Flickr1M

```
tensorlayer.files.load_flickr1M_dataset(tag='sky', size=10, path='data', n_threads=50, printable=False)
```

Load Flickr1M dataset.

Returns a list of images by a given tag from Flickr1M dataset, it will download Flickr1M from [the official website](#) at the first time you use it.

### Parameters

- **tag** (*str or None*) –



**What images to return.**

- If you want to get images with tag, use string like ‘dog’, ‘red’, see [Flickr Search](#).
- If you want to get all images, set to None.
- **size** (*int*) – integer between 1 to 10. 1 means 100k images ... 5 means 500k images, 10 means all 1 million images. Default is 10.
- **path** (*str*) – The path that the data is downloaded to, defaults is `data/flickr25k/`.
- **n\_threads** (*int*) – The number of thread to read image.
- **printable** (*boolean*) – Whether to print information when reading images, default is False.

**Examples**

Use 200k images

```
>>> images = tl.files.load_flickr1M_dataset(tag='zebra', size=2)
```

Use 1 Million images

```
>>> images = tl.files.load_flickr1M_dataset(tag='zebra')
```

**CycleGAN**

`tensorlayer.files.load_cyclegan_dataset` (*filename*='summer2winter\_yosemite',  
path='data')

Load images from CycleGAN’s database, see [this link](#).

**Parameters**

- **filename** (*str*) – The dataset you want, see [this link](#).
- **path** (*str*) – The path that the data is downloaded to, defaults is `data/cyclegan`

**Examples**

```
>>> im_train_A, im_train_B, im_test_A, im_test_B = load_cyclegan_dataset(filename=
↳ 'summer2winter_yosemite')
```

**CelebA**

`tensorlayer.files.load_celebA_dataset` (*path*='data')

Load CelebA dataset

Return a list of image path.

**Parameters** **path** (*str*) – The path that the data is downloaded to, defaults is `data/celebA/`.

## VOC 2007/2012

```
tensorlayer.files.load_voc_dataset (path='data', dataset='2012', contain_classes_in_person=False)
```

Pascal VOC 2007/2012 Dataset.

It has 20 objects: aeroplane, bicycle, bird, boat, bottle, bus, car, cat, chair, cow, diningtable, dog, horse, motorbike, person, pottedplant, sheep, sofa, train, tvmonitor and additional 3 classes : head, hand, foot for person.

### Parameters

- **path** (*str*) – The path that the data is downloaded to, defaults is `data/VOC`.
- **dataset** (*str*) – The VOC dataset version, `2012`, `2007`, `2007test` or `2012test`. We usually train model on `2007+2012` and test it on `2007test`.
- **contain\_classes\_in\_person** (*boolean*) – Whether include head, hand and foot annotation, default is `False`.

### Returns

- **imgs\_file\_list** (*list of str*) – Full paths of all images.
- **imgs\_semseg\_file\_list** (*list of str*) – Full paths of all maps for semantic segmentation. Note that not all images have this map!
- **imgs\_insseg\_file\_list** (*list of str*) – Full paths of all maps for instance segmentation. Note that not all images have this map!
- **imgs\_ann\_file\_list** (*list of str*) – Full paths of all annotations for bounding box and object class, all images have this annotations.
- **classes** (*list of str*) – Classes in order.
- **classes\_in\_person** (*list of str*) – Classes in person.
- **classes\_dict** (*dictionary*) – Class label to integer.
- **n\_objs\_list** (*list of int*) – Number of objects in all images in `imgs_file_list` in order.
- **objs\_info\_list** (*list of str*) – Darknet format for the annotation of all images in `imgs_file_list` in order. `[class_id x_centre y_centre width height]` in ratio format.
- **objs\_info\_dicts** (*dictionary*) – The annotation of all images in `imgs_file_list`, `{imgs_file_list : dictionary for annotation}`, format from `TensorFlow/Models/object-detection`.

### Examples

```
>>> imgs_file_list, imgs_semseg_file_list, imgs_insseg_file_list, imgs_ann_file_
↳list,
>>> classes, classes_in_person, classes_dict,
>>> n_objs_list, objs_info_list, objs_info_dicts = tl.files.load_voc_
↳dataset(dataset="2012", contain_classes_in_person=False)
>>> idx = 26
>>> print(classes)
['aeroplane', 'bicycle', 'bird', 'boat', 'bottle', 'bus', 'car', 'cat', 'chair',
↳'cow', 'diningtable', 'dog', 'horse', 'motorbike', 'person', 'pottedplant',
↳'sheep', 'sofa', 'train', 'tvmonitor']
>>> print(classes_dict)
```

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```

{'sheep': 16, 'horse': 12, 'bicycle': 1, 'bottle': 4, 'cow': 9, 'sofa': 17, 'car
↪': 6, 'dog': 11, 'cat': 7, 'person': 14, 'train': 18, 'diningtable': 10,
↪'aeroplane': 0, 'bus': 5, 'pottedplant': 15, 'tvmonitor': 19, 'chair': 8, 'bird
↪': 2, 'boat': 3, 'motorbike': 13}
>>> print(imgs_file_list[idx])
data/VOC/VOC2012/JPEGImages/2007_000423.jpg
>>> print(n_objs_list[idx])
2
>>> print(imgs_ann_file_list[idx])
data/VOC/VOC2012/Annotations/2007_000423.xml
>>> print(objs_info_list[idx])
14 0.173 0.461333333333 0.142 0.496
14 0.828 0.542666666667 0.188 0.594666666667
>>> ann = tl.prepro.parse_darknet_ann_str_to_list(objs_info_list[idx])
>>> print(ann)
[[14, 0.173, 0.461333333333, 0.142, 0.496], [14, 0.828, 0.542666666667, 0.188, 0.
↪594666666667]]
>>> c, b = tl.prepro.parse_darknet_ann_list_to_cls_box(ann)
>>> print(c, b)
[14, 14] [[0.173, 0.461333333333, 0.142, 0.496], [0.828, 0.542666666667, 0.188, 0.
↪594666666667]]

```

## References

- [Pascal VOC2012 Website](#).
- [Pascal VOC2007 Website](#).

## MPII

`tensorlayer.files.load_mpii_pose_dataset` (*path='data', is\_16\_pos\_only=False*)

Load MPII Human Pose Dataset.

### Parameters

- **path** (*str*) – The path that the data is downloaded to.
- **is\_16\_pos\_only** (*boolean*) – If True, only return the peoples contain 16 pose key-points. (Usually be used for single person pose estimation)

### Returns

- **img\_train\_list** (*list of str*) – The image directories of training data.
- **ann\_train\_list** (*list of dict*) – The annotations of training data.
- **img\_test\_list** (*list of str*) – The image directories of testing data.
- **ann\_test\_list** (*list of dict*) – The annotations of testing data.

## Examples

```

>>> import pprint
>>> import tensorlayer as tl
>>> img_train_list, ann_train_list, img_test_list, ann_test_list = tl.files.load_
↪mpii_pose_dataset()

```

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```
>>> image = tl.vis.read_image(img_train_list[0])
>>> tl.vis.draw_mpii_pose_to_image(image, ann_train_list[0], 'image.png')
>>> pprint.pprint(ann_train_list[0])
```

## References

- [MPII Human Pose Dataset](#). CVPR 14
- [MPII Human Pose Models](#). CVPR 16
- [MPII Human Shape, Poselet Conditioned Pictorial Structures and etc](#)
- [MPII Keypoints and ID](#)

## Google Drive

`tensorlayer.files.download_file_from_google_drive` (*ID*, *destination*)

Download file from Google Drive.

See `tl.files.load_celebA_dataset` for example.

### Parameters

- **ID** (*str*) – The driver ID.
- **destination** (*str*) – The destination for save file.

## 2.6.2 Load and save network

TensorFlow provides `.ckpt` file format to save and restore the models, while we suggest to use standard python file format `.npz` to save models for the sake of cross-platform.

```
## save model as .ckpt
saver = tf.train.Saver()
save_path = saver.save(sess, "model.ckpt")
# restore model from .ckpt
saver = tf.train.Saver()
saver.restore(sess, "model.ckpt")

## save model as .npz
tl.files.save_npz(network.all_params , name='model.npz')
# restore model from .npz (method 1)
load_params = tl.files.load_npz(name='model.npz')
tl.files.assign_params(sess, load_params, network)
# restore model from .npz (method 2)
tl.files.load_and_assign_npz(sess=sess, name='model.npz', network=network)

## you can assign the pre-trained parameters as follow
# 1st parameter
tl.files.assign_params(sess, [load_params[0]], network)
# the first three parameters
tl.files.assign_params(sess, load_params[:3], network)
```

## Save network into list (npz)

`tensorlayer.files.save_npz` (*save\_list=None*, *name='model.npz'*, *sess=None*)

Input parameters and the file name, save parameters into .npz file. Use `tl.utils.load_npz()` to restore.

### Parameters

- **save\_list** (*list of tensor*) – A list of parameters (tensor) to be saved.
- **name** (*str*) – The name of the .npz file.
- **sess** (*None or Session*) – Session may be required in some case.

## Examples

Save model to npz

```
>>> tl.files.save_npz(network.all_params, name='model.npz', sess=sess)
```

Load model from npz (Method 1)

```
>>> load_params = tl.files.load_npz(name='model.npz')
>>> tl.files.assign_params(sess, load_params, network)
```

Load model from npz (Method 2)

```
>>> tl.files.load_and_assign_npz(sess=sess, name='model.npz', network=network)
```

## Notes

If you got session issues, you can change the `value.eval()` to `value.eval(session=sess)`

## References

Saving dictionary using numpy

## Load network from list (npz)

`tensorlayer.files.load_npz` (*path=""*, *name='model.npz'*)

Load the parameters of a Model saved by `tl.files.save_npz()`.

### Parameters

- **path** (*str*) – Folder path to .npz file.
- **name** (*str*) – The name of the .npz file.

**Returns** A list of parameters in order.

**Return type** list of array

## Examples

- See `tl.files.save_npz`

## References

- [Saving dictionary using numpy](#)

## Assign a list of parameters to network

`tensorlayer.files.assign_params(sess, params, network)`

Assign the given parameters to the TensorLayer network.

### Parameters

- **sess** (*Session*) – TensorFlow Session.
- **params** (*list of array*) – A list of parameters (array) in order.
- **network** (*Layer*) – The network to be assigned.

**Returns** A list of tf ops in order that assign params. Support `sess.run(ops)` manually.

**Return type** list of operations

## Examples

- See `tl.files.save_npz`

## References

- [Assign value to a TensorFlow variable](#)

## Load and assign a list of parameters to network

`tensorlayer.files.load_and_assign_npz(sess=None, name=None, network=None)`

Load model from npz and assign to a network.

### Parameters

- **sess** (*Session*) – TensorFlow Session.
- **name** (*str*) – The name of the *.npz* file.
- **network** (*Layer*) – The network to be assigned.

**Returns** Returns False, if the model is not exist.

**Return type** False or network

## Examples

- See `tl.files.save_npz`

## Save network into dict (npz)

`tensorlayer.files.save_npz_dict` (*save\_list=None*, *name='model.npz'*, *sess=None*)

Input parameters and the file name, save parameters as a dictionary into .npz file.

Use `tl.files.load_and_assign_npz_dict()` to restore.

### Parameters

- **save\_list** (*list of parameters*) – A list of parameters (tensor) to be saved.
- **name** (*str*) – The name of the .npz file.
- **sess** (*Session*) – TensorFlow Session.

## Load network from dict (npz)

`tensorlayer.files.load_and_assign_npz_dict` (*name='model.npz'*, *sess=None*)

Restore the parameters saved by `tl.files.save_npz_dict()`.

### Parameters

- **name** (*str*) – The name of the .npz file.
- **sess** (*Session*) – TensorFlow Session.

## Save network into ckpt

`tensorlayer.files.save_ckpt` (*sess=None*, *mode\_name='model.ckpt'*, *save\_dir='checkpoint'*,  
*var\_list=None*, *global\_step=None*, *printable=False*)

Save parameters into *ckpt* file.

### Parameters

- **sess** (*Session*) – TensorFlow Session.
- **mode\_name** (*str*) – The name of the model, default is `model.ckpt`.
- **save\_dir** (*str*) – The path / file directory to the *ckpt*, default is `checkpoint`.
- **var\_list** (*list of tensor*) – The parameters / variables (tensor) to be saved. If empty, save all global variables (default).
- **global\_step** (*int or None*) – Step number.
- **printable** (*boolean*) – Whether to print all parameters information.

See also:

`load_ckpt()`

## Load network from ckpt

`tensorlayer.files.load_ckpt` (*sess=None*, *mode\_name='model.ckpt'*, *save\_dir='checkpoint'*,  
*var\_list=None*, *is\_latest=True*, *printable=False*)

Load parameters from *ckpt* file.

### Parameters

- **sess** (*Session*) – TensorFlow Session.
- **mode\_name** (*str*) – The name of the model, default is `model.ckpt`.

- **save\_dir** (*str*) – The path / file directory to the *ckpt*, default is *checkpoint*.
- **var\_list** (*list of tensor*) – The parameters / variables (tensor) to be saved. If empty, save all global variables (default).
- **is\_latest** (*boolean*) – Whether to load the latest *ckpt*, if False, load the *ckpt* with the name of `mode_name`.
- **printable** (*boolean*) – Whether to print all parameters information.

## Examples

- Save all global parameters.

```
>>> tl.files.save_ckpt(sess=sess, mode_name='model.ckpt', save_dir='model',  
↳ printable=True)
```

- Save specific parameters.

```
>>> tl.files.save_ckpt(sess=sess, mode_name='model.ckpt', var_list=net.all_params,  
↳ save_dir='model', printable=True)
```

- Load latest ckpt.

```
>>> tl.files.load_ckpt(sess=sess, var_list=net.all_params, save_dir='model',  
↳ printable=True)
```

- Load specific ckpt.

```
>>> tl.files.load_ckpt(sess=sess, mode_name='model.ckpt', var_list=net.all_params,  
↳ save_dir='model', is_latest=False, printable=True)
```

## 2.6.3 Load and save variables

### Save variables as .npy

`tensorlayer.files.save_any_to_npy(save_dict=None, name='file.npy')`

Save variables to *.npy* file.

#### Parameters

- **save\_dict** (*dictionary*) – The variables to be saved.
- **name** (*str*) – File name.

## Examples

```
>>> tl.files.save_any_to_npy(save_dict={'data': ['a', 'b']}, name='test.npy')  
>>> data = tl.files.load_npy_to_any(name='test.npy')  
>>> print(data)  
{'data': ['a', 'b']}
```



## Load variables from .npy

`tensorlayer.files.load_npy_to_any(path="", name='file.npy')`  
Load .npy file.

### Parameters

- **path** (*str*) – Path to the file (optional).
- **name** (*str*) – File name.

### Examples

- see `tl.files.save_any_to_npy()`

## 2.6.4 Folder/File functions

### Check file exists

`tensorlayer.files.file_exists(filepath)`  
Check whether a file exists by given file path.

### Check folder exists

`tensorlayer.files.folder_exists(folderpath)`  
Check whether a folder exists by given folder path.

### Delete file

`tensorlayer.files.del_file(filepath)`  
Delete a file by given file path.

### Delete folder

`tensorlayer.files.del_folder(folderpath)`  
Delete a folder by given folder path.

### Read file

`tensorlayer.files.read_file(filepath)`  
Read a file and return a string.

### Examples

```
>>> data = tl.files.read_file('data.txt')
```

## Load file list from folder

```
tensorlayer.files.load_file_list(path=None,      regx='\\.jpg',      printable=True,
                                keep_prefix=False)
```

Return a file list in a folder by given a path and regular expression.

### Parameters

- **path** (*str* or *None*) – A folder path, if *None*, use the current directory.
- **regx** (*str*) – The regx of file name.
- **printable** (*boolean*) – Whether to print the files infomation.
- **keep\_prefix** (*boolean*) – Whether to keep path in the file name.

## Examples

```
>>> file_list = tl.files.load_file_list(path=None, regx='w1pre_[0-9]+\.(npz)')
```

## Load folder list from folder

```
tensorlayer.files.load_folder_list(path="")
```

Return a folder list in a folder by given a folder path.

**Parameters** **path** (*str*) – A folder path.

## Check and Create folder

```
tensorlayer.files.exists_or_mkdir(path, verbose=True)
```

Check a folder by given name, if not exist, create the folder and return False, if directory exists, return True.

### Parameters

- **path** (*str*) – A folder path.
- **verbose** (*boolean*) – If True (default), prints results.

**Returns** True if folder already exist, otherwise, returns False and create the folder.

**Return type** boolean

## Examples

```
>>> tl.files.exists_or_mkdir("checkpoints/train")
```

## Download or extract

```
tensorlayer.files.maybe_download_and_extract(filename, working_directory, url_source,
                                              extract=False, expected_bytes=None)
```

Checks if file exists in `working_directory` otherwise tries to download the file, and optionally also tries to extract the file if format is “.zip” or “.tar”

### Parameters

- **filename** (*str*) – The name of the (to be) downloaded file.
- **working\_directory** (*str*) – A folder path to search for the file in and download the file to
- **url** (*str*) – The URL to download the file from
- **extract** (*boolean*) – If True, tries to uncompress the downloaded file is “.tar.gz/.tar.bz2” or “.zip” file, default is False.
- **expected\_bytes** (*int or None*) – If set tries to verify that the downloaded file is of the specified size, otherwise raises an Exception, defaults is None which corresponds to no check being performed.

**Returns** File path of the downloaded (uncompressed) file.

**Return type** str

### Examples

```
>>> down_file = tl.files.maybe_download_and_extract(filename='train-images-idx3-
↳ubyte.gz',
...                                                working_directory='data/',
...                                                url_source='http://yann.lecun.com/
↳exdb/mnist/')
>>> tl.files.maybe_download_and_extract(filename='ADEChallengeData2016.zip',
...                                    working_directory='data/',
...                                    url_source='http://sceneparsing.
↳csail.mit.edu/data/',
...                                    extract=True)
```

## 2.6.5 Sort

### List of string with number in human order

tensorlayer.files.**natural\_keys** (*text*)  
Sort list of string with number in human order.

### Examples

```
>>> l = ['im1.jpg', 'im31.jpg', 'im11.jpg', 'im21.jpg', 'im03.jpg', 'im05.jpg']
>>> l.sort(key=tl.files.natural_keys)
['im1.jpg', 'im03.jpg', 'im05', 'im11.jpg', 'im21.jpg', 'im31.jpg']
>>> l.sort() # that is what we dont want
['im03.jpg', 'im05', 'im1.jpg', 'im11.jpg', 'im21.jpg', 'im31.jpg']
```

### References

- [link](#)

## 2.6.6 Visualizing npz file

`tensorlayer.files.npz_to_W_pdf` (*path=None*, *regex='w1pre\_[0-9]+\.(npz)'*)  
Convert the first weight matrix of *.npz* file to *.pdf* by using *tl.visualize.W()*.

### Parameters

- **path** (*str*) – A folder path to *.npz* files.
- **regex** (*str*) – Regx for the file name.

### Examples

Convert the first weight matrix of *w1\_pre...npz* file to *w1\_pre...pdf*.

```
>>> tl.files.npz_to_W_pdf(path='/Users/.../npz_file/', regex='w1pre_[0-9]+\.(npz)')
```

## 2.7 API - Iteration

Data iteration.

<code>minibatches</code> ( <i>inputs</i> , <i>targets</i> , <i>batch_size</i> , ...)	Generate a generator that input a group of example in <code>numpy.array</code> and their labels, return the examples and labels by the given batch size.
<code>seq_minibatches</code> ( <i>inputs</i> , <i>targets</i> , <i>batch_size</i> , ...)	Generate a generator that return a batch of sequence inputs and targets.
<code>seq_minibatches2</code> ( <i>inputs</i> , <i>targets</i> , ...)	Generate a generator that iterates on two list of words.
<code>ptb_iterator</code> ( <i>raw_data</i> , <i>batch_size</i> , <i>num_steps</i> )	Generate a generator that iterates on a list of words, see <a href="#">PTB example</a> .

### 2.7.1 Non-time series

`tensorlayer.iterate.minibatches` (*inputs=None*, *targets=None*, *batch\_size=None*, *allow\_dynamic\_batch\_size=False*, *shuffle=False*)

Generate a generator that input a group of example in `numpy.array` and their labels, return the examples and labels by the given batch size.

### Parameters

- **inputs** (`numpy.array`) – The input features, every row is a example.
- **targets** (`numpy.array`) – The labels of inputs, every row is a example.
- **batch\_size** (*int*) – The batch size.
- **allow\_dynamic\_batch\_size** (*boolean*) – Allow the use of the last data batch in case the number of examples is not a multiple of *batch\_size*, this may result in unexpected behaviour if other functions expect a fixed-sized batch-size.
- **shuffle** (*boolean*) – Indicating whether to use a shuffling queue, shuffle the dataset before return.

## Examples

```
>>> X = np.asarray([[ 'a', 'a'], [ 'b', 'b'], [ 'c', 'c'], [ 'd', 'd'], [ 'e', 'e'], [ 'f', 'f'
↳ ''])
>>> y = np.asarray([0, 1, 2, 3, 4, 5])
>>> for batch in tl.iterate.minibatches(inputs=X, targets=y, batch_size=2,
↳ shuffle=False):
>>>     print(batch)
(array([[ 'a', 'a'], [ 'b', 'b']], dtype='<U1'), array([0, 1]))
(array([[ 'c', 'c'], [ 'd', 'd']], dtype='<U1'), array([2, 3]))
(array([[ 'e', 'e'], [ 'f', 'f']], dtype='<U1'), array([4, 5]))
```

## Notes

If you have two inputs and one label and want to shuffle them together, e.g. X1 (1000, 100), X2 (1000, 80) and Y (1000, 1), you can stack them together (`np.hstack((X1, X2))`) into (1000, 180) and feed to `inputs`. After getting a batch, you can split it back into X1 and X2.

## 2.7.2 Time series

### Sequence iteration 1

`tensorlayer.iterate.seq_minibatches` (*inputs*, *targets*, *batch\_size*, *seq\_length*, *stride*=1)

Generate a generator that return a batch of sequence inputs and targets. If *batch\_size*=100 and *seq\_length*=5, one return will have 500 rows (examples).

#### Parameters

- **inputs** (*numpy.array*) – The input features, every row is a example.
- **targets** (*numpy.array*) – The labels of inputs, every element is a example.
- **batch\_size** (*int*) – The batch size.
- **seq\_length** (*int*) – The sequence length.
- **stride** (*int*) – The stride step, default is 1.

## Examples

Synced sequence input and output.

```
>>> X = np.asarray([[ 'a', 'a'], [ 'b', 'b'], [ 'c', 'c'], [ 'd', 'd'], [ 'e', 'e'], [ 'f', 'f'
↳ ''])
>>> y = np.asarray([0, 1, 2, 3, 4, 5])
>>> for batch in tl.iterate.seq_minibatches(inputs=X, targets=y, batch_size=2,
↳ seq_length=2, stride=1):
>>>     print(batch)
(array([[ 'a', 'a'], [ 'b', 'b'], [ 'b', 'b'], [ 'c', 'c']], dtype='<U1'), array([0,
↳ 1, 1, 2]))
(array([[ 'c', 'c'], [ 'd', 'd'], [ 'd', 'd'], [ 'e', 'e']], dtype='<U1'), array([2,
↳ 3, 3, 4]))
```

Many to One

```

>>> return_last = True
>>> num_steps = 2
>>> X = np.asarray(['a', 'a'], ['b', 'b'], ['c', 'c'], ['d', 'd'], ['e', 'e'], ['f', 'f',
↪ ''])
>>> Y = np.asarray([0, 1, 2, 3, 4, 5])
>>> for batch in tl.iterate.seq_minibatches(inputs=X, targets=Y, batch_size=2,
↪ seq_length=num_steps, stride=1):
>>>     x, y = batch
>>>     if return_last:
>>>         tmp_y = y.reshape((-1, num_steps) + y.shape[1:])
>>>         y = tmp_y[:, -1]
>>>     print(x, y)
[['a' 'a']
['b' 'b']
['b' 'b']
['c' 'c']] [1 2]
[['c' 'c']
['d' 'd']
['d' 'd']
['e' 'e']] [3 4]

```

## Sequence iteration 2

`tensorlayer.iterate.seq_minibatches2` (*inputs, targets, batch\_size, num\_steps*)

Generate a generator that iterates on two list of words. Yields (Returns) the source contexts and the target context by the given *batch\_size* and *num\_steps* (sequence\_length). In TensorFlow's tutorial, this generates the *batch\_size* pointers into the raw PTB data, and allows minibatch iteration along these pointers.

### Parameters

- **inputs** (*list of data*) – The context in list format; note that context usually be represented by splitting by space, and then convert to unique word IDs.
- **targets** (*list of data*) – The context in list format; note that context usually be represented by splitting by space, and then convert to unique word IDs.
- **batch\_size** (*int*) – The batch size.
- **num\_steps** (*int*) – The number of unrolls. i.e. sequence length

**Yields** *Pairs of the batched data, each a matrix of shape [batch\_size, num\_steps].*

**Raises** `ValueError` : if *batch\_size* or *num\_steps* are too high.

## Examples

```

>>> X = [i for i in range(20)]
>>> Y = [i for i in range(20, 40)]
>>> for batch in tl.iterate.seq_minibatches2(X, Y, batch_size=2, num_steps=3):
...     x, y = batch
...     print(x, y)

```

```
[[ 0.  1.  2.] [ 10. 11. 12.] [[ 20. 21. 22.] [ 30. 31. 32.]]
```

```
[[ 3.  4.  5.] [ 13. 14. 15.] [[ 23. 24. 25.] [ 33. 34. 35.]]
```

```
[[ 6.  7.  8.] [ 16. 17. 18.] [[ 26. 27. 28.] [ 36. 37. 38.]]
```

## Notes

- Hint, if the input data are images, you can modify the source code `data = np.zeros([batch_size, batch_len])` to `data = np.zeros([batch_size, batch_len, inputs.shape[1], inputs.shape[2], inputs.shape[3]])`.

## PTB dataset iteration

`tensorlayer.iterate.ptb_iterator` (*raw\_data*, *batch\_size*, *num\_steps*)

Generate a generator that iterates on a list of words, see [PTB example](#). Yields the source contexts and the target context by the given *batch\_size* and *num\_steps* (*sequence\_length*).

In TensorFlow's tutorial, this generates *batch\_size* pointers into the raw PTB data, and allows minibatch iteration along these pointers.

### Parameters

- **raw\_data** (*a list*) – the context in list format; note that context usually be represented by splitting by space, and then convert to unique word IDs.
- **batch\_size** (*int*) – the batch size.
- **num\_steps** (*int*) – the number of unrolls. i.e. *sequence\_length*

### Yields

- *Pairs of the batched data, each a matrix of shape [batch\_size, num\_steps].*
- *The second element of the tuple is the same data time-shifted to the*
- *right by one.*

**Raises** `ValueError` : if *batch\_size* or *num\_steps* are too high.

## Examples

```
>>> train_data = [i for i in range(20)]
>>> for batch in tl.iterate.ptb_iterator(train_data, batch_size=2, num_steps=3):
>>>     x, y = batch
>>>     print(x, y)
[[ 0  1  2] <---x                                1st subset/ iteration
 [10 11 12]]
[[ 1  2  3] <---y
 [11 12 13]]
```

**[[ 3 4 5] <— 1st batch input 2nd subset/ iteration [13 14 15]] <— 2nd batch input**

**[[ 4 5 6] <— 1st batch target [14 15 16]] <— 2nd batch target**

**[[ 6 7 8] 3rd subset/ iteration [16 17 18]]**

**[[ 7 8 9] [17 18 19]]**

## 2.8 API - Layers

TensorLayer provides rich layer implementations trailed for various benchmarks and domain-specific problems. In addition, we also support transparent access to native TensorFlow parameters. For example, we provide not only layers

for local response normalization, but also layers that allow user to apply `tf.nn.lrn` on `network.outputs`. More functions can be found in [TensorFlow API](#).

## 2.8.1 Name Scope and Sharing Parameters

These functions help you to reuse parameters for different inference (graph), and get a list of parameters by given name. About TensorFlow parameters sharing click [here](#).

### Get variables with name

```
tensorlayer.layers.get_variables_with_name(name=None, train_only=True, verbose=False)
```

Get a list of TensorFlow variables by a given name scope.

#### Parameters

- **name** (*str*) – Get the variables that contain this name.
- **train\_only** (*boolean*) – If True, only get the trainable variables.
- **verbose** (*boolean*) – If True, print the information of all variables.

**Returns** A list of TensorFlow variables

**Return type** list of Tensor

### Examples

```
>>> import tensorlayer as tl
>>> dense_vars = tl.layers.get_variables_with_name('dense', True, True)
```

### Get layers with name

```
tensorlayer.layers.get_layers_with_name(net, name="", verbose=False)
```

Get a list of layers' output in a network by a given name scope.

#### Parameters

- **net** (*Layer*) – The last layer of the network.
- **name** (*str*) – Get the layers' output that contain this name.
- **verbose** (*boolean*) – If True, print information of all the layers' output

**Returns** A list of layers' output (TensorFlow tensor)

**Return type** list of Tensor

### Examples

```
>>> import tensorlayer as tl
>>> layers = tl.layers.get_layers_with_name(net, "CNN", True)
```



## Print variables

`tensorlayer.layers.print_all_variables (train_only=False)`  
 Print information of trainable or all variables, without `tl.layers.initialize_global_variables(sess)`.

**Parameters** `train_only` (*boolean*) –

**Whether print trainable variables only.**

- If True, print the trainable variables.
- If False, print all variables.

## Initialize variables

`tensorlayer.layers.initialize_global_variables (sess)`  
 Initialize the global variables of TensorFlow.

**Warning: THIS FUNCTION IS DEPRECATED:** It will be removed after after 2018-09-30.  
*Instructions for updating:* This API is deprecated in favor of `tf.global_variables_initializer`.

Run `sess.run(tf.global_variables_initializer())` for TF 0.12+ or `sess.run(tf.initialize_all_variables())` for TF 0.11.

**Parameters** `sess` (*Session*) – TensorFlow session.

## 2.8.2 Understanding the Basic Layer

All TensorLayer layers have a number of properties in common:

- `layer.outputs` : a Tensor, the outputs of current layer.
- `layer.all_params` : a list of Tensor, all network variables in order.
- `layer.all_layers` : a list of Tensor, all network outputs in order.
- `layer.all_drop` : a dictionary of {placeholder : float}, all keeping probabilities of noise layers.

All TensorLayer layers have a number of methods in common:

- `layer.print_params()` : print network variable information in order (after `tl.layers.initialize_global_variables(sess)`). alternatively, print all variables by `tl.layers.print_all_variables()`.
- `layer.print_layers()` : print network layer information in order.
- `layer.count_params()` : print the number of parameters in the network.

A network starts with the input layer and is followed by layers stacked in order. A network is essentially a `Layer` class. The key properties of a network are `network.all_params`, `network.all_layers` and `network.all_drop`. The `all_params` is a list which store pointers to all network parameters in order. For example, the following script define a 3 layer network, then:

```
all_params = [W1, b1, W2, b2, W_out, b_out]
```

To get specified variable information, you can use `network.all_params[2:3]` or `get_variables_with_name()`. `all_layers` is a list which stores the pointers to the outputs of all layers, see the example as follow:

```
all_layers = [drop(?,784), relu(?,800), drop(?,800), relu(?,800), drop(?,800)], identity(?,10)]
```

where ? reflects a given batch size. You can print the layer and parameters information by using `network.print_layers()` and `network.print_params()`. To count the number of parameters in a network, run `network.count_params()`.

```
sess = tf.InteractiveSession()

x = tf.placeholder(tf.float32, shape=[None, 784], name='x')
y_ = tf.placeholder(tf.int64, shape=[None, ], name='y_')

network = tl.layers.InputLayer(x, name='input_layer')
network = tl.layers.DropoutLayer(network, keep=0.8, name='drop1')
network = tl.layers.DenseLayer(network, n_units=800,
                                act=tf.nn.relu, name='relu1')
network = tl.layers.DropoutLayer(network, keep=0.5, name='drop2')
network = tl.layers.DenseLayer(network, n_units=800,
                                act=tf.nn.relu, name='relu2')
network = tl.layers.DropoutLayer(network, keep=0.5, name='drop3')
network = tl.layers.DenseLayer(network, n_units=10,
                                act=None, name='output')

y = network.outputs
y_op = tf.argmax(tf.nn.softmax(y), 1)

cost = tl.cost.cross_entropy(y, y_)

train_params = network.all_params

train_op = tf.train.AdamOptimizer(learning_rate, beta1=0.9, beta2=0.999,
                                  epsilon=1e-08, use_locking=False).minimize(cost, var_list_
↳= train_params)

tl.layers.initialize_global_variables(sess)

network.print_params()
network.print_layers()
```

In addition, `network.all_drop` is a dictionary which stores the keeping probabilities of all noise layers. In the above network, they represent the keeping probabilities of dropout layers.

In case for training, you can enable all dropout layers as follow:

```
feed_dict = {x: X_train_a, y_: y_train_a}
feed_dict.update( network.all_drop )
loss, _ = sess.run([cost, train_op], feed_dict=feed_dict)
feed_dict.update( network.all_drop )
```

In case for evaluating and testing, you can disable all dropout layers as follow.

```
feed_dict = {x: X_val, y_: y_val}
feed_dict.update(dp_dict)
print("    val loss: %f" % sess.run(cost, feed_dict=feed_dict))
print("    val acc: %f" % np.mean(y_val ==
                                sess.run(y_op, feed_dict=feed_dict)))
```

For more details, please read the MNIST examples in the example folder.

## 2.8.3 Layer list

<code>get_variables_with_name([name, train_only, ...])</code>	Get a list of TensorFlow variables by a given name scope.
<code>get_layers_with_name(net[, name, verbose])</code>	Get a list of layers' output in a network by a given name scope.
<code>set_name_reuse([enable])</code>	DEPRECATED FUNCTION
<code>print_all_variables([train_only])</code>	Print information of trainable or all variables, without <code>tl.layers.initialize_global_variables(sess)</code> .
<code>initialize_global_variables(sess)</code>	Initialize the global variables of TensorFlow.
<code>Layer(prev_layer[, act, name])</code>	The basic <code>Layer</code> class represents a single layer of a neural network.
<code>InputLayer(inputs[, name])</code>	The <code>InputLayer</code> class is the starting layer of a neural network.
<code>OneHotInputLayer([inputs, depth, on_value, ...])</code>	The <code>OneHotInputLayer</code> class is the starting layer of a neural network, see <code>tf.one_hot</code> .
<code>Word2vecEmbeddingInputlayer(inputs[, ...])</code>	The <code>Word2vecEmbeddingInputlayer</code> class is a fully connected layer.
<code>EmbeddingInputlayer(inputs[, ...])</code>	The <code>EmbeddingInputlayer</code> class is a look-up table for word embedding.
<code>AverageEmbeddingInputlayer(inputs, ..., ...)</code>	The <code>AverageEmbeddingInputlayer</code> averages over embeddings of inputs.
<code>DenseLayer(prev_layer[, n_units, act, ...])</code>	The <code>DenseLayer</code> class is a fully connected layer.
<code>ReconLayer(prev_layer[, x_recon, n_units, ...])</code>	A reconstruction layer for <code>DenseLayer</code> to implement AutoEncoder.
<code>DropoutLayer(prev_layer[, keep, is_fix, ...])</code>	The <code>DropoutLayer</code> class is a noise layer which randomly set some activations to zero according to a keeping probability.
<code>GaussianNoiseLayer(prev_layer[, mean, ...])</code>	The <code>GaussianNoiseLayer</code> class is noise layer that adding noise with gaussian distribution to the activation.
<code>DropconnectDenseLayer(prev_layer[, keep, ...])</code>	The <code>DropconnectDenseLayer</code> class is <code>DenseLayer</code> with DropConnect behaviour which randomly removes connections between this layer and the previous layer according to a keeping probability.
<code>Conv1dLayer(prev_layer[, act, shape, ...])</code>	The <code>Conv1dLayer</code> class is a 1D CNN layer, see <code>tf.nn.convolution</code> .
<code>Conv2dLayer(prev_layer[, act, shape, ...])</code>	The <code>Conv2dLayer</code> class is a 2D CNN layer, see <code>tf.nn.conv2d</code> .
<code>DeConv2dLayer(prev_layer[, act, shape, ...])</code>	A de-convolution 2D layer.
<code>Conv3dLayer(prev_layer[, shape, strides, ...])</code>	The <code>Conv3dLayer</code> class is a 3D CNN layer, see <code>tf.nn.conv3d</code> .
<code>DeConv3dLayer(prev_layer[, act, shape, ...])</code>	The <code>DeConv3dLayer</code> class is deconvolutional 3D layer, see <code>tf.nn.conv3d_transpose</code> .
<code>UpSampling2dLayer(prev_layer, size[, ...])</code>	The <code>UpSampling2dLayer</code> class is a up-sampling 2D layer.
<code>DownSampling2dLayer(prev_layer, size[, ...])</code>	The <code>DownSampling2dLayer</code> class is down-sampling 2D layer.
<code>AtrousConv1dLayer(prev_layer[, n_filter, ...])</code>	Simplified version of <code>AtrousConv1dLayer</code> .
<code>AtrousConv2dLayer(prev_layer[, n_filter, ...])</code>	The <code>AtrousConv2dLayer</code> class is 2D atrous convolution (a.k.a.

Continued on next page

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<i>AtrousDeConv2dLayer</i> (prev_layer[, shape, ...])	The <i>AtrousDeConv2dLayer</i> class is 2D atrous convolution transpose, see <a href="#">tf.nn.atrous_conv2d_transpose</a> .
<i>Conv1d</i> (prev_layer[, n_filter, filter_size, ...])	Simplified version of <i>Conv1dLayer</i> .
<i>Conv2d</i> (prev_layer[, n_filter, filter_size, ...])	Simplified version of <i>Conv2dLayer</i> .
<i>DeConv2d</i> (prev_layer[, n_filter, ...])	Simplified version of <i>DeConv2dLayer</i> .
<i>DeConv3d</i> (prev_layer[, n_filter, ...])	Simplified version of The <i>DeConv3dLayer</i> , see <a href="#">tf.contrib.layers.conv3d_transpose</a> .
<i>DepthwiseConv2d</i> (prev_layer[, shape, ...])	Separable/Depthwise Convolutional 2D layer, see <a href="#">tf.nn.depthwise_conv2d</a> .
<i>SeparableConv1d</i> (prev_layer[, n_filter, ...])	The <i>SeparableConv1d</i> class is a 1D depthwise separable convolutional layer, see <a href="#">tf.layers.separable_conv1d</a> .
<i>SeparableConv2d</i> (prev_layer[, n_filter, ...])	The <i>SeparableConv2d</i> class is a 2D depthwise separable convolutional layer, see <a href="#">tf.layers.separable_conv2d</a> .
<i>DeformableConv2d</i> (prev_layer[, offset_layer, ...])	The <i>DeformableConv2d</i> class is a 2D Deformable Convolutional Networks.
<i>GroupConv2d</i> (prev_layer[, n_filter, ...])	The <i>GroupConv2d</i> class is 2D grouped convolution, see <a href="#">here</a> .
<i>PadLayer</i> (prev_layer[, padding, mode, name])	The <i>PadLayer</i> class is a padding layer for any mode and dimension.
<i>PoolLayer</i> (prev_layer[, ksize, strides, ...])	The <i>PoolLayer</i> class is a Pooling layer.
<i>ZeroPad1d</i> (prev_layer, padding[, name])	The <i>ZeroPad1d</i> class is a 1D padding layer for signal [batch, length, channel].
<i>ZeroPad2d</i> (prev_layer, padding[, name])	The <i>ZeroPad2d</i> class is a 2D padding layer for image [batch, height, width, channel].
<i>ZeroPad3d</i> (prev_layer, padding[, name])	The <i>ZeroPad3d</i> class is a 3D padding layer for volume [batch, depth, height, width, channel].
<i>MaxPool1d</i> (prev_layer[, filter_size, ...])	Max pooling for 1D signal.
<i>MeanPool1d</i> (prev_layer[, filter_size, ...])	Mean pooling for 1D signal.
<i>MaxPool2d</i> (prev_layer[, filter_size, ...])	Max pooling for 2D image.
<i>MeanPool2d</i> (prev_layer[, filter_size, ...])	Mean pooling for 2D image [batch, height, width, channel].
<i>MaxPool3d</i> (prev_layer[, filter_size, ...])	Max pooling for 3D volume.
<i>MeanPool3d</i> (prev_layer[, filter_size, ...])	Mean pooling for 3D volume.
<i>GlobalMaxPool1d</i> (prev_layer[, data_format, name])	The <i>GlobalMaxPool1d</i> class is a 1D Global Max Pooling layer.
<i>GlobalMeanPool1d</i> (prev_layer[, data_format, name])	The <i>GlobalMeanPool1d</i> class is a 1D Global Mean Pooling layer.
<i>GlobalMaxPool2d</i> (prev_layer[, data_format, name])	The <i>GlobalMaxPool2d</i> class is a 2D Global Max Pooling layer.
<i>GlobalMeanPool2d</i> (prev_layer[, data_format, name])	The <i>GlobalMeanPool2d</i> class is a 2D Global Mean Pooling layer.
<i>GlobalMaxPool3d</i> (prev_layer[, data_format, name])	The <i>GlobalMaxPool3d</i> class is a 3D Global Max Pooling layer.
<i>GlobalMeanPool3d</i> (prev_layer[, data_format, name])	The <i>GlobalMeanPool3d</i> class is a 3D Global Mean Pooling layer.
<i>SubpixelConv1d</i> (prev_layer[, scale, act, name])	It is a 1D sub-pixel up-sampling layer.
<i>SubpixelConv2d</i> (prev_layer[, scale, ...])	It is a 2D sub-pixel up-sampling layer, usually be used for Super-Resolution applications, see <a href="#">SRGAN</a> for example.

Continued on next page

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<i>SpatialTransformer2dAffineLayer</i> (prev_layer, ...)	The <i>SpatialTransformer2dAffineLayer</i> class is a 2D Spatial Transformer Layer for 2D Affine Transformation.
<i>transformer</i> (U, theta, out_size[, name])	Spatial Transformer Layer for 2D Affine Transformation, see <i>SpatialTransformer2dAffineLayer</i> class.
<i>batch_transformer</i> (U, thetas, out_size[, name])	Batch Spatial Transformer function for 2D Affine Transformation.
<i>BatchNormLayer</i> (prev_layer[, decay, epsilon, ...])	The <i>BatchNormLayer</i> is a batch normalization layer for both fully-connected and convolution outputs.
<i>LocalResponseNormLayer</i> (prev_layer[, ...])	The <i>LocalResponseNormLayer</i> layer is for Local Response Normalization.
<i>InstanceNormLayer</i> (prev_layer[, act, ...])	The <i>InstanceNormLayer</i> class is a for instance normalization.
<i>LayerNormLayer</i> (prev_layer[, center, scale, ...])	The <i>LayerNormLayer</i> class is for layer normalization, see <code>tf.contrib.layers.layer_norm</code> .
<i>GroupNormLayer</i> (prev_layer[, groups, ...])	The <i>GroupNormLayer</i> layer is for Group Normalization.
<i>SwitchNormLayer</i> (prev_layer[, act, epsilon, ...])	The <i>SwitchNormLayer</i> is a switchable normalization.
<i>ROIPoolingLayer</i> (prev_layer, rois[, ...])	The region of interest pooling layer.
<i>TimeDistributedLayer</i> (prev_layer[, ...])	The <i>TimeDistributedLayer</i> class that applies a function to every timestep of the input tensor.
<i>RNNLayer</i> (prev_layer, cell_fn[, ...])	The <i>RNNLayer</i> class is a fixed length recurrent layer for implementing vanilla RNN, LSTM, GRU and etc.
<i>BiRNNLayer</i> (prev_layer, cell_fn[, ...])	The <i>BiRNNLayer</i> class is a fixed length Bidirectional recurrent layer.
<i>ConvRNNCell</i>	Abstract object representing an Convolutional RNN Cell.
<i>BasicConvLSTMCell</i> (shape, filter_size, ...[, ...])	Basic Conv LSTM recurrent network cell.
<i>ConvLSTMLayer</i> (prev_layer[, cell_shape, ...])	A fixed length Convolutional LSTM layer.
<i>advanced_indexing_op</i> (inputs, index)	Advanced Indexing for Sequences, returns the outputs by given sequence lengths.
<i>retrieve_seq_length_op</i> (data)	An op to compute the length of a sequence from input shape of [batch_size, n_step(max), n_features], it can be used when the features of padding (on right hand side) are all zeros.
<i>retrieve_seq_length_op2</i> (data)	An op to compute the length of a sequence, from input shape of [batch_size, n_step(max)], it can be used when the features of padding (on right hand side) are all zeros.
<i>retrieve_seq_length_op3</i> (data[, pad_val])	Return tensor for sequence length, if input is <code>tf.string</code> .
<i>target_mask_op</i> (data[, pad_val])	Return tensor for mask, if input is <code>tf.string</code> .
<i>DynamicRNNLayer</i> (prev_layer, cell_fn[, ...])	The <i>DynamicRNNLayer</i> class is a dynamic recurrent layer, see <code>tf.nn.dynamic_rnn</code> .
<i>BiDynamicRNNLayer</i> (prev_layer, cell_fn[, ...])	The <i>BiDynamicRNNLayer</i> class is a RNN layer, you can implement vanilla RNN, LSTM and GRU with it.
<i>Seq2Seq</i> (net_encode_in, net_decode_in, cell_fn)	The <i>Seq2Seq</i> class is a simple <i>DynamicRNNLayer</i> based Seq2seq layer without using <code>tl.contrib.seq2seq</code> .
<i>FlattenLayer</i> (prev_layer[, name])	A layer that reshapes high-dimension input into a vector.
<i>ReshapeLayer</i> (prev_layer, shape[, name])	A layer that reshapes a given tensor.

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Table 8 – continued from previous page

<i>TransposeLayer</i> (prev_layer, perm[, name])	A layer that transposes the dimension of a tensor.
<i>LambdaLayer</i> (prev_layer, fn[, fn_args, name])	A layer that takes a user-defined function using TensorFlow Lambda, for multiple inputs see <i>ElementwiseLambdaLayer</i> .
<i>ConcatLayer</i> (prev_layer[, concat_dim, name])	A layer that concatenates multiple tensors according to given axis.
<i>ElementwiseLayer</i> (prev_layer[, combine_fn, ...])	A layer that combines multiple <i>Layer</i> that have the same output shapes according to an element-wise operation.
<i>ElementwiseLambdaLayer</i> (layers, fn[, ...])	A layer that use a custom function to combine multiple <i>Layer</i> inputs.
<i>ExpandDimsLayer</i> (prev_layer, axis[, name])	The <i>ExpandDimsLayer</i> class inserts a dimension of 1 into a tensor's shape, see <code>tf.expand_dims()</code> .
<i>TileLayer</i> (prev_layer[, multiples, name])	The <i>TileLayer</i> class constructs a tensor by tiling a given tensor, see <code>tf.tile()</code> .
<i>StackLayer</i> (layers[, axis, name])	The <i>StackLayer</i> class is a layer for stacking a list of rank-R tensors into one rank-(R+1) tensor, see <code>tf.stack()</code> .
<i>UnStackLayer</i> (prev_layer[, num, axis, name])	The <i>UnStackLayer</i> class is a layer for unstacking the given dimension of a rank-R tensor into rank-(R-1) tensors., see <code>tf.unstack()</code> .
<i>SlimNetsLayer</i> (prev_layer, slim_layer[, ...])	A layer that merges TF-Slim models into TensorLayer.
<i>SignLayer</i> (prev_layer[, name])	The <i>SignLayer</i> class is for quantizing the layer outputs to -1 or 1 while inferencing.
<i>ScaleLayer</i> (prev_layer[, init_scale, name])	The <i>AddScaleLayer</i> class is for multiplying a trainable scale value to the layer outputs.
<i>BinaryDenseLayer</i> (prev_layer[, n_units, act, ...])	The <i>BinaryDenseLayer</i> class is a binary fully connected layer, which weights are either -1 or 1 while inferencing.
<i>BinaryConv2d</i> (prev_layer[, n_filter, ...])	The <i>BinaryConv2d</i> class is a 2D binary CNN layer, which weights are either -1 or 1 while inference.
<i>TernaryDenseLayer</i> (prev_layer[, n_units, ...])	The <i>TernaryDenseLayer</i> class is a ternary fully connected layer, which weights are either -1 or 1 or 0 while inference.
<i>TernaryConv2d</i> (prev_layer[, n_filter, ...])	The <i>TernaryConv2d</i> class is a 2D ternary CNN layer, which weights are either -1 or 1 or 0 while inference.
<i>DorefaDenseLayer</i> (prev_layer[, bitW, bitA, ...])	The <i>DorefaDenseLayer</i> class is a binary fully connected layer, which weights are 'bitW' bits and the output of the previous layer are 'bitA' bits while inferencing.
<i>DorefaConv2d</i> (prev_layer[, bitW, bitA, ...])	The <i>DorefaConv2d</i> class is a 2D quantized convolutional layer, which weights are 'bitW' bits and the output of the previous layer are 'bitA' bits while inferencing.
<i>QuanDenseLayer</i> (prev_layer[, n_units, act, ...])	The <i>QuanDenseLayer</i> class is a quantized fully connected layer with BN, which weights are 'bitW' bits and the output of the previous layer are 'bitA' bits while inferencing.
<i>QuanDenseLayerWithBN</i> (prev_layer[, n_units, ...])	The <i>QuanDenseLayer</i> class is a quantized fully connected layer with BN, which weights are 'bitW' bits and the output of the previous layer are 'bitA' bits while inferencing.

Continued on next page

Table 8 – continued from previous page

<code>QuanConv2d(prev_layer[, n_filter, ...])</code>	The <code>QuanConv2dWithBN</code> class is a quantized convolutional layer with BN, which weights are ‘bitW’ bits and the output of the previous layer are ‘bitA’ bits while inferencing.
<code>QuanConv2dWithBN(prev_layer[, n_filter, ...])</code>	The <code>QuanConv2dWithBN</code> class is a quantized convolutional layer with BN, which weights are ‘bitW’ bits and the output of the previous layer are ‘bitA’ bits while inferencing.
<code>PReLULayer(prev_layer[, channel_shared, ...])</code>	The <code>PReLULayer</code> class is Parametric Rectified Linear layer.
<code>PReLU6Layer(prev_layer[, channel_shared, ...])</code>	The <code>PReLU6Layer</code> class is Parametric Rectified Linear layer integrating ReLU6 behaviour.
<code>PTReLU6Layer(prev_layer[, channel_shared, ...])</code>	The <code>PTReLU6Layer</code> class is Parametric Rectified Linear layer integrating ReLU6 behaviour.
<code>MultiplexerLayer(layers[, name])</code>	The <code>MultiplexerLayer</code> selects inputs to be forwarded to output.
<code>flatten_reshape(variable[, name])</code>	Reshapes a high-dimension vector input.
<code>clear_layers_name()</code>	DEPRECATED FUNCTION
<code>initialize_rnn_state(state[, feed_dict])</code>	Returns the initialized RNN state.
<code>list_remove_repeat(x)</code>	Remove the repeated items in a list, and return the processed list.
<code>merge_networks([layers])</code>	Merge all parameters, layers and dropout probabilities to a <code>Layer</code> .

## 2.8.4 Customizing Layers

### A Simple Layer

To implement a custom layer in TensorLayer, you will have to write a Python class that subclasses `Layer` and implement the outputs expression.

The following is an example implementation of a layer that multiplies its input by 2:

```
class DoubleLayer(Layer):
    def __init__(
        self,
        layer = None,
        name = 'double_layer',
    ):
        # manage layer (fixed)
        super(DoubleLayer, self).__init__(prev_layer=prev_layer, name=name)

        # the input of this layer is the output of previous layer (fixed)
        self.inputs = layer.outputs

        # operation (customized)
        self.outputs = self.inputs * 2

        # update layer (customized)
        self._add_layers(self.outputs)
```



## Your Dense Layer

Before creating your own TensorLayer layer, let's have a look at the Dense layer. It creates a weight matrix and a bias vector if not exists, and then implements the output expression. At the end, for a layer with parameters, we also append the parameters into `all_params`.

```
class MyDenseLayer(Layer):
    def __init__(
        self,
        layer = None,
        n_units = 100,
        act = tf.nn.relu,
        name = 'simple_dense',
    ):
        # manage layer (fixed)
        super(MyDenseLayer, self).__init__(prev_layer=prev_layer, act=act, name=name)

        # the input of this layer is the output of previous layer (fixed)
        self.inputs = layer.outputs

        # print out info (customized)
        print("  MyDenseLayer %s: %d, %s" % (self.name, n_units, act))

        # operation (customized)
        n_in = int(self.inputs._shape[-1])
        with tf.variable_scope(name) as vs:
            # create new parameters
            W = tf.get_variable(name='W', shape=(n_in, n_units))
            b = tf.get_variable(name='b', shape=(n_units))
            # tensor operation
            self.outputs = self._apply_activation(tf.matmul(self.inputs, W) + b)

        # update layer (customized)
        self._add_layers(self.outputs)
        self._add_params([W, b])
```

## 2.8.5 Basic Layer

**class** `tensorlayer.layers.Layer` (*prev\_layer*, *act=None*, *name=None*, *\*args*, *\*\*kwargs*)

The basic *Layer* class represents a single layer of a neural network.

It should be subclassed when implementing new types of layers. Because each layer can keep track of the layer(s) feeding into it, a network's output *Layer* instance can double as a handle to the full network.

### Parameters

- **prev\_layer** (*Layer* or *None*) – Previous layer (optional), for adding all properties of previous layer(s) to this layer.
- **act** (*activation function (None by default)*) – The activation function of this layer.
- **name** (*str* or *None*) – A unique layer name.

**print\_params** (*details=True*, *session=None*)

Print all parameters of this network.

**print\_layers** ()

Print all outputs of all layers of this network.



**count\_params()**

Return the number of parameters of this network.

**get\_all\_params()**

Return the parameters in a list of array.

## Examples

- Define model

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder("float32", [None, 100])
>>> n = tl.layers.InputLayer(x, name='in')
>>> n = tl.layers.DenseLayer(n, 80, name='d1')
>>> n = tl.layers.DenseLayer(n, 80, name='d2')
```

- Get information

```
>>> print(n)
Last layer is: DenseLayer (d2) [None, 80]
>>> n.print_layers()
[TL]   layer   0: d1/Identity:0      (?, 80)      float32
[TL]   layer   1: d2/Identity:0      (?, 80)      float32
>>> n.print_params(False)
[TL]   param   0: d1/W:0              (100, 80)    float32_ref
[TL]   param   1: d1/b:0              (80,)        float32_ref
[TL]   param   2: d2/W:0              (80, 80)    float32_ref
[TL]   param   3: d2/b:0              (80,)        float32_ref
[TL]   num of params: 14560
>>> n.count_params()
14560
```

- Slicing the outputs

```
>>> n2 = n[:, :30]
>>> print(n2)
Last layer is: Layer (d2) [None, 30]
```

- Iterating the outputs

```
>>> for l in n:
>>>     print(l)
Tensor("d1/Identity:0", shape=(?, 80), dtype=float32)
Tensor("d2/Identity:0", shape=(?, 80), dtype=float32)
```

## 2.8.6 Input Layers

### Input Layer

**class** tensorlayer.layers.**InputLayer** (*inputs, name='input'*)

The *InputLayer* class is the starting layer of a neural network.

### Parameters

- **inputs** (*placeholder or tensor*) – The input of a network.
- **name** (*str*) – A unique layer name.

## One-hot Input Layer

```
class tensorlayer.layers.OneHotInputLayer (inputs=None, depth=None, on_value=None,
                                           off_value=None, axis=None, dtype=None,
                                           name='input')
```

The `OneHotInputLayer` class is the starting layer of a neural network, see `tf.one_hot`.

### Parameters

- **inputs** (*placeholder or tensor*) – The input of a network.
- **depth** (*None or int*) – If the input indices is rank N, the output will have rank N+1. The new axis is created at dimension *axis* (default: the new axis is appended at the end).
- **on\_value** (*None or number*) – The value to represnt *ON*. If None, it will default to the value 1.
- **off\_value** (*None or number*) – The value to represnt *OFF*. If None, it will default to the value 0.
- **axis** (*None or int*) – The axis.
- **dtype** (*None or TensorFlow dtype*) – The data type, None means `tf.float32`.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.int32, shape=[None])
>>> net = tl.layers.OneHotInputLayer(x, depth=8, name='one_hot_encoding')
(?, 8)
```

## Word2Vec Embedding Layer

```
class tensorlayer.layers.Word2vecEmbeddingInputlayer (inputs, train_labels=None,
                                                       vocabulary_size=80000,
                                                       embedding_size=200,
                                                       num_sampled=64,
                                                       nce_loss_args=None,
                                                       E_init=<sphinx.ext.autodoc.importer._MockObject
                                                       object>, E_init_args=None,
                                                       nce_W_init=<sphinx.ext.autodoc.importer._MockObject
                                                       object>,
                                                       nce_W_init_args=None,
                                                       nce_b_init=<sphinx.ext.autodoc.importer._MockObject
                                                       object>,
                                                       nce_b_init_args=None,
                                                       name='word2vec')
```

The `Word2vecEmbeddingInputlayer` class is a fully connected layer. For Word Embedding, words are

input as integer index. The output is the embedded word vector.

### Parameters

- **inputs** (*placeholder or tensor*) – The input of a network. For word inputs, please use integer index format, 2D tensor : [batch\_size, num\_steps(num\_words)]
- **train\_labels** (*placeholder*) – For word labels. integer index format
- **vocabulary\_size** (*int*) – The size of vocabulary, number of words
- **embedding\_size** (*int*) – The number of embedding dimensions
- **num\_sampled** (*int*) – The number of negative examples for NCE loss
- **nce\_loss\_args** (*dictionary*) – The arguments for tf.nn.nce\_loss()
- **E\_init** (*initializer*) – The initializer for initializing the embedding matrix
- **E\_init\_args** (*dictionary*) – The arguments for embedding initializer
- **nce\_W\_init** (*initializer*) – The initializer for initializing the nce decoder weight matrix
- **nce\_W\_init\_args** (*dictionary*) – The arguments for initializing the nce decoder weight matrix
- **nce\_b\_init** (*initializer*) – The initializer for initializing of the nce decoder bias vector
- **nce\_b\_init\_args** (*dictionary*) – The arguments for initializing the nce decoder bias vector
- **name** (*str*) – A unique layer name

### nce\_cost

*Tensor* – The NCE loss.

### outputs

*Tensor* – The embedding layer outputs.

### normalized\_embeddings

*Tensor* – Normalized embedding matrix.

## Examples

With TensorLayer: see `tensorlayer/example/tutorial_word2vec_basic.py`

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> batch_size = 8
>>> train_inputs = tf.placeholder(tf.int32, shape=(batch_size))
>>> train_labels = tf.placeholder(tf.int32, shape=(batch_size, 1))
>>> net = tl.layers.Word2vecEmbeddingInputlayer(inputs=train_inputs,
...      train_labels=train_labels, vocabulary_size=1000, embedding_size=200,
...      num_sampled=64, name='word2vec')
(8, 200)
>>> cost = net.nce_cost
>>> train_params = net.all_params
>>> cost = net.nce_cost
>>> train_params = net.all_params
```

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```
>>> train_op = tf.train.GradientDescentOptimizer(learning_rate).minimize(cost,
↳var_list=train_params)
>>> normalized_embeddings = net.normalized_embeddings
```

Without TensorLayer: see [tensorflow/examples/tutorials/word2vec/word2vec\\_basic.py](https://www.tensorflow.org/examples/tutorials/word2vec/word2vec_basic.py)

```
>>> train_inputs = tf.placeholder(tf.int32, shape=(batch_size))
>>> train_labels = tf.placeholder(tf.int32, shape=(batch_size, 1))
>>> embeddings = tf.Variable(
...     tf.random_uniform([vocabulary_size, embedding_size], -1.0, 1.0))
>>> embed = tf.nn.embedding_lookup(embeddings, train_inputs)
>>> nce_weights = tf.Variable(
...     tf.truncated_normal([vocabulary_size, embedding_size],
...                           stddev=1.0 / math.sqrt(embedding_size)))
>>> nce_biases = tf.Variable(tf.zeros([vocabulary_size]))
>>> cost = tf.reduce_mean(
...     tf.nn.nce_loss(weights=nce_weights, biases=nce_biases,
...                     inputs=embed, labels=train_labels,
...                     num_sampled=num_sampled, num_classes=vocabulary_size,
...                     num_true=1))
```

## References

[tensorflow/examples/tutorials/word2vec/word2vec\\_basic.py](https://www.tensorflow.org/examples/tutorials/word2vec/word2vec_basic.py)

## Embedding Input Layer

```
class tensorlayer.layers.EmbeddingInputlayer (inputs, vocabulary_size=80000,
embedding_size=200,
E_init=<sphinx.ext.autodoc.importer._MockObject
object>, E_init_args=None,
name='embedding')
```

The *EmbeddingInputlayer* class is a look-up table for word embedding.

Word content are accessed using integer indexes, then the output is the embedded word vector. To train a word embedding matrix, you can use *Word2vecEmbeddingInputlayer*. If you have a pre-trained matrix, you can assign the parameters into it.

### Parameters

- **inputs** (*placeholder*) – The input of a network. For word inputs. Please use integer index format, 2D tensor: (batch\_size, num\_steps(num\_words)).
- **vocabulary\_size** (*int*) – The size of vocabulary, number of words.
- **embedding\_size** (*int*) – The number of embedding dimensions.
- **E\_init** (*initializer*) – The initializer for the embedding matrix.
- **E\_init\_args** (*dictionary*) – The arguments for embedding matrix initializer.
- **name** (*str*) – A unique layer name.

### outputs

*tensor* – The embedding layer output is a 3D tensor in the shape: (batch\_size, num\_steps(num\_words), embedding\_size).

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> batch_size = 8
>>> x = tf.placeholder(tf.int32, shape=(batch_size, ))
>>> net = tl.layers.EmbeddingInputlayer(inputs=x, vocabulary_size=1000, embedding_
↪size=50, name='embed')
(8, 50)
```

## Average Embedding Input Layer

```
class tensorlayer.layers.AverageEmbeddingInputlayer (inputs, vocabulary_size, embed-
                                                    ding_size, pad_value=0, embed-
                                                    dings_initializer=<sphinx.ext.autodoc.importer._MockOb
                                                    ject>,
                                                    embed-
                                                    dings_kwargs=None,
                                                    name='average_embedding')
```

The *AverageEmbeddingInputlayer* averages over embeddings of inputs. This is often used as the input layer for models like DAN[1] and FastText[2].

### Parameters

- **inputs** (*placeholder or tensor*) – The network input. For word inputs, please use integer index format, 2D tensor: (batch\_size, num\_steps(num\_words)).
- **vocabulary\_size** (*int*) – The size of vocabulary.
- **embedding\_size** (*int*) – The dimension of the embedding vectors.
- **pad\_value** (*int*) – The scalar padding value used in inputs, 0 as default.
- **embeddings\_initializer** (*initializer*) – The initializer of the embedding matrix.
- **embeddings\_kwargs** (*None or dictionary*) – The arguments to get embedding matrix variable.
- **name** (*str*) – A unique layer name.

## References

- [1] Iyyer, M., Manjunatha, V., Boyd-Graber, J., & Daum'e III, H. (2015). Deep Unordered Composition Rivals Syntactic Methods for Text Classification. In Association for Computational Linguistics.
- [2] Joulin, A., Grave, E., Bojanowski, P., & Mikolov, T. (2016). [Bag of Tricks for Efficient Text Classification](#).

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> batch_size = 8
>>> length = 5
>>> x = tf.placeholder(tf.int32, shape=(batch_size, length))
```

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```
>>> net = tl.layers.AverageEmbeddingInputLayer(x, vocabulary_size=1000, embedding_
↪size=50, name='avg')
(8, 50)
```

## 2.8.7 Activation Layers

### PReLU Layer

```
class tensorlayer.layers.PReluLayer (prev_layer,                                channel_shared=False,
                                     a_init=<sphinx.ext.autodoc.importer._MockObject
                                     object>, a_init_args=None, name='PReluLayer')
```

The *PReluLayer* class is Parametric Rectified Linear layer.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **channel\_shared** (*boolean*) – If True, single weight is shared by all channels.
- **a\_init** (*initializer*) – The initializer for initializing the alpha(s).
- **a\_init\_args** (*dictionary*) – The arguments for initializing the alpha(s).
- **name** (*str*) – A unique layer name.

#### References

- Delving Deep into Rectifiers: Surpassing Human-Level Performance on ImageNet Classification
- Convolutional Deep Belief Networks on CIFAR-10 [A. Krizhevsky, 2010]

### PReLU6 Layer

```
class tensorlayer.layers.PRelu6Layer (prev_layer,                                channel_shared=False,
                                       a_init=<sphinx.ext.autodoc.importer._MockObject
                                       object>, a_init_args=None, name='PReLU6_layer')
```

The *PReLU6Layer* class is Parametric Rectified Linear layer integrating ReLU6 behaviour.

This Layer is a modified version of the *PReluLayer*.

This activation layer use a modified version `tl.act.leaky_relu()` introduced by the following paper: Rectifier Nonlinearities Improve Neural Network Acoustic Models [A. L. Maas et al., 2013]

This activation function also use a modified version of the activation function `tf.nn.relu6()` introduced by the following paper: Convolutional Deep Belief Networks on CIFAR-10 [A. Krizhevsky, 2010]

This activation layer push further the logic by adding *leaky* behaviour both below zero and above six.

#### The function return the following results:

- When  $x < 0$ :  $f(x) = \text{alpha\_low} * x$ .
- When  $x$  in  $[0, 6]$ :  $f(x) = x$ .
- When  $x > 6$ :  $f(x) = 6$ .

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **channel\_shared** (*boolean*) – If True, single weight is shared by all channels.
- **a\_init** (*initializer*) – The initializer for initializing the alpha(s).
- **a\_init\_args** (*dictionary*) – The arguments for initializing the alpha(s).
- **name** (*str*) – A unique layer name.

## References

- Delving Deep into Rectifiers: Surpassing Human-Level Performance on ImageNet Classification
- Rectifier Nonlinearities Improve Neural Network Acoustic Models [A. L. Maas et al., 2013]
- Convolutional Deep Belief Networks on CIFAR-10 [A. Krizhevsky, 2010]

## PTReLU6 Layer

```
class tensorlayer.layers.PTReLU6Layer (prev_layer,                      channel_shared=False,
                                         a_init=<sphinx.ext.autodoc.importer._MockObject
                                         object>,                      a_init_args=None,
                                         name='PTReLU6_layer')
```

The *PTReLU6Layer* class is Parametric Rectified Linear layer integrating ReLU6 behaviour.

This Layer is a modified version of the *PReLU6Layer*.

This activation layer use a modified version `tl.act.leaky_relu()` introduced by the following paper: [Rectifier Nonlinearities Improve Neural Network Acoustic Models \[A. L. Maas et al., 2013\]](#)

This activation function also use a modified version of the activation function `tf.nn.relu6()` introduced by the following paper: [Convolutional Deep Belief Networks on CIFAR-10 \[A. Krizhevsky, 2010\]](#)

This activation layer push further the logic by adding *leaky* behaviour both below zero and above six.

**The function return the following results:**

- When  $x < 0$ :  $f(x) = \text{alpha\_low} * x$ .
- When  $x$  in  $[0, 6]$ :  $f(x) = x$ .
- When  $x > 6$ :  $f(x) = 6 + (\text{alpha\_high} * (x-6))$ .

This version goes one step beyond *PReLU6Layer* by introducing leaky behaviour on the positive side when  $x > 6$ .

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **channel\_shared** (*boolean*) – If True, single weight is shared by all channels.
- **a\_init** (*initializer*) – The initializer for initializing the alpha(s).
- **a\_init\_args** (*dictionary*) – The arguments for initializing the alpha(s).
- **name** (*str*) – A unique layer name.

## References

- Delving Deep into Rectifiers: Surpassing Human-Level Performance on ImageNet Classification
- Convolutional Deep Belief Networks on CIFAR-10 [A. Krizhevsky, 2010]
- Rectifier Nonlinearities Improve Neural Network Acoustic Models [A. L. Maas et al., 2013]

## 2.8.8 Convolutional Layers

### Simplified Convolutions

For users don't familiar with TensorFlow, the following simplified functions may easier for you. We will provide more simplified functions later, but if you are good at TensorFlow, the professional APIs may better for you.

#### Conv1d

```
class tensorlayer.layers.Conv1d(prev_layer,          n_filter=32,          filter_size=5,
                                stride=1,            dilation_rate=1,        act=None,
                                padding='SAME',        data_format='channels_last',
                                W_init=<sphinx.ext.autodoc.importer._MockObject object>,
                                b_init=<sphinx.ext.autodoc.importer._MockObject object>,
                                W_init_args=None, b_init_args=None, name='conv1d')
```

Simplified version of `Conv1dLayer`.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer
- **n\_filter** (*int*) – The number of filters
- **filter\_size** (*int*) – The filter size
- **stride** (*int*) – The stride step
- **dilation\_rate** (*int*) – Specifying the dilation rate to use for dilated convolution.
- **act** (*activation function*) – The function that is applied to the layer activations
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **data\_format** (*str*) – channels\_last ‘NWC’ (default) or channels\_first.
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer (deprecated).
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer (deprecated).
- **name** (*str*) – A unique layer name



## Examples

```
>>> x = tf.placeholder(tf.float32, (batch_size, width))
>>> y_ = tf.placeholder(tf.int64, shape=(batch_size,))
>>> n = InputLayer(x, name='in')
>>> n = ReshapeLayer(n, (-1, width, 1), name='rs')
>>> n = Conv1d(n, 64, 3, 1, act=tf.nn.relu, name='c1')
>>> n = MaxPool1d(n, 2, 2, padding='valid', name='m1')
>>> n = Conv1d(n, 128, 3, 1, act=tf.nn.relu, name='c2')
>>> n = MaxPool1d(n, 2, 2, padding='valid', name='m2')
>>> n = Conv1d(n, 128, 3, 1, act=tf.nn.relu, name='c3')
>>> n = MaxPool1d(n, 2, 2, padding='valid', name='m3')
>>> n = FlattenLayer(n, name='f')
>>> n = DenseLayer(n, 500, tf.nn.relu, name='d1')
>>> n = DenseLayer(n, 100, tf.nn.relu, name='d2')
>>> n = DenseLayer(n, 2, None, name='o')
```

## Conv2d

```
class tensorlayer.layers.Conv2d(prev_layer, n_filter=32, filter_size=(3, 3),
                                strides=(1, 1), act=None, padding='SAME',
                                data_format='channels_last', dilation_rate=(1, 1),
                                W_init=<sphinx.ext.autodoc.importer._MockObject
                                object>, b_init=<sphinx.ext.autodoc.importer._MockObject
                                object>, W_init_args=None, b_init_args=None,
                                use_cudnn_on_gpu=None, name='conv2d')
```

Simplified version of [Conv2dLayer](#).

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **n\_filter** (*int*) – The number of filters.
- **filter\_size** (*tuple of int*) – The filter size (height, width).
- **strides** (*tuple of int*) – The sliding window strides of corresponding input dimensions. It must be in the same order as the shape parameter.
- **act** (*activation function*) – The activation function of this layer.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **data\_format** (*str*) – “channels\_last” (NHWC, default) or “channels\_first” (NCHW).
- **W\_init** (*initializer*) – The initializer for the the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer (for TF < 1.5).
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer (for TF < 1.5).
- **use\_cudnn\_on\_gpu** (*bool*) – Default is False (for TF < 1.5).
- **name** (*str*) – A unique layer name.

**Returns** A [Conv2dLayer](#) object.

Return type *Layer*

## Examples

```
>>> x = tf.placeholder(tf.float32, shape=(None, 28, 28, 1))
>>> net = InputLayer(x, name='inputs')
>>> net = Conv2d(net, 64, (3, 3), act=tf.nn.relu, name='conv1_1')
>>> net = Conv2d(net, 64, (3, 3), act=tf.nn.relu, name='conv1_2')
>>> net = MaxPool2d(net, (2, 2), name='pool1')
>>> net = Conv2d(net, 128, (3, 3), act=tf.nn.relu, name='conv2_1')
>>> net = Conv2d(net, 128, (3, 3), act=tf.nn.relu, name='conv2_2')
>>> net = MaxPool2d(net, (2, 2), name='pool2')
```

## Simplified Deconvolutions

For users don't familiar with TensorFlow, the following simplified functions may easier for you. We will provide more simplified functions later, but if you are good at TensorFlow, the professional APIs may better for you.

### DeConv2d

```
class tensorlayer.layers.DeConv2d(prev_layer,          n_filter=32,          filter_size=(3,
3),          strides=(2,          2),          padding='SAME',
act=None,          data_format='channels_last',
W_init=<sphinx.ext.autodoc.importer._MockObject object>, b_init=<sphinx.ext.autodoc.importer._MockObject
object>, W_init_args=None, b_init_args=None,
name='decnn2d')
```

Simplified version of *DeConv2dLayer*.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **n\_filter** (*int*) – The number of filters.
- **filter\_size** (*tuple of int*) – The filter size (height, width).
- **out\_size** (*tuple of int*) – Require if TF version < 1.3, (height, width) of output.
- **strides** (*tuple of int*) – The stride step (height, width).
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **act** (*activation function*) – The activation function of this layer.
- **data\_format** (*str*) – “channels\_last” (NHWC, default) or “channels\_first” (NCHW).
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer (For TF < 1.3).
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer (For TF < 1.3).

- **name** (*str*) – A unique layer name.

## DeConv3d

```
class tensorlayer.layers.DeConv3d(prev_layer,      n_filter=32,      filter_size=(3,      3,
3),      strides=(2,      2,      2),      padding='SAME',
act=None,      data_format='channels_last',
W_init=<sphinx.ext.autodoc.importer._MockObject object>, b_init=<sphinx.ext.autodoc.importer._MockObject
object>,      W_init_args=None,      b_init_args=None,
name='decnn3d')
```

Simplified version of The [DeConv3dLayer](#), see [tf.contrib.layers.conv3d\\_transpose](#).

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **n\_filter** (*int*) – The number of filters.
- **filter\_size** (*tuple of int*) – The filter size (depth, height, width).
- **stride** (*tuple of int*) – The stride step (depth, height, width).
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **act** (*activation function*) – The activation function of this layer.
- **data\_format** (*str*) – “channels\_last” (NDHWC, default) or “channels\_first” (NCDHW).
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip bias.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer (For TF < 1.3).
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer (For TF < 1.3).
- **name** (*str*) – A unique layer name.

## Expert Convolutions

### Conv1dLayer

```
class tensorlayer.layers.Conv1dLayer(prev_layer, act=None, shape=(5, 1, 5), stride=1, dila-
tion_rate=1, padding='SAME', data_format='NWC',
W_init=<sphinx.ext.autodoc.importer._MockObject ob-
ject>, b_init=<sphinx.ext.autodoc.importer._MockObject
object>,      W_init_args=None,      b_init_args=None,
name='cnn1d')
```

The [Conv1dLayer](#) class is a 1D CNN layer, see [tf.nn.convolution](#).

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **act** (*activation function*) – The activation function of this layer.

- **shape** (*tuple of int*) – The shape of the filters: (filter\_length, in\_channels, out\_channels).
- **stride** (*int*) – The number of entries by which the filter is moved right at a step.
- **dilation\_rate** (*int*) – Filter up-sampling/input down-sampling rate.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **data\_format** (*str*) – Default is ‘NWC’ as it is a 1D CNN.
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **name** (*str*) – A unique layer name

## Conv2dLayer

```
class tensorlayer.layers.Conv2dLayer (prev_layer, act=None, shape=(5, 5, 1, 100),
                                     strides=(1, 1, 1, 1), padding='SAME',
                                     W_init=<sphinx.ext.autodoc.importer._MockObject ob-
                                     ject>, b_init=<sphinx.ext.autodoc.importer._MockObject
                                     object>, W_init_args=None, b_init_args=None,
                                     use_cudnn_on_gpu=None, data_format=None,
                                     name='cnn_layer')
```

The `Conv2dLayer` class is a 2D CNN layer, see [tf.nn.conv2d](#).

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **act** (*activation function*) – The activation function of this layer.
- **shape** (*tuple of int*) – The shape of the filters: (filter\_height, filter\_width, in\_channels, out\_channels).
- **strides** (*tuple of int*) – The sliding window strides of corresponding input dimensions. It must be in the same order as the `shape` parameter.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **use\_cudnn\_on\_gpu** (*bool*) – Default is False.
- **data\_format** (*str*) – “NHWC” or “NCHW”, default is “NHWC”.
- **name** (*str*) – A unique layer name.

## Notes

- `shape` = [h, w, the number of output channel of previous layer, the number of output channels]
- the number of output channel of a layer is its last dimension.

## Examples

With TensorLayer

```
>>> x = tf.placeholder(tf.float32, shape=(None, 28, 28, 1))
>>> net = tl.layers.InputLayer(x, name='input_layer')
>>> net = tl.layers.Conv2dLayer(net,
...                             act = tf.nn.relu,
...                             shape = (5, 5, 1, 32), # 32 features for each 5x5 patch
...                             strides = (1, 1, 1, 1),
...                             padding='SAME',
...                             W_init=tf.truncated_normal_initializer(stddev=5e-2),
...                             b_init = tf.constant_initializer(value=0.0),
...                             name = 'cnn_layer1') # output: (?, 28, 28, 32)
>>> net = tl.layers.PoolLayer(net,
...                             ksize=(1, 2, 2, 1),
...                             strides=(1, 2, 2, 1),
...                             padding='SAME',
...                             pool = tf.nn.max_pool,
...                             name = 'pool_layer1',) # output: (?, 14, 14, 32)
```

Without TensorLayer, you can implement 2D convolution as follow.

```
>>> W = tf.Variable(W_init(shape=[5, 5, 1, 32], ), name='W_conv')
>>> b = tf.Variable(b_init(shape=[32], ), name='b_conv')
>>> outputs = tf.nn.relu( tf.nn.conv2d(inputs, W,
...                                     strides=[1, 1, 1, 1],
...                                     padding='SAME') + b )
```

## Conv3dLayer

```
class tensorlayer.layers.Conv3dLayer (prev_layer, shape=(2, 2, 2, 3, 32), strides=(1,
2, 2, 2, 1), padding='SAME', act=None,
W_init=<sphinx.ext.autodoc.importer._MockObject ob-
ject>, b_init=<sphinx.ext.autodoc.importer._MockObject
object>, W_init_args=None, b_init_args=None,
name='cnn3d_layer')
```

The `Conv3dLayer` class is a 3D CNN layer, see `tf.nn.conv3d`.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **shape** (*tuple of int*) – Shape of the filters: (filter\_depth, filter\_height, filter\_width, in\_channels, out\_channels).
- **strides** (*tuple of int*) – The sliding window strides for corresponding input dimensions. Must be in the same order as the shape dimension.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.

- **act** (*activation function*) – The activation function of this layer.
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> x = tf.placeholder(tf.float32, (None, 100, 100, 100, 3))
>>> n = tl.layers.InputLayer(x, name='in3')
>>> n = tl.layers.Conv3dLayer(n, shape=(2, 2, 2, 3, 32), strides=(1, 2, 2, 2, 1))
[None, 50, 50, 50, 32]
```

## Expert Deconvolutions

### DeConv2dLayer

```
class tensorlayer.layers.DeConv2dLayer (prev_layer, act=None, shape=(3, 3, 128,
256), output_shape=(1, 256, 256, 128),
strides=(1, 2, 2, 1), padding='SAME',
W_init=<sphinx.ext.autodoc.importer.MockObject
object>, b_init=<sphinx.ext.autodoc.importer.MockObject
object>, W_init_args=None, b_init_args=None,
name='decnn2d_layer')
```

A de-convolution 2D layer.

See `tf.nn.conv2d_transpose`.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **act** (*activation function*) – The activation function of this layer.
- **shape** (*tuple of int*) – Shape of the filters: (height, width, output\_channels, in\_channels). The filter's in\_channels dimension must match that of value.
- **output\_shape** (*tuple of int*) – Output shape of the deconvolution.
- **strides** (*tuple of int*) – The sliding window strides for corresponding input dimensions.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for initializing the weight matrix.
- **b\_init\_args** (*dictionary*) – The arguments for initializing the bias vector.
- **name** (*str*) – A unique layer name.

## Notes

- We recommend to use *DeConv2d* with TensorFlow version higher than 1.3.
- `shape = [h, w, the number of output channels of this layer, the number of output channel of the previous layer]`.
- `output_shape = [batch_size, any, any, the number of output channels of this layer]`.
- the number of output channel of a layer is its last dimension.

## Examples

A part of the generator in DCGAN example

```
>>> batch_size = 64
>>> inputs = tf.placeholder(tf.float32, [batch_size, 100], name='z_noise')
>>> net_in = tl.layers.InputLayer(inputs, name='g/in')
>>> net_h0 = tl.layers.DenseLayer(net_in, n_units = 8192,
...                               W_init = tf.random_normal_initializer(stddev=0.02),
...                               act = None, name='g/h0/lin')
>>> print(net_h0.outputs._shape)
(64, 8192)
>>> net_h0 = tl.layers.ReshapeLayer(net_h0, shape=(-1, 4, 4, 512), name='g/h0/
↳reshape')
>>> net_h0 = tl.layers.BatchNormLayer(net_h0, act=tf.nn.relu, is_train=is_train,
↳name='g/h0/batch_norm')
>>> print(net_h0.outputs._shape)
(64, 4, 4, 512)
>>> net_h1 = tl.layers.DeConv2dLayer(net_h0,
...                                  shape=(5, 5, 256, 512),
...                                  output_shape=(batch_size, 8, 8, 256),
...                                  strides=(1, 2, 2, 1),
...                                  act=None, name='g/h1/decon2d')
>>> net_h1 = tl.layers.BatchNormLayer(net_h1, act=tf.nn.relu, is_train=is_train,
↳name='g/h1/batch_norm')
>>> print(net_h1.outputs._shape)
(64, 8, 8, 256)
```

## U-Net

```
>>> ....
>>> conv10 = tl.layers.Conv2dLayer(conv9, act=tf.nn.relu,
...                               shape=(3,3,1024,1024), strides=(1,1,1,1), padding='SAME',
...                               W_init=w_init, b_init=b_init, name='conv10')
>>> print(conv10.outputs)
(batch_size, 32, 32, 1024)
>>> deconv1 = tl.layers.DeConv2dLayer(conv10, act=tf.nn.relu,
...                                   shape=(3,3,512,1024), strides=(1,2,2,1), output_shape=(batch_size,64,
↳64,512),
...                                   padding='SAME', W_init=w_init, b_init=b_init, name='devcon1_1')
```

## DeConv3dLayer

```
class tensorlayer.layers.DeConv3dLayer (prev_layer, act=None, shape=(2, 2, 2, 128, 256), output_shape=(1, 12, 32, 32, 128), strides=(1, 2, 2, 2, 1), padding='SAME', W_init=<sphinx.ext.autodoc.importer._MockObject object>, b_init=<sphinx.ext.autodoc.importer._MockObject object>, W_init_args=None, b_init_args=None, name='decnn3d_layer')
```

The *DeConv3dLayer* class is deconvolutional 3D layer, see `tf.nn.conv3d_transpose`.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **act** (*activation function*) – The activation function of this layer.
- **shape** (*tuple of int*) – The shape of the filters: (depth, height, width, output\_channels, in\_channels). The filter’s in\_channels dimension must match that of value.
- **output\_shape** (*tuple of int*) – The output shape of the deconvolution.
- **strides** (*tuple of int*) – The sliding window strides for corresponding input dimensions.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **name** (*str*) – A unique layer name.

## Atrous (De)Convolutions

### AtrousConv1dLayer

```
tensorlayer.layers.AtrousConv1dLayer (prev_layer, n_filter=32, filter_size=2, stride=1, dilation=1, act=None, padding='SAME', data_format='NWC', W_init=<sphinx.ext.autodoc.importer._MockObject object>, b_init=<sphinx.ext.autodoc.importer._MockObject object>, W_init_args=None, b_init_args=None, name='atrous_1d')
```

Simplified version of *AtrousConv1dLayer*.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **n\_filter** (*int*) – The number of filters.
- **filter\_size** (*int*) – The filter size.
- **stride** (*tuple of int*) – The strides: (height, width).
- **dilation** (*int*) – The filter dilation size.



- **act** (*activation function*) – The activation function of this layer.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **data\_format** (*str*) – Default is ‘NWC’ as it is a 1D CNN.
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **name** (*str*) – A unique layer name.

**Returns** A *AtrousConv1dLayer* object

**Return type** *Layer*

## AtrousConv2dLayer

```
class tensorlayer.layers.AtrousConv2dLayer (prev_layer,    n_filter=32,    filter_size=(3,
                                                    3), rate=2, act=None, padding='SAME',
                                                    W_init=<sphinx.ext.autodoc.importer._MockObject
object>, b_init=<sphinx.ext.autodoc.importer._MockObject
object>,          W_init_args=None,
                                                    b_init_args=None, name='atrous_2d')
```

The *AtrousConv2dLayer* class is 2D atrous convolution (a.k.a. convolution with holes or dilated convolution) 2D layer, see `tf.nn.atrous_conv2d`.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer with a 4D output tensor in the shape of (batch, height, width, channels).
- **n\_filter** (*int*) – The number of filters.
- **filter\_size** (*tuple of int*) – The filter size: (height, width).
- **rate** (*int*) – The stride that we sample input values in the height and width dimensions. This equals the rate that we up-sample the filters by inserting zeros across the height and width dimensions. In the literature, this parameter is sometimes mentioned as input stride or dilation.
- **act** (*activation function*) – The activation function of this layer.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **name** (*str*) – A unique layer name.

## AtrousDeConv2dLayer

```
class tensorlayer.layers.AtrousDeConv2dLayer (prev_layer, shape=(3, 3, 128, 256),
                                              output_shape=(1, 64, 64, 128),
                                              rate=2, act=None, padding='SAME',
                                              W_init=<sphinx.ext.autodoc.importer._MockObject
                                              object>, b_init=<sphinx.ext.autodoc.importer._MockObject
                                              object>, W_init_args=None,
                                              b_init_args=None,
                                              name='atrous_2d_transpose')
```

The *AtrousDeConv2dLayer* class is 2D atrous convolution transpose, see `tf.nn.atrous_conv2d_transpose`.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer with a 4D output tensor in the shape of (batch, height, width, channels).
- **shape** (*tuple of int*) – The shape of the filters: (filter\_height, filter\_width, out\_channels, in\_channels).
- **output\_shape** (*tuple of int*) – Output shape of the deconvolution.
- **rate** (*int*) – The stride that we sample input values in the height and width dimensions. This equals the rate that we up-sample the filters by inserting zeros across the height and width dimensions. In the literature, this parameter is sometimes mentioned as input stride or dilation.
- **act** (*activation function*) – The activation function of this layer.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **name** (*str*) – A unique layer name.

## Deformable Convolutions

### DeformableConv2d

```
class tensorlayer.layers.DeformableConv2d (prev_layer, offset_layer=None,
                                           n_filter=32, filter_size=(3, 3),
                                           act=None, name='deformable_conv_2d',
                                           W_init=<sphinx.ext.autodoc.importer._MockObject
                                           object>, b_init=<sphinx.ext.autodoc.importer._MockObject
                                           object>, W_init_args=None,
                                           b_init_args=None)
```

The *DeformableConv2d* class is a 2D *Deformable Convolutional Networks*.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.

- **offset\_layer** (*Layer*) – To predict the offset of convolution operations. The output shape is (batchsize, input height, input width, 2\*(number of element in the convolution kernel)) e.g. if apply a 3\*3 kernel, the number of the last dimension should be 18 (2\*3\*3)
- **n\_filter** (*int*) – The number of filters.
- **filter\_size** (*tuple of int*) – The filter size (height, width).
- **act** (*activation function*) – The activation function of this layer.
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> net = tl.layers.InputLayer(x, name='input_layer')
>>> offset1 = tl.layers.Conv2d(net, 18, (3, 3), (1, 1), act=act, padding='SAME',
↳name='offset1')
>>> net = tl.layers.DeformableConv2d(net, offset1, 32, (3, 3), act=act, name=
↳'deformable1')
>>> offset2 = tl.layers.Conv2d(net, 18, (3, 3), (1, 1), act=act, padding='SAME',
↳name='offset2')
>>> net = tl.layers.DeformableConv2d(net, offset2, 64, (3, 3), act=act, name=
↳'deformable2')
```

## References

- The deformation operation was adapted from the implementation in [here](#)

## Notes

- The padding is fixed to 'SAME'.
- The current implementation is not optimized for memory usage. Please use it carefully.

## Depthwise Convolutions

### DepthwiseConv2d

```
class tensorlayer.layers.DepthwiseConv2d(prev_layer, shape=(3, 3), strides=(1,
1), act=None, padding='SAME', dilation_rate=(1, 1), depth_multiplier=1,
W_init=<sphinx.ext.autodoc.importer._MockObject
object>, b_init=<sphinx.ext.autodoc.importer._MockObject
object>, W_init_args=None, b_init_args=None,
name='depthwise_conv2d')
```

Separable/Depthwise Convolutional 2D layer, see [tf.nn.depthwise\\_conv2d](#).

**Input:** 4-D Tensor (batch, height, width, in\_channels).

**Output:** 4-D Tensor (batch, new height, new width, in\_channels \* depth\_multiplier).

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **filter\_size** (*tuple of int*) – The filter size (height, width).
- **stride** (*tuple of int*) – The stride step (height, width).
- **act** (*activation function*) – The activation function of this layer.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **dilation\_rate** (*tuple of 2 int*) – The dilation rate in which we sample input values across the height and width dimensions in atrous convolution. If it is greater than 1, then all values of strides must be 1.
- **depth\_multiplier** (*int*) – The number of channels to expand to.
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip bias.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **name** (*str*) – A unique layer name.

### Examples

```
>>> net = InputLayer(x, name='input')
>>> net = Conv2d(net, 32, (3, 3), (2, 2), b_init=None, name='cin')
>>> net = BatchNormLayer(net, act=tf.nn.relu, is_train=is_train, name='bnin')
...
>>> net = DepthwiseConv2d(net, (3, 3), (1, 1), b_init=None, name='cdw1')
>>> net = BatchNormLayer(net, act=tf.nn.relu, is_train=is_train, name='bn11')
>>> net = Conv2d(net, 64, (1, 1), (1, 1), b_init=None, name='c1')
>>> net = BatchNormLayer(net, act=tf.nn.relu, is_train=is_train, name='bn12')
...
>>> net = DepthwiseConv2d(net, (3, 3), (2, 2), b_init=None, name='cdw2')
>>> net = BatchNormLayer(net, act=tf.nn.relu, is_train=is_train, name='bn21')
>>> net = Conv2d(net, 128, (1, 1), (1, 1), b_init=None, name='c2')
>>> net = BatchNormLayer(net, act=tf.nn.relu, is_train=is_train, name='bn22')
```

### References

- [tflearn's grouped\\_conv\\_2d](#)
- [keras's separableconv2d](#)

## Group Convolutions

### GroupConv2d

```
class tensorlayer.layers.GroupConv2d(prev_layer, n_filter=32, filter_size=(3, 3), strides=(2, 2), n_group=2, act=None, padding='SAME', W_init=<sphinx.ext.autodoc.importer._MockObject object>, b_init=<sphinx.ext.autodoc.importer._MockObject object>, W_init_args=None, b_init_args=None, name='groupconv')
```

The `GroupConv2d` class is 2D grouped convolution, see [here](#).

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **n\_filter** (*int*) – The number of filters.
- **filter\_size** (*int*) – The filter size.
- **stride** (*int*) – The stride step.
- **n\_group** (*int*) – The number of groups.
- **act** (*activation function*) – The activation function of this layer.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **name** (*str*) – A unique layer name.

## Separable Convolutions

### SeparableConv1d

```
class tensorlayer.layers.SeparableConv1d(prev_layer, n_filter=100, filter_size=3, strides=1, act=None, padding='valid', data_format='channels_last', dilation_rate=1, depth_multiplier=1, depthwise_init=None, pointwise_init=None, b_init=<sphinx.ext.autodoc.importer._MockObject object>, W_init_args=None, b_init_args=None, name='seperable1d')
```

The `SeparableConv1d` class is a 1D depthwise separable convolutional layer, see `tf.layers.seperable_conv1d`.

This layer performs a depthwise convolution that acts separately on channels, followed by a pointwise convolution that mixes channels.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.

- **n\_filter** (*int*) – The dimensionality of the output space (i.e. the number of filters in the convolution).
- **filter\_size** (*int*) – Specifying the spatial dimensions of the filters. Can be a single integer to specify the same value for all spatial dimensions.
- **strides** (*int*) – Specifying the stride of the convolution. Can be a single integer to specify the same value for all spatial dimensions. Specifying any stride value != 1 is incompatible with specifying any dilation\_rate value != 1.
- **padding** (*str*) – One of “valid” or “same” (case-insensitive).
- **data\_format** (*str*) – One of channels\_last (default) or channels\_first. The ordering of the dimensions in the inputs. channels\_last corresponds to inputs with shape (batch, height, width, channels) while channels\_first corresponds to inputs with shape (batch, channels, height, width).
- **dilation\_rate** (*int*) – Specifying the dilation rate to use for dilated convolution. Can be a single integer to specify the same value for all spatial dimensions. Currently, specifying any dilation\_rate value != 1 is incompatible with specifying any stride value != 1.
- **depth\_multiplier** (*int*) – The number of depthwise convolution output channels for each input channel. The total number of depthwise convolution output channels will be equal to num\_filters\_in \* depth\_multiplier.
- **depthwise\_init** (*initializer*) – for the depthwise convolution kernel.
- **pointwise\_init** (*initializer*) – For the pointwise convolution kernel.
- **b\_init** (*initializer*) – For the bias vector. If None, ignore bias in the pointwise part only.
- **name** (*a str*) – A unique layer name.

## SeparableConv2d

```
class tensorlayer.layers.SeparableConv2d (prev_layer, n_filter=100, filter_size=(3, 3),
                                           strides=(1, 1), act=None, padding='valid',
                                           data_format='channels_last', dilation_rate=(1, 1),
                                           depth_multiplier=1, depthwise_init=None,
                                           pointwise_init=None, b_init=<sphinx.ext.autodoc.importer._MockObject
                                           object>, W_init_args=None, b_init_args=None,
                                           name='seperable')
```

The `SeparableConv2d` class is a 2D depthwise separable convolutional layer, see `tf.layers.separable_conv2d`.

This layer performs a depthwise convolution that acts separately on channels, followed by a pointwise convolution that mixes channels. While `DepthwiseConv2d` performs depthwise convolution only, which allow us to add batch normalization between depthwise and pointwise convolution.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **n\_filter** (*int*) – The dimensionality of the output space (i.e. the number of filters in the convolution).
- **filter\_size** (*tuple/list of 2 int*) – Specifying the spatial dimensions of the filters. Can be a single integer to specify the same value for all spatial dimensions.

- **strides** (*tuple/list of 2 int*) – Specifying the strides of the convolution. Can be a single integer to specify the same value for all spatial dimensions. Specifying any stride value  $\neq 1$  is incompatible with specifying any `dilation_rate` value  $\neq 1$ .
- **padding** (*str*) – One of “valid” or “same” (case-insensitive).
- **data\_format** (*str*) – One of `channels_last` (default) or `channels_first`. The ordering of the dimensions in the inputs. `channels_last` corresponds to inputs with shape (batch, height, width, channels) while `channels_first` corresponds to inputs with shape (batch, channels, height, width).
- **dilation\_rate** (*integer or tuple/list of 2 int*) – Specifying the dilation rate to use for dilated convolution. Can be a single integer to specify the same value for all spatial dimensions. Currently, specifying any `dilation_rate` value  $\neq 1$  is incompatible with specifying any stride value  $\neq 1$ .
- **depth\_multiplier** (*int*) – The number of depthwise convolution output channels for each input channel. The total number of depthwise convolution output channels will be equal to `num_filters_in * depth_multiplier`.
- **depthwise\_init** (*initializer*) – for the depthwise convolution kernel.
- **pointwise\_init** (*initializer*) – For the pointwise convolution kernel.
- **b\_init** (*initializer*) – For the bias vector. If `None`, ignore bias in the pointwise part only.
- **name** (*a str*) – A unique layer name.

## SubPixel Convolutions

### SubpixelConv1d

```
class tensorlayer.layers.SubpixelConv1d(prev_layer, scale=2, act=None,
                                         name='subpixel_conv1d')
```

It is a 1D sub-pixel up-sampling layer.

Calls a TensorFlow function that directly implements this functionality. We assume input has dim (batch, width, r)

#### Parameters

- **net** (*Layer*) – Previous layer with output shape of (batch, width, r).
- **scale** (*int*) – The up-scaling ratio, a wrong setting will lead to Dimension size error.
- **act** (*activation function*) – The activation function of this layer.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> t_signal = tf.placeholder('float32', [10, 100, 4], name='x')
>>> n = tl.layers.InputLayer(t_signal, name='in')
>>> n = tl.layers.SubpixelConv1d(n, scale=2, name='s')
>>> print(n.outputs.shape)
(10, 200, 2)
```

## References

[Audio Super Resolution Implementation.](#)

## SubpixelConv2d

**class** `tensorlayer.layers.SubpixelConv2d`(*prev\_layer*, *scale=2*, *n\_out\_channel=None*, *act=None*, *name='subpixel\_conv2d'*)

It is a 2D sub-pixel up-sampling layer, usually be used for Super-Resolution applications, see [SRGAN](#) for example.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer,
- **scale** (*int*) – The up-scaling ratio, a wrong setting will lead to dimension size error.
- **n\_out\_channel** (*int or None*) – The number of output channels. - If None, automatically set `n_out_channel == the number of input channels / (scale x scale)`. - The number of input channels == `(scale x scale) x The number of output channels`.
- **act** (*activation function*) – The activation function of this layer.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> # examples here just want to tell you how to set the n_out_channel.
>>> import numpy as np
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = np.random.rand(2, 16, 16, 4)
>>> X = tf.placeholder("float32", shape=(2, 16, 16, 4), name="X")
>>> net = tl.layers.InputLayer(X, name='input')
>>> net = tl.layers.SubpixelConv2d(net, scale=2, n_out_channel=1, name='subpixel_
↳ conv2d')
>>> sess = tf.Session()
>>> y = sess.run(net.outputs, feed_dict={X: x})
>>> print(x.shape, y.shape)
(2, 16, 16, 4) (2, 32, 32, 1)
```

```
>>> x = np.random.rand(2, 16, 16, 4*10)
>>> X = tf.placeholder("float32", shape=(2, 16, 16, 4*10), name="X")
>>> net = tl.layers.InputLayer(X, name='input2')
>>> net = tl.layers.SubpixelConv2d(net, scale=2, n_out_channel=10, name='subpixel_
↳ conv2d2')
>>> y = sess.run(net.outputs, feed_dict={X: x})
>>> print(x.shape, y.shape)
(2, 16, 16, 40) (2, 32, 32, 10)
```

```
>>> x = np.random.rand(2, 16, 16, 25*10)
>>> X = tf.placeholder("float32", shape=(2, 16, 16, 25*10), name="X")
>>> net = tl.layers.InputLayer(X, name='input3')
>>> net = tl.layers.SubpixelConv2d(net, scale=5, n_out_channel=None, name=
↳ 'subpixel_conv2d3')
```

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```
>>> y = sess.run(net.outputs, feed_dict={X: x})
>>> print(x.shape, y.shape)
(2, 16, 16, 250) (2, 80, 80, 10)
```

## References

- [Real-Time Single Image and Video Super-Resolution Using an Efficient Sub-Pixel Convolutional Neural Network](#)

## 2.8.9 Dense Layers

### Dense Layer

```
class tensorlayer.layers.DenseLayer(prev_layer, n_units=100, act=None,
                                     W_init=<sphinx.ext.autodoc.importer._MockObject object>,
                                     b_init=<sphinx.ext.autodoc.importer._MockObject object>,
                                     W_init_args=None, b_init_args=None,
                                     name='dense')
```

The *DenseLayer* class is a fully connected layer.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **n\_units** (*int*) – The number of units of this layer.
- **act** (*activation function*) – The activation function of this layer.
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **name** (*a str*) – A unique layer name.

### Examples

With TensorLayer

```
>>> net = tl.layers.InputLayer(x, name='input')
>>> net = tl.layers.DenseLayer(net, 800, act=tf.nn.relu, name='relu')
```

Without native TensorLayer APIs, you can do as follow.

```
>>> W = tf.Variable(
...     tf.random_uniform([n_in, n_units], -1.0, 1.0), name='W')
>>> b = tf.Variable(tf.zeros(shape=[n_units]), name='b')
>>> y = tf.nn.relu(tf.matmul(inputs, W) + b)
```

## Notes

If the layer input has more than two axes, it needs to be flattened by using *FlattenLayer*.

## Drop Connect Dense Layer

```
class tensorlayer.layers.DropconnectDenseLayer (prev_layer,                keep=0.5,
                                                n_units=100,                act=None,
                                                W_init=<sphinx.ext.autodoc.importer._MockObject
                                                object>,
                                                b_init=<sphinx.ext.autodoc.importer._MockObject
                                                object>,                W_init_args=None,
                                                b_init_args=None,
                                                name='dropconnect_layer')
```

The *DropconnectDenseLayer* class is *DenseLayer* with DropConnect behaviour which randomly re-moves connections between this layer and the previous layer according to a keeping probability.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **keep** (*float*) – The keeping probability. The lower the probability it is, the more activations are set to zero.
- **n\_units** (*int*) – The number of units of this layer.
- **act** (*activation function*) – The activation function of this layer.
- **W\_init** (*weights initializer*) – The initializer for the weight matrix.
- **b\_init** (*biases initializer*) – The initializer for the bias vector.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> net = tl.layers.InputLayer(x, name='input_layer')
>>> net = tl.layers.DropconnectDenseLayer(net, keep=0.8,
...   n_units=800, act=tf.nn.relu, name='relu1')
>>> net = tl.layers.DropconnectDenseLayer(net, keep=0.5,
...   n_units=800, act=tf.nn.relu, name='relu2')
>>> net = tl.layers.DropconnectDenseLayer(net, keep=0.5,
...   n_units=10, name='output')
```

## References

- Wan, L. (2013). Regularization of neural networks using dropconnect

## 2.8.10 Dropout Layers

**class** `tensorlayer.layers.DropoutLayer` (*prev\_layer*, *keep*=0.5, *is\_fix*=False, *is\_train*=True, *seed*=None, *name*='dropout\_layer')

The *DropoutLayer* class is a noise layer which randomly set some activations to zero according to a keeping probability.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **keep** (*float*) – The keeping probability. The lower the probability it is, the more activations are set to zero.
- **is\_fix** (*boolean*) – Fixing probability or nor. Default is False. If True, the keeping probability is fixed and cannot be changed via *feed\_dict*.
- **is\_train** (*boolean*) – Trainable or not. If False, skip this layer. Default is True.
- **seed** (*int* or *None*) – The seed for random dropout.
- **name** (*str*) – A unique layer name.

### Examples

Method 1: Using `all_drop` see `tutorial_mlp_dropout1.py`

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> net = tl.layers.InputLayer(x, name='input_layer')
>>> net = tl.layers.DropoutLayer(net, keep=0.8, name='drop1')
>>> net = tl.layers.DenseLayer(net, n_units=800, act=tf.nn.relu, name='relu1')
>>> ...
>>> # For training, enable dropout as follow.
>>> feed_dict = {x: X_train_a, y_: y_train_a}
>>> feed_dict.update( net.all_drop ) # enable noise layers
>>> sess.run(train_op, feed_dict=feed_dict)
>>> ...
>>> # For testing, disable dropout as follow.
>>> dp_dict = tl.utils.dict_to_one( net.all_drop ) # disable noise layers
>>> feed_dict = {x: X_val_a, y_: y_val_a}
>>> feed_dict.update(dp_dict)
>>> err, ac = sess.run([cost, acc], feed_dict=feed_dict)
>>> ...
```

Method 2: Without using `all_drop` see `tutorial_mlp_dropout2.py`

```
>>> def mlp(x, is_train=True, reuse=False):
>>>     with tf.variable_scope("MLP", reuse=reuse):
>>>         tl.layers.set_name_reuse(reuse)
>>>         net = tl.layers.InputLayer(x, name='input')
>>>         net = tl.layers.DropoutLayer(net, keep=0.8, is_fix=True,
>>>                                     is_train=is_train, name='drop1')
>>>         ...
>>>     return net
```

```
>>> net_train = mlp(x, is_train=True, reuse=False)
>>> net_test = mlp(x, is_train=False, reuse=True)
```

## 2.8.11 Extend Layers

### Expand Dims Layer

**class** `tensorlayer.layers.ExpandDimsLayer` (*prev\_layer*, *axis*, *name*='expand\_dims')

The *ExpandDimsLayer* class inserts a dimension of 1 into a tensor's shape, see `tf.expand_dims()` .

#### Parameters

- **prev\_layer** (*Layer*) – The previous layer.
- **axis** (*int*) – The dimension index at which to expand the shape of input.
- **name** (*str*) – A unique layer name.

#### Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, (None, 100))
>>> n = tl.layers.InputLayer(x, name='in')
>>> n = tl.layers.ExpandDimsLayer(n, 2)
[None, 100, 1]
```

### Tile layer

**class** `tensorlayer.layers.TileLayer` (*prev\_layer*, *multiples*=None, *name*='tile')

The *TileLayer* class constructs a tensor by tiling a given tensor, see `tf.tile()` .

#### Parameters

- **prev\_layer** (*Layer*) – The previous layer.
- **multiples** (*tensor*) – Must be one of the following types: int32, int64. 1-D Length must be the same as the number of dimensions in input.
- **name** (*str*) – A unique layer name.

#### Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, (None, 100))
>>> n = tl.layers.InputLayer(x, name='in')
>>> n = tl.layers.ExpandDimsLayer(n, 2)
>>> n = tl.layers.TileLayer(n, [-1, 1, 3])
[None, 100, 3]
```

## 2.8.12 External Libraries Layers

### TF-Slim Layer

TF-Slim models can be connected into TensorLayer. All Google's Pre-trained model can be used easily , see [Slim-model](#).

```
class tensorlayer.layers.SlimNetsLayer (prev_layer, slim_layer, slim_args=None,  
                                         name='tfslim_layer')
```

A layer that merges TF-Slim models into TensorLayer.

Models can be found in [slim-model](#), see Inception V3 example on [Github](#).

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **slim\_layer** (*a slim network function*) – The network you want to stack onto, end with `return net, end_points`.
- **slim\_args** (*dictionary*) – The arguments for the slim model.
- **name** (*str*) – A unique layer name.

#### Notes

- As TF-Slim stores the layers as dictionary, the `all_layers` in this network is not in order ! Fortunately, the `all_params` are in order.

## 2.8.13 Flow Control Layer

```
class tensorlayer.layers.MultiplexerLayer (layers, name='mux_layer')
```

The *MultiplexerLayer* selects inputs to be forwarded to output. see *tutorial\_mnist\_multiplexer.py*.

#### Parameters

- **layers** (a list of *Layer*) – The input layers.
- **name** (*str*) – A unique layer name.

**sel**

*placeholder* – The placeholder takes an integer for selecting which layer to output.

#### Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, shape=(None, 784), name='x')
>>> # define the network
>>> net_in = tl.layers.InputLayer(x, name='input')
>>> net_in = tl.layers.DropoutLayer(net_in, keep=0.8, name='drop1')
>>> # net 0
>>> net_0 = tl.layers.DenseLayer(net_in, n_units=800, act=tf.nn.relu, name='net0/
↳relu1')
>>> net_0 = tl.layers.DropoutLayer(net_0, keep=0.5, name='net0/drop2')
>>> net_0 = tl.layers.DenseLayer(net_0, n_units=800, act=tf.nn.relu, name='net0/
↳relu2')
>>> # net 1
>>> net_1 = tl.layers.DenseLayer(net_in, n_units=800, act=tf.nn.relu, name='net1/
↳relu1')
>>> net_1 = tl.layers.DropoutLayer(net_1, keep=0.8, name='net1/drop2')
>>> net_1 = tl.layers.DenseLayer(net_1, n_units=800, act=tf.nn.relu, name='net1/
↳relu2')
>>> net_1 = tl.layers.DropoutLayer(net_1, keep=0.8, name='net1/drop3')
```

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```

>>> net_1 = tl.layers.DenseLayer(net_1, n_units=800, act=tf.nn.relu, name='net1/
↳relu3')
>>> # multiplexer
>>> net_mux = tl.layers.MultiplexerLayer(layers=[net_0, net_1], name='mux')
>>> network = tl.layers.ReshapeLayer(net_mux, shape=(-1, 800), name='reshape')
>>> network = tl.layers.DropoutLayer(network, keep=0.5, name='drop3')
>>> # output layer
>>> network = tl.layers.DenseLayer(network, n_units=10, act=None, name='output')

```

## 2.8.14 Image Resampling Layers

### 2D UpSampling

```

class tensorlayer.layers.UpSampling2dLayer (prev_layer,          size,          is_scale=True,
                                             method=0,          align_corners=False,
                                             name='upsample2d_layer')

```

The `UpSampling2dLayer` class is a up-sampling 2D layer.

See `tf.image.resize_images`.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer with 4-D Tensor of the shape (batch, height, width, channels) or 3-D Tensor of the shape (height, width, channels).
- **size** (*tuple of int/float*) – (height, width) scale factor or new size of height and width.
- **is\_scale** (*boolean*) – If True (default), the *size* is a scale factor; otherwise, the *size* is the numbers of pixels of height and width.
- **method** (*int*) –

The resize method selected through the index. Defaults index is 0 which is `ResizeMethod.BILINEAR`.

- Index 0 is `ResizeMethod.BILINEAR`, Bilinear interpolation.
- Index 1 is `ResizeMethod.NEAREST_NEIGHBOR`, Nearest neighbor interpolation.
- Index 2 is `ResizeMethod.BICUBIC`, Bicubic interpolation.
- Index 3 `ResizeMethod.AREA`, Area interpolation.
- **align\_corners** (*boolean*) – If True, align the corners of the input and output. Default is False.
- **name** (*str*) – A unique layer name.

### 2D DownSampling

```

class tensorlayer.layers.DownSampling2dLayer (prev_layer,          size,          is_scale=True,
                                              method=0,          align_corners=False,
                                              name='downsample2d_layer')

```

The `DownSampling2dLayer` class is down-sampling 2D layer.

See `tf.image.resize_images`.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer with 4-D Tensor in the shape of (batch, height, width, channels) or 3-D Tensor in the shape of (height, width, channels).
- **size** (*tuple of int/float*) – (height, width) scale factor or new size of height and width.
- **is\_scale** (*boolean*) – If True (default), the *size* is the scale factor; otherwise, the *size* are numbers of pixels of height and width.
- **method** (*int*) –

The resize method selected through the index. Defaults index is 0 which is `ResizeMethod.BILINEAR`.

- Index 0 is `ResizeMethod.BILINEAR`, Bilinear interpolation.
- Index 1 is `ResizeMethod.NEAREST_NEIGHBOR`, Nearest neighbor interpolation.
- Index 2 is `ResizeMethod.BICUBIC`, Bicubic interpolation.
- Index 3 `ResizeMethod.AREA`, Area interpolation.
- **align\_corners** (*boolean*) – If True, exactly align all 4 corners of the input and output. Default is False.
- **name** (*str*) – A unique layer name.

## 2.8.15 Lambda Layers

### Lambda Layer

**class** `tensorlayer.layers.LambdaLayer` (*prev\_layer, fn, fn\_args=None, name='lambda\_layer'*)

A layer that takes a user-defined function using TensorFlow Lambda, for multiple inputs see [ElementwiseLambdaLayer](#).

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **fn** (*function*) – The function that applies to the outputs of previous layer.
- **fn\_args** (*dictionary or None*) – The arguments for the function (option).
- **name** (*str*) – A unique layer name.

### Examples

Non-parametric case

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, shape=[None, 1], name='x')
>>> net = tl.layers.InputLayer(x, name='input')
>>> net = tl.layers.LambdaLayer(net, lambda x: 2*x, name='lambda')
```

Parametric case, merge other wrappers into `TensorLayer`

```
>>> from keras.layers import *
>>> from tensorlayer.layers import *
>>> def keras_block(x):
>>>     x = Dropout(0.8)(x)
>>>     x = Dense(800, activation='relu')(x)
>>>     x = Dropout(0.5)(x)
>>>     x = Dense(800, activation='relu')(x)
>>>     x = Dropout(0.5)(x)
>>>     logits = Dense(10, activation='linear')(x)
>>>     return logits
>>> net = InputLayer(x, name='input')
>>> net = LambdaLayer(net, fn=keras_block, name='keras')
```

## ElementWise Lambda Layer

**class** tensorlayer.layers.**ElementwiseLambdaLayer**(*layers, fn, fn\_args=None, act=None, name='elementwiselambda\_layer'*)

A layer that use a custom function to combine multiple *Layer* inputs.

### Parameters

- **layers** (list of *Layer*) – The list of layers to combine.
- **fn** (*function*) – The function that applies to the outputs of previous layer.
- **fn\_args** (*dictionary or None*) – The arguments for the function (option).
- **act** (*activation function*) – The activation function of this layer.
- **name** (*str*) – A unique layer name.

## Examples

$z = \text{mean} + \text{noise} * \text{tf.exp}(\text{std} * 0.5)$

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
```

```
>>> def func(noise, mean, std):
>>>     return mean + noise * tf.exp(std * 0.5)
```

```
>>> x = tf.placeholder(tf.float32, [None, 200])
>>> noise_tensor = tf.random_normal(tf.stack([tf.shape(x)[0], 200]))
>>> noise = tl.layers.InputLayer(noise_tensor)
>>> net = tl.layers.InputLayer(x)
>>> net = tl.layers.DenseLayer(net, n_units=200, act=tf.nn.relu, name='dense1')
>>> mean = tl.layers.DenseLayer(net, n_units=200, name='mean')
>>> std = tl.layers.DenseLayer(net, n_units=200, name='std')
>>> z = tl.layers.ElementwiseLambdaLayer([noise, mean, std], fn=func, name='z')
```



## 2.8.16 Merge Layers

### Concat Layer

**class** `tensorlayer.layers.ConcatLayer` (*prev\_layer*, *concat\_dim=-1*, *name='concat\_layer'*)

A layer that concatenates multiple tensors according to given axis.

#### Parameters

- **prev\_layer** (list of *Layer*) – List of layers to concatenate.
- **concat\_dim** (*int*) – The dimension to concatenate.
- **name** (*str*) – A unique layer name.

#### Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> sess = tf.InteractiveSession()
>>> x = tf.placeholder(tf.float32, shape=[None, 784])
>>> inputs = tl.layers.InputLayer(x, name='input_layer')
[TL]   InputLayer input_layer (?, 784)
>>> net1 = tl.layers.DenseLayer(inputs, 800, act=tf.nn.relu, name='relu1_1')
[TL]   DenseLayer relu1_1: 800, relu
>>> net2 = tl.layers.DenseLayer(inputs, 300, act=tf.nn.relu, name='relu2_1')
[TL]   DenseLayer relu2_1: 300, relu
>>> net = tl.layers.ConcatLayer([net1, net2], 1, name='concat_layer')
[TL]   ConcatLayer concat_layer, 1100
>>> tl.layers.initialize_global_variables(sess)
>>> net.print_params()
[TL]   param 0: relu1_1/W:0          (784, 800)          float32_ref
[TL]   param 1: relu1_1/b:0          (800,)              float32_ref
[TL]   param 2: relu2_1/W:0          (784, 300)          float32_ref
[TL]   param 3: relu2_1/b:0          (300,)              float32_ref
      num of params: 863500
>>> net.print_layers()
[TL]   layer 0: relu1_1/Relu:0        (?, 800)             float32
[TL]   layer 1: relu2_1/Relu:0        (?, 300)             float32
[TL]   layer 2: concat_layer:0        (?, 1100)            float32
```

### ElementWise Layer

**class** `tensorlayer.layers.ElementwiseLayer` (*prev\_layer*, *combine\_fn=<sphinx.ext.autodoc.importer.\_MockObject object>*, *act=None*, *name='elementwise\_layer'*)

A layer that combines multiple *Layer* that have the same output shapes according to an element-wise operation.

#### Parameters

- **prev\_layer** (list of *Layer*) – The list of layers to combine.
- **combine\_fn** (a *TensorFlow* element-wise combine function) – e.g. AND is `tf.minimum`; OR is `tf.maximum`; ADD is `tf.add`; MUL is `tf.multiply` and so on. See [TensorFlow Math API](#).

- **act** (*activation function*) – The activation function of this layer.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, shape=[None, 784])
>>> inputs = tl.layers.InputLayer(x, name='input_layer')
>>> net_0 = tl.layers.DenseLayer(inputs, n_units=500, act=tf.nn.relu, name='net_0
↳')
>>> net_1 = tl.layers.DenseLayer(inputs, n_units=500, act=tf.nn.relu, name='net_1
↳')
>>> net = tl.layers.ElementwiseLayer([net_0, net_1], combine_fn=tf.minimum, name=
↳'minimum')
>>> net.print_params(False)
[TL]   param   0: net_0/W:0                (784, 500)          float32_ref
[TL]   param   1: net_0/b:0                (500,)             float32_ref
[TL]   param   2: net_1/W:0                (784, 500)          float32_ref
[TL]   param   3: net_1/b:0                (500,)             float32_ref
>>> net.print_layers()
[TL]   layer   0: net_0/Relu:0              (?, 500)            float32
[TL]   layer   1: net_1/Relu:0              (?, 500)            float32
[TL]   layer   2: minimum:0                 (?, 500)            float32
```

## 2.8.17 Noise Layer

```
class tensorlayer.layers.GaussianNoiseLayer(prev_layer, mean=0.0, std-
dev=1.0, is_train=True, seed=None,
name='gaussian_noise_layer')
```

The *GaussianNoiseLayer* class is noise layer that adding noise with gaussian distribution to the activation.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **mean** (*float*) – The mean. Default is 0.
- **stddev** (*float*) – The standard deviation. Default is 1.
- **is\_train** (*boolean*) – Is trainable layer. If False, skip this layer. default is True.
- **seed** (*int or None*) – The seed for random noise.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, shape=(100, 784))
>>> net = tl.layers.InputLayer(x, name='input')
>>> net = tl.layers.DenseLayer(net, n_units=100, act=tf.nn.relu, name='dense3')
>>> net = tl.layers.GaussianNoiseLayer(net, name='gaussian')
(64, 100)
```

## 2.8.18 Normalization Layers

For local response normalization as it does not have any weights and arguments, you can also apply `tf.nn.lrn` on `network.outputs`.

### Batch Normalization

```
class tensorlayer.layers.BatchNormLayer (prev_layer, decay=0.9, epsilon=1e-05, act=None, is_train=False, beta_init=<sphinx.ext.autodoc.importer._MockObject object>, gamma_init=<sphinx.ext.autodoc.importer._MockObject object>, moving_mean_init=<sphinx.ext.autodoc.importer._MockObject object>, data_format='channels_last', name='batchnorm_layer')
```

The *BatchNormLayer* is a batch normalization layer for both fully-connected and convolution outputs. See `tf.nn.batch_normalization` and `tf.nn.moments`.

#### Parameters

- **prev\_layer** (*Layer*) – The previous layer.
- **decay** (*float*) – A decay factor for *ExponentialMovingAverage*. Suggest to use a large value for large dataset.
- **epsilon** (*float*) – Epsilon.
- **act** (*activation function*) – The activation function of this layer.
- **is\_train** (*boolean*) – Is being used for training or inference.
- **beta\_init** (*initializer or None*) – The initializer for initializing beta, if None, skip beta. Usually you should not skip beta unless you know what happened.
- **gamma\_init** (*initializer or None*) – The initializer for initializing gamma, if None, skip gamma. When the batch normalization layer is use instead of ‘biases’, or the next layer is linear, this can be disabled since the scaling can be done by the next layer. see [Inception-ResNet-v2](#)
- **name** (*str*) – A unique layer name.

#### References

- [Source](#)
- [stackoverflow](#)

### Local Response Normalization

```
class tensorlayer.layers.LocalResponseNormLayer (prev_layer, depth_radius=None, bias=None, alpha=None, beta=None, name='lrn_layer')
```

The *LocalResponseNormLayer* layer is for Local Response Normalization. See `tf.nn.local_response_normalization` or `tf.nn.lrn` for new TF version. The 4-D input tensor is a 3-D array of 1-D vectors (along the last dimension), and each vector is normalized independently. Within a given vector, each component is divided by the weighted square-sum of inputs within `depth_radius`.

#### Parameters

- **prev\_layer** (*Layer*) – The previous layer with a 4D output shape.
- **depth\_radius** (*int*) – Depth radius. 0-D. Half-width of the 1-D normalization window.
- **bias** (*float*) – An offset which is usually positive and shall avoid dividing by 0.
- **alpha** (*float*) – A scale factor which is usually positive.
- **beta** (*float*) – An exponent.
- **name** (*str*) – A unique layer name.

## Instance Normalization

```
class tensorlayer.layers.InstanceNormLayer (prev_layer,      act=None,      epsilon=1e-05,
                                             name='instan_norm')
```

The *InstanceNormLayer* class is a for instance normalization.

### Parameters

- **prev\_layer** (*Layer*) – The previous layer.
- **act** (*activation function*.) – The activation function of this layer.
- **epsilon** (*float*) – Epsilon.
- **name** (*str*) – A unique layer name

## Layer Normalization

```
class tensorlayer.layers.LayerNormLayer (prev_layer, center=True, scale=True, act=None,
                                          reuse=None,      variables_collections=None,
                                          outputs_collections=None,      trainable=True,
                                          begin_norm_axis=1,      begin_params_axis=-1,
                                          name='layernorm')
```

The *LayerNormLayer* class is for layer normalization, see [tf.contrib.layers.layer\\_norm](#).

### Parameters

- **prev\_layer** (*Layer*) – The previous layer.
- **act** (*activation function*) – The activation function of this layer.
- **others** – [tf.contrib.layers.layer\\_norm](#).

## Group Normalization

```
class tensorlayer.layers.GroupNormLayer (prev_layer,      groups=32,      epsilon=1e-06,
                                          act=None,      data_format='channels_last',
                                          name='groupnorm')
```

The *GroupNormLayer* layer is for Group Normalization. See [tf.contrib.layers.group\\_norm](#).

### Parameters

- **prev\_layer** (*Layer*) – The previous layer.
- **act** (*activation function*) – The activation function of this layer.
- **epsilon** (*float*) – Epsilon.
- **name** (*str*) – A unique layer name

## Switch Normalization

```
class tensorlayer.layers.SwitchNormLayer (prev_layer,      act=None,      epsilon=1e-05,
                                           beta_init=<sphinx.ext.autodoc.importer._MockObject
                                           object>, gamma_init=<sphinx.ext.autodoc.importer._MockObject
                                           object>, moving_mean_init=<sphinx.ext.autodoc.importer._MockObject
                                           object>, name='switchnorm_layer')
```

The *SwitchNormLayer* is a switchable normalization.

### Parameters

- **prev\_layer** (*Layer*) – The previous layer.
- **act** (*activation function*) – The activation function of this layer.
- **epsilon** (*float*) – Epsilon.
- **beta\_init** (*initializer or None*) – The initializer for initializing beta, if None, skip beta. Usually you should not skip beta unless you know what happened.
- **gamma\_init** (*initializer or None*) – The initializer for initializing gamma, if None, skip gamma. When the batch normalization layer is use instead of ‘biases’, or the next layer is linear, this can be disabled since the scaling can be done by the next layer. see [Inception-ResNet-v2](#)
- **name** (*str*) – A unique layer name.

### References

- [Differentiable Learning-to-Normalize via Switchable Normalization](#)
- [Zhihu \(CN\)](#)

## 2.8.19 Object Detection Layer

```
class tensorlayer.layers.ROIPOOLingLayer (prev_layer, rois, pool_height=2, pool_width=2,
                                           name='roipooling_layer')
```

The region of interest pooling layer.

### Parameters

- **prev\_layer** (*Layer*) – The previous layer.
- **rois** (*tuple of int*) – Regions of interest in the format of (feature map index, upper left, bottom right).
- **pool\_width** (*int*) – The size of the pooling sections.
- **pool\_height** – The size of the pooling sections.
- **name** (*str*) – A unique layer name.

### Notes

- This implementation is imported from [Deepsense-AI](#).
- Please install it by the instruction [HERE](#).

## 2.8.20 Padding Layers

### Pad Layer (Expert API)

Padding layer for any modes.

```
class tensorlayer.layers.PadLayer (prev_layer, padding=None, mode='CONSTANT',  
                                     name='pad_layer')
```

The *PadLayer* class is a padding layer for any mode and dimension. Please see [tf.pad](#) for usage.

#### Parameters

- **prev\_layer** (*Layer*) – The previous layer.
- **padding** (*list of lists of 2 ints, or a Tensor of type int32.*) – The int32 values to pad.
- **mode** (*str*) – “CONSTANT”, “REFLECT”, or “SYMMETRIC” (case-insensitive).
- **name** (*str*) – A unique layer name.

#### Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> images = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> net = tl.layers.InputLayer(images, name='in')
>>> net = tl.layers.PadLayer(net, [[0, 0], [3, 3], [3, 3], [0, 0]], "REFLECT",  
↪ name='inpad')
```

### 1D Zero padding

```
class tensorlayer.layers.ZeroPad1d (prev_layer, padding, name='zeropad1d')
```

The *ZeroPad1d* class is a 1D padding layer for signal [batch, length, channel].

#### Parameters

- **prev\_layer** (*Layer*) – The previous layer.
- **padding** (*int, or tuple of 2 ints*) –
  - If int, zeros to add at the beginning and end of the padding dimension (axis 1).
  - If tuple of 2 ints, zeros to add at the beginning and at the end of the padding dimension.
- **name** (*str*) – A unique layer name.

### 2D Zero padding

```
class tensorlayer.layers.ZeroPad2d (prev_layer, padding, name='zeropad2d')
```

The *ZeroPad2d* class is a 2D padding layer for image [batch, height, width, channel].

#### Parameters

- **prev\_layer** (*Layer*) – The previous layer.
- **padding** (*int, or tuple of 2 ints, or tuple of 2 tuples of 2 ints.*) –

- If int, the same symmetric padding is applied to width and height.
- If tuple of 2 ints, interpreted as two different symmetric padding values for height and width as (`symmetric_height_pad`, `symmetric_width_pad`).
- If tuple of 2 tuples of 2 ints, interpreted as ((`top_pad`, `bottom_pad`), (`left_pad`, `right_pad`)).
- **name** (*str*) – A unique layer name.

### 3D Zero padding

**class** `tensorlayer.layers.ZeroPad3d` (*prev\_layer*, *padding*, *name*='zeropad3d')

The *ZeroPad3d* class is a 3D padding layer for volume [batch, depth, height, width, channel].

#### Parameters

- **prev\_layer** (*Layer*) – The previous layer.
- **padding** (*int*, or *tuple of 2 ints*, or *tuple of 2 tuples of 2 ints*.) –
  - If int, the same symmetric padding is applied to width and height.
  - If tuple of 2 ints, interpreted as two different symmetric padding values for height and width as (`symmetric_dim1_pad`, `symmetric_dim2_pad`, `symmetric_dim3_pad`).
  - If tuple of 2 tuples of 2 ints, interpreted as ((`left_dim1_pad`, `right_dim1_pad`), (`left_dim2_pad`, `right_dim2_pad`), (`left_dim3_pad`, `right_dim3_pad`)).
- **name** (*str*) – A unique layer name.

## 2.8.21 Pooling Layers

### Pool Layer (Expert API)

Pooling layer for any dimensions and any pooling functions.

**class** `tensorlayer.layers.PoolLayer` (*prev\_layer*, *ksize*=(1, 2, 2, 1), *strides*=(1, 2, 2, 1), *padding*='SAME', *pool*=`<sphinx.ext.autodoc.importer.MockObject object>`, *name*='pool\_layer')

The *PoolLayer* class is a Pooling layer. You can choose `tf.nn.max_pool` and `tf.nn.avg_pool` for 2D input or `tf.nn.max_pool3d` and `tf.nn.avg_pool3d` for 3D input.

#### Parameters

- **prev\_layer** (*Layer*) – The previous layer.
- **ksize** (*tuple of int*) – The size of the window for each dimension of the input tensor. Note that: `len(ksize) >= 4`.
- **strides** (*tuple of int*) – The stride of the sliding window for each dimension of the input tensor. Note that: `len(strides) >= 4`.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **pool** (*pooling function*) – One of `tf.nn.max_pool`, `tf.nn.avg_pool`, `tf.nn.max_pool3d` and `tf.nn.avg_pool3d`. See [TensorFlow pooling APIs](#)

- **name** (*str*) – A unique layer name.

## Examples

- see [Conv2dLayer](#).

## 1D Max pooling

```
class tensorlayer.layers.MaxPool1d(prev_layer, filter_size=3, strides=2, padding='valid',  
                                     data_format='channels_last', name='maxpool1d')
```

Max pooling for 1D signal.

### Parameters

- **prev\_layer** (*Layer*) – The previous layer with a output rank as 3 [batch, length, channel].
- **filter\_size** (*tuple of int*) – Pooling window size.
- **strides** (*tuple of int*) – Strides of the pooling operation.
- **padding** (*str*) – The padding method: 'valid' or 'same'.
- **data\_format** (*str*) – One of channels\_last (default, [batch, length, channel]) or channels\_first. The ordering of the dimensions in the inputs.
- **name** (*str*) – A unique layer name.

## 1D Mean pooling

```
class tensorlayer.layers.MeanPool1d(prev_layer, filter_size=3, strides=2, padding='valid',  
                                       data_format='channels_last', name='meanpool1d')
```

Mean pooling for 1D signal.

### Parameters

- **prev\_layer** (*Layer*) – The previous layer with a output rank as 3.
- **filter\_size** (*tuple of int*) – Pooling window size.
- **strides** (*tuple of int*) – Strides of the pooling operation.
- **padding** (*str*) – The padding method: 'valid' or 'same'.
- **data\_format** (*str*) – One of channels\_last (default, [batch, length, channel]) or channels\_first. The ordering of the dimensions in the inputs.
- **name** (*str*) – A unique layer name.

## 2D Max pooling

```
class tensorlayer.layers.MaxPool2d(prev_layer, filter_size=(3, 3), strides=(2, 2),  
                                     padding='SAME', data_format='channels_last',  
                                     name='maxpool2d')
```

Max pooling for 2D image.

### Parameters

- **prev\_layer** (*Layer*) – The previous layer with a output rank as 4.



- **filter\_size** (*tuple of int*) – (height, width) for filter size.
- **strides** (*tuple of int*) – (height, width) for strides.
- **padding** (*str*) – The padding method: ‘valid’ or ‘same’.
- **data\_format** (*str*) – One of channels\_last (default, [batch, height, width, channel]) or channels\_first. The ordering of the dimensions in the inputs.
- **name** (*str*) – A unique layer name.

## 2D Mean pooling

```
class tensorlayer.layers.MeanPool2d(prev_layer, filter_size=(3, 3), strides=(2, 2),
                                     padding='SAME', data_format='channels_last',
                                     name='meanpool2d')
```

Mean pooling for 2D image [batch, height, width, channel].

### Parameters

- **prev\_layer** (*Layer*) – The previous layer with a output rank as 4 [batch, height, width, channel].
- **filter\_size** (*tuple of int*) – (height, width) for filter size.
- **strides** (*tuple of int*) – (height, width) for strides.
- **padding** (*str*) – The padding method: ‘valid’ or ‘same’.
- **data\_format** (*str*) – One of channels\_last (default, [batch, height, width, channel]) or channels\_first. The ordering of the dimensions in the inputs.
- **name** (*str*) – A unique layer name.

## 3D Max pooling

```
class tensorlayer.layers.MaxPool3d(prev_layer, filter_size=(3, 3, 3), strides=(2, 2, 2),
                                     padding='valid', data_format='channels_last',
                                     name='maxpool3d')
```

Max pooling for 3D volume.

### Parameters

- **prev\_layer** (*Layer*) – The previous layer with a output rank as 5.
- **filter\_size** (*tuple of int*) – Pooling window size.
- **strides** (*tuple of int*) – Strides of the pooling operation.
- **padding** (*str*) – The padding method: ‘valid’ or ‘same’.
- **data\_format** (*str*) – One of channels\_last (default, [batch, depth, height, width, channel]) or channels\_first. The ordering of the dimensions in the inputs.
- **name** (*str*) – A unique layer name.

**Returns** A max pooling 3-D layer with a output rank as 5.

**Return type** *Layer*

### 3D Mean pooling

```
class tensorlayer.layers.MeanPool3d(prev_layer, filter_size=(3, 3, 3), strides=(2, 2, 2), padding='valid', data_format='channels_last', name='meanpool3d')
```

Mean pooling for 3D volume.

#### Parameters

- **prev\_layer** (*Layer*) – The previous layer with a output rank as 5.
- **filter\_size** (*tuple of int*) – Pooling window size.
- **strides** (*tuple of int*) – Strides of the pooling operation.
- **padding** (*str*) – The padding method: 'valid' or 'same'.
- **data\_format** (*str*) – One of channels\_last (default, [batch, depth, height, width, channel]) or channels\_first. The ordering of the dimensions in the inputs.
- **name** (*str*) – A unique layer name.

**Returns** A mean pooling 3-D layer with a output rank as 5.

**Return type** *Layer*

### 1D Global Max pooling

```
class tensorlayer.layers.GlobalMaxPool1d(prev_layer, data_format='channels_last', name='globalmaxpool1d')
```

The *GlobalMaxPool1d* class is a 1D Global Max Pooling layer.

#### Parameters

- **prev\_layer** (*Layer*) – The previous layer with a output rank as 3 [batch, length, channel].
- **data\_format** (*str*) – One of channels\_last (default, [batch, length, channel]) or channels\_first. The ordering of the dimensions in the inputs.
- **name** (*str*) – A unique layer name.

#### Examples

```
>>> x = tf.placeholder("float32", [None, 100, 30])
>>> n = InputLayer(x, name='in')
>>> n = GlobalMaxPool1d(n)
[None, 30]
```

### 1D Global Mean pooling

```
class tensorlayer.layers.GlobalMeanPool1d(prev_layer, data_format='channels_last', name='globalmeanpool1d')
```

The *GlobalMeanPool1d* class is a 1D Global Mean Pooling layer.

#### Parameters

- **prev\_layer** (*Layer*) – The previous layer with a output rank as 3 [batch, length, channel].

- **data\_format** (*str*) – One of channels\_last (default, [batch, length, channel]) or channels\_first. The ordering of the dimensions in the inputs.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder("float32", [None, 100, 30])
>>> n = tl.layers.InputLayer(x, name='in')
>>> n = tl.layers.GlobalMeanPool1d(n)
[None, 30]
```

## 2D Global Max pooling

```
class tensorlayer.layers.GlobalMaxPool2d(prev_layer, data_format='channels_last',
                                           name='globalmaxpool2d')
```

The *GlobalMaxPool2d* class is a 2D Global Max Pooling layer.

### Parameters

- **prev\_layer** (*Layer*) – The previous layer with a output rank as 4 [batch, height, width, channel].
- **data\_format** (*str*) – One of channels\_last (default, [batch, height, width, channel]) or channels\_first. The ordering of the dimensions in the inputs.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder("float32", [None, 100, 100, 30])
>>> n = tl.layers.InputLayer(x, name='in2')
>>> n = tl.layers.GlobalMaxPool2d(n)
[None, 30]
```

## 2D Global Mean pooling

```
class tensorlayer.layers.GlobalMeanPool2d(prev_layer, data_format='channels_last',
                                           name='globalmeanpool2d')
```

The *GlobalMeanPool2d* class is a 2D Global Mean Pooling layer.

### Parameters

- **prev\_layer** (*Layer*) – The previous layer with a output rank as 4 [batch, height, width, channel].
- **data\_format** (*str*) – One of channels\_last (default, [batch, height, width, channel]) or channels\_first. The ordering of the dimensions in the inputs.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder("float32", [None, 100, 100, 30])
>>> n = tl.layers.InputLayer(x, name='in2')
>>> n = tl.layers.GlobalMeanPool2d(n)
[None, 30]
```

## 3D Global Max pooling

```
class tensorlayer.layers.GlobalMaxPool3d(prev_layer, data_format='channels_last',
                                           name='globalmaxpool3d')
```

The *GlobalMaxPool3d* class is a 3D Global Max Pooling layer.

### Parameters

- **prev\_layer** (*Layer*) – The previous layer with a output rank as 5 [batch, depth, height, width, channel].
- **data\_format** (*str*) – One of channels\_last (default, [batch, depth, height, width, channel]) or channels\_first. The ordering of the dimensions in the inputs.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder("float32", [None, 100, 100, 100, 30])
>>> n = tl.layers.InputLayer(x, name='in')
>>> n = tl.layers.GlobalMaxPool3d(n)
[None, 30]
```

## 3D Global Mean pooling

```
class tensorlayer.layers.GlobalMeanPool3d(prev_layer, data_format='channels_last',
                                           name='globalmeanpool3d')
```

The *GlobalMeanPool3d* class is a 3D Global Mean Pooling layer.

### Parameters

- **prev\_layer** (*Layer*) – The previous layer with a output rank as 5 [batch, depth, height, width, channel].
- **data\_format** (*str*) – One of channels\_last (default, [batch, depth, height, width, channel]) or channels\_first. The ordering of the dimensions in the inputs.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder("float32", [None, 100, 100, 100, 30])
>>> n = tl.layers.InputLayer(x, name='in')
>>> n = tl.layers.GlobalMeanPool2d(n)
[None, 30]
```

## 2.8.22 Quantized Nets

This is an experimental API package for building Quantized Neural Networks. We are using matrix multiplication rather than add-minus and bit-count operation at the moment. Therefore, these APIs would not speed up the inferencing, for production, you can train model via TensorLayer and deploy the model into other customized C/C++ implementation (We probably provide users an extra C/C++ binary net framework that can load model from TensorLayer).

Note that, these experimental APIs can be changed in the future

### Sign

**class** `tensorlayer.layers.SignLayer` (*prev\_layer*, *name='sign'*)

The *SignLayer* class is for quantizing the layer outputs to -1 or 1 while inferencing.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **name** (*a str*) – A unique layer name.

### Scale

**class** `tensorlayer.layers.ScaleLayer` (*prev\_layer*, *init\_scale=0.05*, *name='scale'*)

The *AddScaleLayer* class is for multiplying a trainable scale value to the layer outputs. Usually be used on the output of binary net.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **init\_scale** (*float*) – The initial value for the scale factor.
- **name** (*a str*) – A unique layer name.

### Binary Dense Layer

**class** `tensorlayer.layers.BinaryDenseLayer` (*prev\_layer*, *n\_units=100*, *act=None*, *use\_gemm=False*, *W\_init=<sphinx.ext.autodoc.importer.\_MockObject object>*, *b\_init=<sphinx.ext.autodoc.importer.\_MockObject object>*, *W\_init\_args=None*, *b\_init\_args=None*, *name='binary\_dense'*)

The *BinaryDenseLayer* class is a binary fully connected layer, which weights are either -1 or 1 while inferencing.

Note that, the bias vector would not be binarized.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **n\_units** (*int*) – The number of units of this layer.
- **act** (*activation function*) – The activation function of this layer, usually set to `tf.act.sign` or apply *SignLayer* after *BatchNormLayer*.
- **use\_gemm** (*boolean*) – If True, use `gemm` instead of `tf.matmul` for inference. (TODO).
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **name** (*a str*) – A unique layer name.

## Binary (De)Convolutions

### BinaryConv2d

```
class tensorlayer.layers.BinaryConv2d(prev_layer, n_filter=32, filter_size=(3, 3), strides=(1, 1), act=None, padding='SAME', use_gemm=False, W_init=<sphinx.ext.autodoc.importer._MockObject object>, b_init=<sphinx.ext.autodoc.importer._MockObject object>, W_init_args=None, b_init_args=None, use_cudnn_on_gpu=None, data_format=None, name='binary_cnn2d')
```

The *BinaryConv2d* class is a 2D binary CNN layer, which weights are either -1 or 1 while inference.

Note that, the bias vector would not be binarized.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **n\_filter** (*int*) – The number of filters.
- **filter\_size** (*tuple of int*) – The filter size (height, width).
- **strides** (*tuple of int*) – The sliding window strides of corresponding input dimensions. It must be in the same order as the `shape` parameter.
- **act** (*activation function*) – The activation function of this layer.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **use\_gemm** (*boolean*) – If True, use `gemm` instead of `tf.matmul` for inference. (TODO).
- **W\_init** (*initializer*) – The initializer for the the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **use\_cudnn\_on\_gpu** (*bool*) – Default is False.

- **data\_format** (*str*) – “NHWC” or “NCHW”, default is “NHWC”.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, [None, 256, 256, 3])
>>> net = tl.layers.InputLayer(x, name='input')
>>> net = tl.layers.BinaryConv2d(net, 32, (5, 5), (1, 1), padding='SAME', name=
↳ 'bcnn1')
>>> net = tl.layers.MaxPool2d(net, (2, 2), (2, 2), padding='SAME', name='pool1')
>>> net = tl.layers.BatchNormLayer(net, act=tl.act.htanh, is_train=True, name='bn1
↳ ')
...
>>> net = tl.layers.SignLayer(net)
>>> net = tl.layers.BinaryConv2d(net, 64, (5, 5), (1, 1), padding='SAME', name=
↳ 'bcnn2')
>>> net = tl.layers.MaxPool2d(net, (2, 2), (2, 2), padding='SAME', name='pool2')
>>> net = tl.layers.BatchNormLayer(net, act=tl.act.htanh, is_train=True, name='bn2
↳ ')
```

## Ternary Dense Layer

### TernaryDenseLayer

```
class tensorlayer.layers.TernaryDenseLayer (prev_layer, n_units=100,
                                             act=None, use_gemm=False,
                                             W_init=<sphinx.ext.autodoc.importer._MockObject
object>, b_init=<sphinx.ext.autodoc.importer._MockObject
object>, W_init_args=None,
                                             b_init_args=None, name='ternary_dense')
```

The *TernaryDenseLayer* class is a ternary fully connected layer, which weights are either -1 or 1 or 0 while inference.

Note that, the bias vector would not be tenaried.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **n\_units** (*int*) – The number of units of this layer.
- **act** (*activation function*) – The activation function of this layer, usually set to `tf.act.sign` or apply *SignLayer* after *BatchNormLayer*.
- **use\_gemm** (*boolean*) – If True, use `gemm` instead of `tf.matmul` for inference. (TODO).
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.

- **name** (*a str*) – A unique layer name.

## Ternary Convolutions

### TernaryConv2d

```
class tensorlayer.layers.TernaryConv2d(prev_layer,          n_filter=32,          filter_size=(3,
3),          strides=(1,          1),          act=None,
padding='SAME',          use_gemm=False,
W_init=<sphinx.ext.autodoc.importer._MockObject
object>, b_init=<sphinx.ext.autodoc.importer._MockObject
object>, W_init_args=None, b_init_args=None,
use_cudnn_on_gpu=None,          data_format=None,
name='ternary_cnn2d')
```

The `TernaryConv2d` class is a 2D binary CNN layer, which weights are either -1 or 1 or 0 while inference.

Note that, the bias vector would not be tenarized.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **n\_filter** (*int*) – The number of filters.
- **filter\_size** (*tuple of int*) – The filter size (height, width).
- **strides** (*tuple of int*) – The sliding window strides of corresponding input dimensions. It must be in the same order as the `shape` parameter.
- **act** (*activation function*) – The activation function of this layer.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **use\_gemm** (*boolean*) – If True, use `gemm` instead of `tf.matmul` for inference. (TODO).
- **W\_init** (*initializer*) – The initializer for the the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **use\_cudnn\_on\_gpu** (*bool*) – Default is False.
- **data\_format** (*str*) – “NHWC” or “NCHW”, default is “NHWC”.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, [None, 256, 256, 3])
>>> net = tl.layers.InputLayer(x, name='input')
>>> net = tl.layers.TernaryConv2d(net, 32, (5, 5), (1, 1), padding='SAME', name=
↪ 'bcnn1')
>>> net = tl.layers.MaxPool2d(net, (2, 2), (2, 2), padding='SAME', name='pool1')
```

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```

>>> net = tl.layers.BatchNormLayer(net, act=tl.act.htanh, is_train=True, name='bn1
↳ ')
...
>>> net = tl.layers.SignLayer(net)
>>> net = tl.layers.TernaryConv2d(net, 64, (5, 5), (1, 1), padding='SAME', name=
↳ 'bcnn2')
>>> net = tl.layers.MaxPool2d(net, (2, 2), (2, 2), padding='SAME', name='pool2')
>>> net = tl.layers.BatchNormLayer(net, act=tl.act.htanh, is_train=True, name='bn2
↳ ')

```

## DoReFa Convolutions

### DorefaConv2d

```

class tensorlayer.layers.DorefaConv2d(prev_layer, bitW=1, bitA=3, n_filter=32, fil-
ter_size=(3, 3), strides=(1, 1), act=None,
padding='SAME', use_gemm=False,
W_init=<sphinx.ext.autodoc.importer._MockObject
object>, b_init=<sphinx.ext.autodoc.importer._MockObject
object>, W_init_args=None, b_init_args=None,
use_cudnn_on_gpu=None, data_format=None,
name='dorefa_cnn2d')

```

The *DorefaConv2d* class is a 2D quantized convolutional layer, which weights are ‘bitW’ bits and the output of the previous layer are ‘bitA’ bits while inferencing.

Note that, the bias vector would not be binarized.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **bitW** (*int*) – The bits of this layer’s parameter
- **bitA** (*int*) – The bits of the output of previous layer
- **n\_filter** (*int*) – The number of filters.
- **filter\_size** (*tuple of int*) – The filter size (height, width).
- **strides** (*tuple of int*) – The sliding window strides of corresponding input dimensions. It must be in the same order as the *shape* parameter.
- **act** (*activation function*) – The activation function of this layer.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **use\_gemm** (*boolean*) – If True, use *gemm* instead of *tf.matmul* for inferencing. (TODO).
- **W\_init** (*initializer*) – The initializer for the the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **use\_cudnn\_on\_gpu** (*bool*) – Default is False.
- **data\_format** (*str*) – “NHWC” or “NCHW”, default is “NHWC”.

- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, [None, 256, 256, 3])
>>> net = tl.layers.InputLayer(x, name='input')
>>> net = tl.layers.DorefaConv2d(net, 32, (5, 5), (1, 1), padding='SAME', name=
↳ 'bcnn1')
>>> net = tl.layers.MaxPool2d(net, (2, 2), (2, 2), padding='SAME', name='pool1')
>>> net = tl.layers.BatchNormLayer(net, act=tl.act.htanh, is_train=True, name='bn1
↳ ')
...
>>> net = tl.layers.SignLayer(net)
>>> net = tl.layers.DorefaConv2d(net, 64, (5, 5), (1, 1), padding='SAME', name=
↳ 'bcnn2')
>>> net = tl.layers.MaxPool2d(net, (2, 2), (2, 2), padding='SAME', name='pool2')
>>> net = tl.layers.BatchNormLayer(net, act=tl.act.htanh, is_train=True, name='bn2
↳ ')
```

## DoReFa Convolutions

### DorefaConv2d

```
class tensorlayer.layers.DorefaConv2d(prev_layer, bitW=1, bitA=3, n_filter=32, filter_size=(3, 3), strides=(1, 1), act=None, padding='SAME', use_gemm=False, W_init=<sphinx.ext.autodoc.importer._MockObject object>, b_init=<sphinx.ext.autodoc.importer._MockObject object>, W_init_args=None, b_init_args=None, use_cudnn_on_gpu=None, data_format=None, name='dorefa_cnn2d')
```

The `DorefaConv2d` class is a 2D quantized convolutional layer, which weights are ‘bitW’ bits and the output of the previous layer are ‘bitA’ bits while inferencing.

Note that, the bias vector would not be binarized.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **bitW** (*int*) – The bits of this layer’s parameter
- **bitA** (*int*) – The bits of the output of previous layer
- **n\_filter** (*int*) – The number of filters.
- **filter\_size** (*tuple of int*) – The filter size (height, width).
- **strides** (*tuple of int*) – The sliding window strides of corresponding input dimensions. It must be in the same order as the shape parameter.
- **act** (*activation function*) – The activation function of this layer.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.

- **use\_gemm** (*boolean*) – If True, use `gemm` instead of `tf.matmul` for inferencing. (TODO).
- **W\_init** (*initializer*) – The initializer for the the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **use\_cudnn\_on\_gpu** (*bool*) – Default is False.
- **data\_format** (*str*) – “NHWC” or “NCHW”, default is “NHWC”.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, [None, 256, 256, 3])
>>> net = tl.layers.InputLayer(x, name='input')
>>> net = tl.layers.DorefaConv2d(net, 32, (5, 5), (1, 1), padding='SAME', name=
↳ 'bcnn1')
>>> net = tl.layers.MaxPool2d(net, (2, 2), (2, 2), padding='SAME', name='pool1')
>>> net = tl.layers.BatchNormLayer(net, act=tl.act.htanh, is_train=True, name='bn1
↳ ')
...
>>> net = tl.layers.SignLayer(net)
>>> net = tl.layers.DorefaConv2d(net, 64, (5, 5), (1, 1), padding='SAME', name=
↳ 'bcnn2')
>>> net = tl.layers.MaxPool2d(net, (2, 2), (2, 2), padding='SAME', name='pool2')
>>> net = tl.layers.BatchNormLayer(net, act=tl.act.htanh, is_train=True, name='bn2
↳ ')
```

## Quantization Dense Layer

### QuanDenseLayer

```
class tensorlayer.layers.QuanDenseLayer (prev_layer,          n_units=100,          act=None,
                                         bitW=8,             bitA=8,             use_gemm=False,
                                         W_init=<sphinx.ext.autodoc.importer._MockObject
object>, b_init=<sphinx.ext.autodoc.importer._MockObject
object>, W_init_args=None, b_init_args=None,
                                         name='quan_dense')
```

The `QuanDenseLayer` class is a quantized fully connected layer with BN, which weights are ‘bitW’ bits and the output of the previous layer are ‘bitA’ bits while inferencing.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **n\_units** (*int*) – The number of units of this layer.
- **act** (*activation function*) – The activation function of this layer.
- **bitW** (*int*) – The bits of this layer’s parameter

- **bitA** (*int*) – The bits of the output of previous layer
- **use\_gemm** (*boolean*) – If True, use gemm instead of `tf.matmul` for inference. (TODO).
- **W\_init** (*initializer*) – The initializer for the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **name** (*a str*) – A unique layer name.

## QuanDenseLayerWithBN

```
class tensorlayer.layers.QuanDenseLayerWithBN(prev_layer, n_units=100, act=None,  
                                              decay=0.9, epsilon=1e-05,  
                                              is_train=False, bitW=8, bitA=8,  
                                              gamma_init=<sphinx.ext.autodoc.importer._MockObject  
object>, beta_init=<sphinx.ext.autodoc.importer._MockObject  
object>, use_gemm=False,  
                                              W_init=<sphinx.ext.autodoc.importer._MockObject  
object>, W_init_args=None,  
                                              name='quan_dense_with_bn')
```

The `QuanDenseLayer` class is a quantized fully connected layer with BN, which weights are ‘bitW’ bits and the output of the previous layer are ‘bitA’ bits while inferencing.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **n\_units** (*int*) – The number of units of this layer.
- **act** (*activation function*) – The activation function of this layer.
- **decay** (*float*) – A decay factor for *ExponentialMovingAverage*. Suggest to use a large value for large dataset.
- **epsilon** (*float*) – Eplison.
- **is\_train** (*boolean*) – Is being used for training or inference.
- **beta\_init** (*initializer or None*) – The initializer for initializing beta, if None, skip beta. Usually you should not skip beta unless you know what happened.
- **gamma\_init** (*initializer or None*) – The initializer for initializing gamma, if None, skip gamma.
- **bitW** (*int*) – The bits of this layer’s parameter
- **bitA** (*int*) – The bits of the output of previous layer
- **decay** – A decay factor for *ExponentialMovingAverage*. Suggest to use a large value for large dataset.
- **epsilon** – Eplison.
- **is\_train** – Is being used for training or inference.
- **beta\_init** – The initializer for initializing beta, if None, skip beta. Usually you should not skip beta unless you know what happened.

- **gamma\_init** – The initializer for initializing gamma, if None, skip gamma.
- **use\_gemm** (*boolean*) – If True, use `gemm` instead of `tf.matmul` for inferencing. (TODO).
- **W\_init** (*initializer*) – The initializer for the the weight matrix.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **name** (*a str*) – A unique layer name.

## Quantization Convolutions

### Quantization

```
class tensorlayer.layers.QuanConv2d(prev_layer, n_filter=32, filter_size=(3,
3), strides=(1, 1), padding='SAME', act=None, bitW=8, bitA=8, use_gemm=False,
W_init=<sphinx.ext.autodoc.importer._MockObject object>, b_init=<sphinx.ext.autodoc.importer._MockObject
object>, W_init_args=None, b_init_args=None, use_cudnn_on_gpu=None, data_format=None,
name='quan_cnn2d')
```

The `QuanConv2dWithBN` class is a quantized convolutional layer with BN, which weights are ‘bitW’ bits and the output of the previous layer are ‘bitA’ bits while inferencing. Note that, the bias vector would not be binarized.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **bitW** (*int*) – The bits of this layer’s parameter
- **bitA** (*int*) – The bits of the output of previous layer
- **n\_filter** (*int*) – The number of filters.
- **filter\_size** (*tuple of int*) – The filter size (height, width).
- **strides** (*tuple of int*) – The sliding window strides of corresponding input dimensions. It must be in the same order as the `shape` parameter.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **act** (*activation function*) – The activation function of this layer.
- **bitW** – The bits of this layer’s parameter
- **bitA** – The bits of the output of previous layer
- **use\_gemm** (*boolean*) – If True, use `gemm` instead of `tf.matmul` for inferencing. (TODO).
- **W\_init** (*initializer*) – The initializer for the the weight matrix.
- **b\_init** (*initializer or None*) – The initializer for the the bias vector. If None, skip biases.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **b\_init\_args** (*dictionary*) – The arguments for the bias vector initializer.
- **use\_cudnn\_on\_gpu** (*bool*) – Default is False.

- **data\_format** (*str*) – “NHWC” or “NCHW”, default is “NHWC”.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, [None, 256, 256, 3])
>>> net = tl.layers.InputLayer(x, name='input')
>>> net = tl.layers.QuanConv2d(net, 32, (5, 5), (1, 1), padding='SAME', act=tf.nn.
↳relu, name='qcnn1')
>>> net = tl.layers.MaxPool2d(net, (2, 2), (2, 2), padding='SAME', name='pool1')
>>> net = tl.layers.BatchNormLayer(net, act=tl.act.htanh, is_train=True, name='bn1
↳')
...
>>> net = tl.layers.QuanConv2d(net, 64, (5, 5), (1, 1), padding='SAME', act=tf.nn.
↳relu, name='qcnn2')
>>> net = tl.layers.MaxPool2d(net, (2, 2), (2, 2), padding='SAME', name='pool2')
>>> net = tl.layers.BatchNormLayer(net, act=tl.act.htanh, is_train=True, name='bn2
↳')
```

## QuanConv2dWithBN

```
class tensorlayer.layers.QuanConv2dWithBN(prev_layer, n_filter=32, filter_size=(3, 3),
                                           strides=(1, 1), padding='SAME', act=None,
                                           decay=0.9, epsilon=1e-05, is_train=False,
                                           gamma_init=<sphinx.ext.autodoc.importer._MockObject
object>, beta_init=<sphinx.ext.autodoc.importer._MockObject
object>, bitW=8, bitA=8, use_gemm=False,
                                           W_init=<sphinx.ext.autodoc.importer._MockObject
object>, W_init_args=None,
                                           use_cudnn_on_gpu=None, data_format=None,
                                           name='quan_cnn2d_bn')
```

The `QuanConv2dWithBN` class is a quantized convolutional layer with BN, which weights are ‘bitW’ bits and the output of the previous layer are ‘bitA’ bits while inferencing.

Note that, the bias vector would keep the same.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **n\_filter** (*int*) – The number of filters.
- **filter\_size** (*tuple of int*) – The filter size (height, width).
- **strides** (*tuple of int*) – The sliding window strides of corresponding input dimensions. It must be in the same order as the `shape` parameter.
- **padding** (*str*) – The padding algorithm type: “SAME” or “VALID”.
- **act** (*activation function*) – The activation function of this layer.
- **decay** (*float*) – A decay factor for *ExponentialMovingAverage*. Suggest to use a large value for large dataset.
- **epsilon** (*float*) – Epsilon.

- **is\_train** (*boolean*) – Is being used for training or inference.
- **beta\_init** (*initializer or None*) – The initializer for initializing beta, if None, skip beta. Usually you should not skip beta unless you know what happened.
- **gamma\_init** (*initializer or None*) – The initializer for initializing gamma, if None, skip gamma.
- **bitW** (*int*) – The bits of this layer’s parameter
- **bitA** (*int*) – The bits of the output of previous layer
- **decay** – A decay factor for *ExponentialMovingAverage*. Suggest to use a large value for large dataset.
- **epsilon** – Epsilon.
- **is\_train** – Is being used for training or inference.
- **beta\_init** – The initializer for initializing beta, if None, skip beta. Usually you should not skip beta unless you know what happened.
- **gamma\_init** – The initializer for initializing gamma, if None, skip gamma.
- **use\_gemm** (*boolean*) – If True, use `gemm` instead of `tf.matmul` for inferencing. (TODO).
- **W\_init** (*initializer*) – The initializer for the the weight matrix.
- **W\_init\_args** (*dictionary*) – The arguments for the weight matrix initializer.
- **use\_cudnn\_on\_gpu** (*bool*) – Default is False.
- **data\_format** (*str*) – “NHWC” or “NCHW”, default is “NHWC”.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, [None, 256, 256, 3])
>>> net = tl.layers.InputLayer(x, name='input')
>>> net = tl.layers.QuanConv2dWithBN(net, 64, (5, 5), (1, 1), act=tf.nn.relu,
↳padding='SAME', is_train=is_train, bitW=bitW, bitA=bitA, name='qcnnbn1')
>>> net = tl.layers.MaxPool2d(net, (3, 3), (2, 2), padding='SAME', name='pool1')
...
>>> net = tl.layers.QuanConv2dWithBN(net, 64, (5, 5), (1, 1), padding='SAME',
↳act=tf.nn.relu, is_train=is_train, bitW=bitW, bitA=bitA, name='qcnnbn2')
>>> net = tl.layers.MaxPool2d(net, (3, 3), (2, 2), padding='SAME', name='pool2')
...
```

## 2.8.23 Recurrent Layers

### Fixed Length Recurrent layer

All recurrent layers can implement any type of RNN cell by feeding different cell function (LSTM, GRU etc).

## RNN layer

```
class tensorlayer.layers.RNNLayer(prev_layer, cell_fn, cell_init_args=None, n_hidden=100,
                                   initializer=<sphinx.ext.autodoc.importer._MockObject object>, n_steps=5, initial_state=None, return_last=False, return_seq_2d=False, name='rnn')
```

The *RNNLayer* class is a fixed length recurrent layer for implementing vanilla RNN, LSTM, GRU and etc.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **cell\_fn** (*TensorFlow cell function*) –

#### A TensorFlow core RNN cell

- See [RNN Cells in TensorFlow](#)
- Note TF1.0+ and TF1.0- are different

- **cell\_init\_args** (*dictionary*) – The arguments for the cell function.
- **n\_hidden** (*int*) – The number of hidden units in the layer.
- **initializer** (*initializer*) – The initializer for initializing the model parameters.
- **n\_steps** (*int*) – The fixed sequence length.
- **initial\_state** (*None or RNN State*) – If None, *initial\_state* is zero state.
- **return\_last** (*boolean*) –

#### Whether return last output or all outputs in each step.

- If True, return the last output, “Sequence input and single output”
- If False, return all outputs, “Synced sequence input and output”
- In other word, if you want to stack more RNNs on this layer, set to False.

- **return\_seq\_2d** (*boolean*) –

#### Only consider this argument when *return\_last* is False

- If True, return 2D Tensor [n\_example, n\_hidden], for stacking DenseLayer after it.
- If False, return 3D Tensor [n\_example/n\_steps, n\_steps, n\_hidden], for stacking multiple RNN after it.

- **name** (*str*) – A unique layer name.

### outputs

*Tensor* – The output of this layer.

### final\_state

*Tensor or StateTuple* –

#### The final state of this layer.

- When *state\_is\_tuple* is False, it is the final hidden and cell states, *states.get\_shape()* = [?, 2 \* n\_hidden].
- When *state\_is\_tuple* is True, it stores two elements: (*c*, *h*).
- In practice, you can get the final state after each iteration during training, then feed it to the initial state of next iteration.



**initial\_state***Tensor or StateTuple –***The initial state of this layer.**

- In practice, you can set your state at the beginning of each epoch or iteration according to your training procedure.

**batch\_size***int or Tensor – It is an integer, if it is able to compute the `batch_size`; otherwise, tensor for dynamic batch size.***Examples**

- For synced sequence input and output, see [PTB example](#)
- For encoding see below.

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> batch_size = 32
>>> num_steps = 5
>>> vocab_size = 3000
>>> hidden_size = 256
>>> keep_prob = 0.8
>>> is_train = True
>>> input_data = tf.placeholder(tf.int32, [batch_size, num_steps])
>>> net = tl.layers.EmbeddingInputlayer(inputs=input_data, vocabulary_size=vocab_
    ↪size,
...     embedding_size=hidden_size, name='embed')
>>> net = tl.layers.DropoutLayer(net, keep=keep_prob, is_fix=True, is_train=is_
    ↪train, name='drop1')
>>> net = tl.layers.RNNLayer(net, cell_fn=tf.contrib.rnn.BasicLSTMCell,
...     n_hidden=hidden_size, n_steps=num_steps, return_last=False, name='lstm1')
>>> net = tl.layers.DropoutLayer(net, keep=keep_prob, is_fix=True, is_train=is_
    ↪train, name='drop2')
>>> net = tl.layers.RNNLayer(net, cell_fn=tf.contrib.rnn.BasicLSTMCell,
...     n_hidden=hidden_size, n_steps=num_steps, return_last=True, name='lstm2')
>>> net = tl.layers.DropoutLayer(net, keep=keep_prob, is_fix=True, is_train=is_
    ↪train, name='drop3')
>>> net = tl.layers.DenseLayer(net, n_units=vocab_size, name='output')
```

- For CNN+LSTM

```
>>> image_size = 100
>>> batch_size = 10
>>> num_steps = 5
>>> x = tf.placeholder(tf.float32, shape=[batch_size, image_size, image_size, 1])
>>> net = tl.layers.InputLayer(x, name='in')
>>> net = tl.layers.Conv2d(net, 32, (5, 5), (2, 2), tf.nn.relu, name='cnn1')
>>> net = tl.layers.MaxPool2d(net, (2, 2), (2, 2), name='pool1')
>>> net = tl.layers.Conv2d(net, 10, (5, 5), (2, 2), tf.nn.relu, name='cnn2')
>>> net = tl.layers.MaxPool2d(net, (2, 2), (2, 2), name='pool2')
>>> net = tl.layers.FlattenLayer(net, name='flatten')
>>> net = tl.layers.ReshapeLayer(net, shape=[-1, num_steps, int(net.outputs._
    ↪shape[-1])])
```

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```
>>> rnn = tl.layers.RNNLayer(net, cell_fn=tf.contrib.rnn.BasicLSTMCell, n_
↳hidden=200, n_steps=num_steps, return_last=False, return_seq_2d=True, name='rnn
↳')
>>> net = tl.layers.DenseLayer(rnn, 3, name='out')
```

## Notes

Input dimension should be rank 3 : [batch\_size, n\_steps, n\_features], if no, please see [ReshapeLayer](#).

## References

- [Neural Network RNN Cells in TensorFlow](#)
- [tensorflow/python/ops/rnn.py](#)
- [tensorflow/python/ops/rnn\\_cell.py](#)
- see TensorFlow tutorial `ptb_word_lm.py`, TensorLayer tutorials `tutorial_ptb_lstm*.py` and `tutorial_generate_text.py`

## Bidirectional layer

```
class tensorlayer.layers.BiRNNLayer (prev_layer, cell_fn, cell_init_args=None, n_hidden=100,
                                     initializer=<sphinx.ext.autodoc.importer.MockObject
                                     object>, n_steps=5, fw_initial_state=None,
                                     bw_initial_state=None, dropout=None, n_layer=1, re-
                                     turn_last=False, return_seq_2d=False, name='birnn')
```

The [BiRNNLayer](#) class is a fixed length Bidirectional recurrent layer.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **cell\_fn** (*TensorFlow cell function*) –  
A TensorFlow core RNN cell.
  - See [RNN Cells in TensorFlow](#).
  - Note TF1.0+ and TF1.0- are different.
- **cell\_init\_args** (*dictionary or None*) – The arguments for the cell function.
- **n\_hidden** (*int*) – The number of hidden units in the layer.
- **initializer** (*initializer*) – The initializer for initializing the model parameters.
- **n\_steps** (*int*) – The fixed sequence length.
- **fw\_initial\_state** (*None or forward RNN State*) – If *None*, *initial\_state* is zero state.
- **bw\_initial\_state** (*None or backward RNN State*) – If *None*, *initial\_state* is zero state.
- **dropout** (*tuple of float or int*) – The input and output keep probability (input\_keep\_prob, output\_keep\_prob). If one int, input and output keep probability are the same.

- **n\_layer** (*int*) – The number of RNN layers, default is 1.

- **return\_last** (*boolean*) –

**Whether return last output or all outputs in each step.**

- If True, return the last output, “Sequence input and single output”
- If False, return all outputs, “Synced sequence input and output”
- In other word, if you want to stack more RNNs on this layer, set to False.

- **return\_seq\_2d** (*boolean*) –

**Only consider this argument when *return\_last* is *False***

- If True, return 2D Tensor [n\_example, n\_hidden], for stacking DenseLayer after it.
- If False, return 3D Tensor [n\_example/n\_steps, n\_steps, n\_hidden], for stacking multiple RNN after it.

- **name** (*str*) – A unique layer name.

#### outputs

*tensor* – The output of this layer.

#### **fw(bw) \_final\_state**

*tensor or StateTuple* –

**The final state of this layer.**

- When *state\_is\_tuple* is *False*, it is the final hidden and cell states, *states.get\_shape()* = *[?, 2 \* n\_hidden]*.
- When *state\_is\_tuple* is *True*, it stores two elements: (*c*, *h*).
- In practice, you can get the final state after each iteration during training, then feed it to the initial state of next iteration.

#### **fw(bw) \_initial\_state**

*tensor or StateTuple* –

**The initial state of this layer.**

- In practice, you can set your state at the begining of each epoch or iteration according to your training procedure.

#### **batch\_size**

*int or tensor* – It is an integer, if it is able to compute the *batch\_size*; otherwise, tensor for dynamic batch size.

## Notes

Input dimension should be rank 3 : [batch\_size, n\_steps, n\_features]. If not, please see [ReshapeLayer](#). For predicting, the sequence length has to be the same with the sequence length of training, while, for normal RNN, we can use sequence length of 1 for predicting.

## References

[Source](#)

## Recurrent Convolution

### Conv RNN Cell

**class** `tensorlayer.layers.ConvRNNCell`  
Abstract object representing an Convolutional RNN Cell.

### Basic Conv LSTM Cell

**class** `tensorlayer.layers.BasicConvLSTMCell` (*shape*, *filter\_size*, *num\_features*,  
*forget\_bias*=1.0, *input\_size*=None, *state\_is\_tuple*=False,  
*act*=<`sphinx.ext.autodoc.importer._MockObject`  
`object`>)

Basic Conv LSTM recurrent network cell.

#### Parameters

- **shape** (*tuple of int*) – The height and width of the cell.
- **filter\_size** (*tuple of int*) – The height and width of the filter
- **num\_features** (*int*) – The hidden size of the cell
- **forget\_bias** (*float*) – The bias added to forget gates (see above).
- **input\_size** (*int*) – Deprecated and unused.
- **state\_is\_tuple** (*boolean*) – If True, accepted and returned states are 2-tuples of the *c\_state* and *m\_state*. If False, they are concatenated along the column axis. The latter behavior will soon be deprecated.
- **act** (*activation function*) – The activation function of this layer, tanh as default.

### Conv LSTM layer

**class** `tensorlayer.layers.ConvLSTMLayer` (*prev\_layer*, *cell\_shape*=None, *feature\_map*=1,  
*filter\_size*=(3, 3), *cell\_fn*=<class 'tensorlayer.layers.recurrent.BasicConvLSTMCell'>,  
*initializer*=<`sphinx.ext.autodoc.importer._MockObject`  
`object`>, *n\_steps*=5, *initial\_state*=None,  
*return\_last*=False, *return\_seq\_2d*=False,  
*name*='convlstm')

A fixed length Convolutional LSTM layer.

See this [paper](#) .

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer
- **cell\_shape** (*tuple of int*) – The shape of each cell width \* height
- **filter\_size** (*tuple of int*) – The size of filter width \* height
- **cell\_fn** (*a convolutional RNN cell*) – Cell function like `BasicConvLSTMCell`
- **feature\_map** (*int*) – The number of feature map in the layer.

- **initializer** (*initializer*) – The initializer for initializing the parameters.
- **n\_steps** (*int*) – The sequence length.
- **initial\_state** (*None or ConvLSTM State*) – If *None*, *initial\_state* is zero state.
- **return\_last** (*boolean*) –

**Whether return last output or all outputs in each step.**

- If True, return the last output, “Sequence input and single output”.
- If False, return all outputs, “Synced sequence input and output”.
- In other word, if you want to stack more RNNs on this layer, set to False.

- **return\_seq\_2d** (*boolean*) –

**Only consider this argument when *return\_last* is *False***

- If True, return 2D Tensor [n\_example, n\_hidden], for stacking DenseLayer after it.
- If False, return 3D Tensor [n\_example/n\_steps, n\_steps, n\_hidden], for stacking multiple RNN after it.

- **name** (*str*) – A unique layer name.

#### outputs

*tensor* – The output of this RNN. *return\_last* = False, outputs = all cell\_output, which is the hidden state.  
*cell\_output.get\_shape()* = (?, h, w, c)

#### final\_state

*tensor or StateTuple* –

**The final state of this layer.**

- When *state\_is\_tuple* = False, it is the final hidden and cell states,
- When *state\_is\_tuple* = True, You can get the final state after each iteration during training, then feed it to the initial state of next iteration.

#### initial\_state

*tensor or StateTuple* – It is the initial state of this ConvLSTM layer, you can use it to initialize your state at the beginning of each epoch or iteration according to your training procedure.

#### batch\_size

*int or tensor* – Is int, if able to compute the batch\_size, otherwise, tensor for ?.

## Advanced Ops for Dynamic RNN

These operations usually be used inside Dynamic RNN layer, they can compute the sequence lengths for different situation and get the last RNN outputs by indexing.

### Output indexing

`tensorlayer.layers.advanced_indexing_op(inputs, index)`

Advanced Indexing for Sequences, returns the outputs by given sequence lengths. When return the last output *DynamicRNNLayer* uses it to get the last outputs with the sequence lengths.

#### Parameters

- **inputs** (*tensor for data*) – With shape of [batch\_size, n\_step(max), n\_features]

- **index** (*tensor for indexing*) – Sequence length in Dynamic RNN. [batch\_size]

## Examples

```
>>> import numpy as np
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> batch_size, max_length, n_features = 3, 5, 2
>>> z = np.random.uniform(low=-1, high=1, size=[batch_size, max_length, n_
    ↳ features]).astype(np.float32)
>>> b_z = tf.constant(z)
>>> sl = tf.placeholder(dtype=tf.int32, shape=[batch_size])
>>> o = advanced_indexing_op(b_z, sl)
>>>
>>> sess = tf.InteractiveSession()
>>> tl.layers.initialize_global_variables(sess)
>>>
>>> order = np.asarray([1,1,2])
>>> print("real",z[0][order[0]-1], z[1][order[1]-1], z[2][order[2]-1])
>>> y = sess.run([o], feed_dict={sl:order})
>>> print("given",order)
>>> print("out", y)
real [-0.93021595  0.53820813] [-0.92548317 -0.77135968] [ 0.89952248  0.19149846]
given [1 1 2]
out [array([[ -0.93021595,  0.53820813],
            [ -0.92548317, -0.77135968],
            [ 0.89952248,  0.19149846]]), dtype=float32)]
```

## References

- Modified from TFlearn (the original code is used for fixed length rnn), [references](#).

## Compute Sequence length 1

`tensorlayer.layers.retrieve_seq_length_op(data)`

An op to compute the length of a sequence from input shape of [batch\_size, n\_step(max), n\_features], it can be used when the features of padding (on right hand side) are all zeros.

**Parameters** **data** (*tensor*) – [batch\_size, n\_step(max), n\_features] with zero padding on right hand side.

## Examples

```
>>> data = [[ [1], [2], [0], [0], [0]],
...         [ [1], [2], [3], [0], [0]],
...         [ [1], [2], [6], [1], [0]]]
>>> data = np.asarray(data)
>>> print(data.shape)
(3, 5, 1)
>>> data = tf.constant(data)
>>> sl = retrieve_seq_length_op(data)
```

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```
>>> sess = tf.InteractiveSession()
>>> tl.layers.initialize_global_variables(sess)
>>> y = sl.eval()
[2 3 4]
```

Multiple features >>> data = [[[1,2],[2,2],[1,2],[1,2],[0,0]], ... [[2,3],[2,4],[3,2],[0,0],[0,0]], ...  
[[3,3],[2,2],[5,3],[1,2],[0,0]] >>> print(sl) [4 3 4]

## References

Borrow from [TFlearn](#).

## Compute Sequence length 2

`tensorlayer.layers.retrieve_seq_length_op2(data)`

An op to compute the length of a sequence, from input shape of [batch\_size, n\_step(max)], it can be used when the features of padding (on right hand side) are all zeros.

**Parameters** `data` (*tensor*) – [batch\_size, n\_step(max)] with zero padding on right hand side.

## Examples

```
>>> data = [[1,2,0,0,0],
...        [1,2,3,0,0],
...        [1,2,6,1,0]]
>>> o = retrieve_seq_length_op2(data)
>>> sess = tf.InteractiveSession()
>>> tl.layers.initialize_global_variables(sess)
>>> print(o.eval())
[2 3 4]
```

## Compute Sequence length 3

`tensorlayer.layers.retrieve_seq_length_op3(data, pad_val=0)`

Return tensor for sequence length, if input is `tf.string`.

## Get Mask

`tensorlayer.layers.target_mask_op(data, pad_val=0)`

Return tensor for mask, if input is `tf.string`.

## Dynamic RNN Layer

### RNN Layer

```
class tensorlayer.layers.DynamicRNNLayer(prev_layer,    cell_fn,    cell_init_args=None,
                                          n_hidden=256,      initializer=<sphinx.ext.autodoc.importer._MockObject
                                                           object>,    sequence_length=None,    initial_state=None,    dropout=None,    n_layer=1,
                                          return_last=None,    return_seq_2d=False,    dynamic_rnn_init_args=None, name='dyrnn')
```

The `DynamicRNNLayer` class is a dynamic recurrent layer, see `tf.nn.dynamic_rnn`.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer
- **cell\_fn** (*TensorFlow cell function*) –  
A TensorFlow core RNN cell
  - See [RNN Cells in TensorFlow](#)
  - Note TF1.0+ and TF1.0- are different
- **cell\_init\_args** (*dictionary or None*) – The arguments for the cell function.
- **n\_hidden** (*int*) – The number of hidden units in the layer.
- **initializer** (*initializer*) – The initializer for initializing the parameters.
- **sequence\_length** (*tensor, array or None*) –  
The sequence length of each row of input data, see [Advanced Ops for Dynamic RNN](#).
  - If None, it uses `retrieve_seq_length_op` to compute the sequence length, i.e. when the features of padding (on right hand side) are all zeros.
  - If using word embedding, you may need to compute the sequence length from the ID array (the integer features before word embedding) by using `retrieve_seq_length_op2` or `retrieve_seq_length_op`.
  - You can also input an numpy array.
  - More details about TensorFlow dynamic RNN in [Wild-ML Blog](#).
- **initial\_state** (*None or RNN State*) – If None, `initial_state` is zero state.
- **dropout** (*tuple of float or int*) –  
The input and output keep probability (`input_keep_prob`, `output_keep_prob`).
  - If one int, input and output keep probability are the same.
- **n\_layer** (*int*) – The number of RNN layers, default is 1.
- **return\_last** (*boolean or None*) –  
Whether return last output or all outputs in each step.
  - If True, return the last output, “Sequence input and single output”
  - If False, return all outputs, “Synced sequence input and output”
  - In other word, if you want to stack more RNNs on this layer, set to False.



- **return\_seq\_2d** (*boolean*) –

Only consider this argument when *return\_last* is *False*

- If True, return 2D Tensor [n\_example, n\_hidden], for stacking DenseLayer after it.
- If False, return 3D Tensor [n\_example/n\_steps, n\_steps, n\_hidden], for stacking multiple RNN after it.

- **dynamic\_rnn\_init\_args** (*dictionary*) – The arguments for `tf.nn.dynamic_rnn`.
- **name** (*str*) – A unique layer name.

#### outputs

*tensor* – The output of this layer.

#### final\_state

*tensor or StateTuple* –

The final state of this layer.

- When *state\_is\_tuple* is *False*, it is the final hidden and cell states, `states.get_shape() = [?, 2 * n_hidden]`.
- When *state\_is\_tuple* is *True*, it stores two elements: (*c*, *h*).
- In practice, you can get the final state after each iteration during training, then feed it to the initial state of next iteration.

#### initial\_state

*tensor or StateTuple* –

The initial state of this layer.

- In practice, you can set your state at the beginning of each epoch or iteration according to your training procedure.

#### batch\_size

*int or tensor* – It is an integer, if it is able to compute the *batch\_size*; otherwise, tensor for dynamic batch size.

#### sequence\_length

*a tensor or array* – The sequence lengths computed by Advanced Opt or the given sequence lengths, [batch\_size]

## Notes

Input dimension should be rank 3 : [batch\_size, n\_steps(max), n\_features], if no, please see [ReshapeLayer](#).

## Examples

Synced sequence input and output, for loss function see `tl.cost.cross_entropy_seq_with_mask`.

```
>>> input_seqs = tf.placeholder(dtype=tf.int64, shape=[batch_size, None], name=
↳ "input")
>>> net = tl.layers.EmbeddingInputlayer(
...     inputs=input_seqs,
...     vocabulary_size=vocab_size,
...     embedding_size=embedding_size,
```

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```

...         name='embedding')
>>> net = tl.layers.DynamicRNNLayer(net,
...     cell_fn=tf.contrib.rnn.BasicLSTMCell, # for TF0.2 use tf.nn.rnn_
↪ cell.BasicLSTMCell,
...     n_hidden=embedding_size,
...     dropout=(0.7 if is_train else None),
...     sequence_length=tl.layers.retrieve_seq_length_op2(input_seqs),
...     return_last=False, # for encoder, set to True
...     return_seq_2d=True, # stack denselayer or_
↪ compute cost after it
...     name='dynamicrnn')
>>> net = tl.layers.DenseLayer(net, n_units=vocab_size, name="output")

```

## References

- Wild-ML Blog
- `dynamic_rnn.ipynb`
- `tf.nn.dynamic_rnn`
- `tflearn rnn`
- `tutorial_dynamic_rnn.py`

## Bidirectional Layer

```

class tensorlayer.layers.BiDynamicRNNLayer (prev_layer, cell_fn, cell_init_args=None,
                                             n_hidden=256, initializer=<sphinx.ext.autodoc.importer._MockObject
                                             object>, sequence_length=None,
                                             fw_initial_state=None,
                                             bw_initial_state=None, dropout=None,
                                             n_layer=1, return_last=False,
                                             return_seq_2d=False, dynamic_
                                             namic_rnn_init_args=None,
                                             name='bi_dynrnn_layer')

```

The `BiDynamicRNNLayer` class is a RNN layer, you can implement vanilla RNN, LSTM and GRU with it.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **cell\_fn** (*TensorFlow cell function*) –  
A TensorFlow core RNN cell
  - See [RNN Cells in TensorFlow](#).
  - Note TF1.0+ and TF1.0- are different.
- **cell\_init\_args** (*dictionary*) – The arguments for the cell initializer.
- **n\_hidden** (*int*) – The number of hidden units in the layer.
- **initializer** (*initializer*) – The initializer for initializing the parameters.
- **sequence\_length** (*tensor, array or None*) –

The sequence length of each row of input data, see **Advanced Ops for Dynamic RNN**.

- If `None`, it uses `retrieve_seq_length_op` to compute the sequence length, i.e. when the features of padding (on right hand side) are all zeros.
- If using word embedding, you may need to compute the sequence length from the ID array (the integer features before word embedding) by using `retrieve_seq_length_op2` or `retrieve_seq_length_op`.
- You can also input an numpy array.
- More details about TensorFlow dynamic RNN in [Wild-ML Blog](#).
- **fw\_initial\_state** (*None or forward RNN State*) – If `None`, `initial_state` is zero state.
- **bw\_initial\_state** (*None or backward RNN State*) – If `None`, `initial_state` is zero state.
- **dropout** (*tuple of float or int*) –

The input and output keep probability (`input_keep_prob`, `output_keep_prob`).

- If one int, input and output keep probability are the same.
- **n\_layer** (*int*) – The number of RNN layers, default is 1.
- **return\_last** (*boolean*) –

Whether return last output or all outputs in each step.

- If `True`, return the last output, “Sequence input and single output”
- If `False`, return all outputs, “Synced sequence input and output”
- In other word, if you want to stack more RNNs on this layer, set to `False`.
- **return\_seq\_2d** (*boolean*) –

Only consider this argument when `return_last` is `False`

- If `True`, return 2D Tensor [`n_example`, `2 * n_hidden`], for stacking `DenseLayer` after it.
- If `False`, return 3D Tensor [`n_example/n_steps`, `n_steps`, `2 * n_hidden`], for stacking multiple RNN after it.
- **dynamic\_rnn\_init\_args** (*dictionary*) – The arguments for `tf.nn.bidirectional_dynamic_rnn`.
- **name** (*str*) – A unique layer name.

#### outputs

*tensor* – The output of this layer. (`?, 2 * n_hidden`)

#### fw(bw)\_final\_state

*tensor or StateTuple* –

The final state of this layer.

- When `state_is_tuple` is `False`, it is the final hidden and cell states, `states.get_shape() = [?, 2 * n_hidden]`.
- When `state_is_tuple` is `True`, it stores two elements: (`c`, `h`).
- In practice, you can get the final state after each iteration during training, then feed it to the initial state of next iteration.

**fw(bw)\_initial\_state**

*tensor or StateTuple* –

The initial state of this layer.

- In practice, you can set your state at the begining of each epoch or iteration according to your training procedure.

**batch\_size**

*int or tensor* – It is an integer, if it is able to compute the *batch\_size*; otherwise, tensor for dynamic batch size.

**sequence\_length**

*a tensor or array* – The sequence lengths computed by Advanced Opt or the given sequence lengths, [batch\_size].

## Notes

Input dimension should be rank 3 : [batch\_size, n\_steps(max), n\_features], if no, please see [ReshapeLayer](#).

## References

- [Wild-ML Blog](#)
- [bidirectional\\_rnn.ipynb](#)

## Sequence to Sequence

### Simple Seq2Seq

```
class tensorlayer.layers.Seq2Seq(net_encode_in, net_decode_in, cell_fn,
                                cell_init_args=None, n_hidden=256, initial-
                                izer=<sphinx.ext.autodoc.importer._MockObject
                                object>, encode_sequence_length=None, de-
                                code_sequence_length=None, initial_state_encode=None,
                                initial_state_decode=None, dropout=None, n_layer=1,
                                return_seq_2d=False, name='seq2seq')
```

The *Seq2Seq* class is a simple *DynamicRNNLayer* based Seq2seq layer without using `tl.contrib.seq2seq`. See [Model and Sequence to Sequence Learning with Neural Networks](#).

- Please check this example [Chatbot in 200 lines of code](#).
- The Author recommends users to read the source code of [DynamicRNNLayer](#) and [Seq2Seq](#).

### Parameters

- **net\_encode\_in** (*Layer*) – Encode sequences, [batch\_size, None, n\_features].
- **net\_decode\_in** (*Layer*) – Decode sequences, [batch\_size, None, n\_features].
- **cell\_fn** (*TensorFlow cell function*) –

#### A TensorFlow core RNN cell

- see [RNN Cells in TensorFlow](#)
- Note TF1.0+ and TF1.0- are different

- **cell\_init\_args** (*dictionary or None*) – The arguments for the cell initializer.
- **n\_hidden** (*int*) – The number of hidden units in the layer.
- **initializer** (*initializer*) – The initializer for the parameters.
- **encode\_sequence\_length** (*tensor*) – For encoder sequence length, see [DynamicRNNLayer](#).
- **decode\_sequence\_length** (*tensor*) – For decoder sequence length, see [DynamicRNNLayer](#).
- **initial\_state\_encode** (*None or RNN state*) – If *None*, *initial\_state\_encode* is zero state, it can be set by placeholder or other RNN.
- **initial\_state\_decode** (*None or RNN state*) – If *None*, *initial\_state\_decode* is the final state of the RNN encoder, it can be set by placeholder or other RNN.
- **dropout** (*tuple of float or int*) –

**The input and output keep probability (input\_keep\_prob, output\_keep\_prob).**

- If one int, input and output keep probability are the same.

- **n\_layer** (*int*) – The number of RNN layers, default is 1.
- **return\_seq\_2d** (*boolean*) –

**Only consider this argument when *return\_last* is *False***

- If True, return 2D Tensor [n\_example, 2 \* n\_hidden], for stacking DenseLayer after it.
- If False, return 3D Tensor [n\_example/n\_steps, n\_steps, 2 \* n\_hidden], for stacking multiple RNN after it.

- **name** (*str*) – A unique layer name.

#### outputs

*tensor* – The output of RNN decoder.

#### initial\_state\_encode

*tensor or StateTuple* – Initial state of RNN encoder.

#### initial\_state\_decode

*tensor or StateTuple* – Initial state of RNN decoder.

#### final\_state\_encode

*tensor or StateTuple* – Final state of RNN encoder.

#### final\_state\_decode

*tensor or StateTuple* – Final state of RNN decoder.

#### Notes

- How to feed data: [Sequence to Sequence Learning with Neural Networks](#)
- `input_seqs: ['how', 'are', 'you', '<PAD_ID>']`
- `decode_seqs: ['<START_ID>', 'I', 'am', 'fine', '<PAD_ID>']`
- `target_seqs: ['I', 'am', 'fine', '<END_ID>', '<PAD_ID>']`
- `target_mask: [1, 1, 1, 1, 0]`

- related functions : `tl.prepro <pad_sequences, precess_sequences, sequences_add_start_id, sequences_get_mask>`

## Examples

```
>>> from tensorlayer.layers import *
>>> batch_size = 32
>>> encode_seqs = tf.placeholder(dtype=tf.int64, shape=[batch_size, None], name=
↳ "encode_seqs")
>>> decode_seqs = tf.placeholder(dtype=tf.int64, shape=[batch_size, None], name=
↳ "decode_seqs")
>>> target_seqs = tf.placeholder(dtype=tf.int64, shape=[batch_size, None], name=
↳ "target_seqs")
>>> target_mask = tf.placeholder(dtype=tf.int64, shape=[batch_size, None], name=
↳ "target_mask") # tl.prepro.sequences_get_mask()
>>> with tf.variable_scope("model"):
>>>     # for chatbot, you can use the same embedding layer,
>>>     # for translation, you may want to use 2 seperated embedding layers
>>>     with tf.variable_scope("embedding") as vs:
>>>         net_encode = EmbeddingInputlayer(
>>>             inputs = encode_seqs,
>>>             vocabulary_size = 10000,
>>>             embedding_size = 200,
>>>             name = 'seq_embedding')
>>>         vs.reuse_variables()
>>>         tl.layers.set_name_reuse(True)
>>>         net_decode = EmbeddingInputlayer(
>>>             inputs = decode_seqs,
>>>             vocabulary_size = 10000,
>>>             embedding_size = 200,
>>>             name = 'seq_embedding')
>>>         net = Seq2Seq(net_encode, net_decode,
>>>             cell_fn = tf.contrib.rnn.BasicLSTMCell,
>>>             n_hidden = 200,
>>>             initializer = tf.random_uniform_initializer(-0.1, 0.1),
>>>             encode_sequence_length = retrieve_seq_length_op2(encode_seqs),
>>>             decode_sequence_length = retrieve_seq_length_op2(decode_seqs),
>>>             initial_state_encode = None,
>>>             dropout = None,
>>>             n_layer = 1,
>>>             return_seq_2d = True,
>>>             name = 'seq2seq')
>>> net_out = DenseLayer(net, n_units=10000, act=None, name='output')
>>> e_loss = tl.cost.cross_entropy_seq_with_mask(logits=net_out.outputs, target_
↳ seqs=target_seqs, input_mask=target_mask, return_details=False, name='cost')
>>> y = tf.nn.softmax(net_out.outputs)
>>> net_out.print_params(False)
```

## 2.8.24 Shape Layers

### Flatten Layer

**class** `tensorlayer.layers.FlattenLayer` (*prev\_layer*, *name='flatten'*)  
A layer that reshapes high-dimension input into a vector.

Then we often apply DenseLayer, RNNLayer, ConcatLayer and etc on the top of a flatten layer. [batch\_size, mask\_row, mask\_col, n\_mask] → [batch\_size, mask\_row \* mask\_col \* n\_mask]

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **name** (*str*) – A unique layer name.

#### Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, shape=[None, 28, 28, 1])
>>> net = tl.layers.InputLayer(x, name='input')
>>> net = tl.layers.FlattenLayer(net, name='flatten')
[?, 784]
```

### Reshape Layer

**class** tensorlayer.layers.**ReshapeLayer** (*prev\_layer, shape, name='reshape'*)

A layer that reshapes a given tensor.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer
- **shape** (*tuple of int*) – The output shape, see `tf.reshape`.
- **name** (*str*) – A unique layer name.

#### Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, shape=(None, 784))
>>> net = tl.layers.InputLayer(x, name='input')
>>> net = tl.layers.ReshapeLayer(net, [-1, 28, 28, 1], name='reshape')
>>> print(net.outputs)
(?, 28, 28, 1)
```

### Transpose Layer

**class** tensorlayer.layers.**TransposeLayer** (*prev\_layer, perm, name='transpose'*)

A layer that transposes the dimension of a tensor.

See `tf.transpose()`.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer
- **perm** (*list of int*) – The permutation of the dimensions, similar with `numpy.transpose`.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, shape=[None, 28, 28, 1])
>>> net = tl.layers.InputLayer(x, name='input')
>>> net = tl.layers.TransposeLayer(net, perm=[0, 1, 3, 2], name='trans')
[None, 28, 1, 28]
```

## 2.8.25 Spatial Transformer

### 2D Affine Transformation

**class** `tensorlayer.layers.SpatialTransformer2dAffineLayer` (*prev\_layer*, *theta\_layer*,  
*out\_size=None*,  
*name='spatial\_trans\_2d\_affine'*)

The *SpatialTransformer2dAffineLayer* class is a 2D Spatial Transformer Layer for 2D Affine Transformation.

#### Parameters

- **prev\_layer** (*Layer*) – Previous layer.
- **theta\_layer** (*Layer*) – The localisation network. - We will use a *DenseLayer* to make the theta size to [batch, 6], value range to [0, 1] (via tanh).
- **out\_size** (*tuple of int or None*) – The size of the output of the network (height, width), the feature maps will be resized by this.
- **name** (*str*) – A unique layer name.

#### References

- [Spatial Transformer Networks](#)
- [TensorFlow/Models](#)

### 2D Affine Transformation function

`tensorlayer.layers.transformer` (*U*, *theta*, *out\_size*, *name='SpatialTransformer2dAffine'*)  
Spatial Transformer Layer for 2D Affine Transformation , see *SpatialTransformer2dAffineLayer* class.

#### Parameters

- **U** (*list of float*) – The output of a convolutional net should have the shape [num\_batch, height, width, num\_channels].
- **theta** (*float*) – The output of the localisation network should be [num\_batch, 6], value range should be [0, 1] (via tanh).
- **out\_size** (*tuple of int*) – The size of the output of the network (height, width)
- **name** (*str*) – Optional function name

**Returns** The transformed tensor.



**Return type** Tensor

## References

- [Spatial Transformer Networks](#)
- [TensorFlow/Models](#)

## Notes

To initialize the network to the identity transform init.

```
>>> import tensorflow as tf
>>> # ``theta`` to
>>> identity = np.array([[1., 0., 0.], [0., 1., 0.]])
>>> identity = identity.flatten()
>>> theta = tf.Variable(initial_value=identity)
```

## Batch 2D Affine Transformation function

`tensorlayer.layers.batch_transformer(U, thetas, out_size, name='BatchSpatialTransformer2dAffine')`  
Batch Spatial Transformer function for 2D Affine Transformation.

### Parameters

- **U** (*list of float*) – tensor of inputs [batch, height, width, num\_channels]
- **thetas** (*list of float*) – a set of transformations for each input [batch, num\_transforms, 6]
- **out\_size** (*list of int*) – the size of the output [out\_height, out\_width]
- **name** (*str*) – optional function name

**Returns** Tensor of size [batch \* num\_transforms, out\_height, out\_width, num\_channels]

**Return type** float

## 2.8.26 Stack Layer

### Stack Layer

**class** `tensorlayer.layers.StackLayer(layers, axis=1, name='stack')`

The *StackLayer* class is a layer for stacking a list of rank-R tensors into one rank-(R+1) tensor, see `tf.stack()`.

### Parameters

- **layers** (*list of Layer*) – Previous layers to stack.
- **axis** (*int*) – Dimension along which to concatenate.
- **name** (*str*) – A unique layer name.

## Examples

```
>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, shape=[None, 30])
>>> net = tl.layers.InputLayer(x, name='input')
>>> net1 = tl.layers.DenseLayer(net, 10, name='dense1')
>>> net2 = tl.layers.DenseLayer(net, 10, name='dense2')
>>> net3 = tl.layers.DenseLayer(net, 10, name='dense3')
>>> net = tl.layers.StackLayer([net1, net2, net3], axis=1, name='stack')
(? , 3, 10)
```

## Unstack Layer

**class** `tensorlayer.layers.UnStackLayer` (*prev\_layer*, *num=None*, *axis=0*, *name='unstack'*)

The *UnStackLayer* class is a layer for unstacking the given dimension of a rank-R tensor into rank-(R-1) tensors., see `tf.unstack()`.

### Parameters

- **prev\_layer** (*Layer*) – Previous layer
- **num** (*int* or *None*) – The length of the dimension axis. Automatically inferred if *None* (the default).
- **axis** (*int*) – Dimension along which axis to concatenate.
- **name** (*str*) – A unique layer name.

**Returns** The list of layer objects unstacked from the input.

**Return type** list of *Layer*

## 2.8.27 Time Distributed Layer

**class** `tensorlayer.layers.TimeDistributedLayer` (*prev\_layer*, *layer\_class=None*,  
*layer\_args=None*,  
*name='time\_distributed'*)

The *TimeDistributedLayer* class that applies a function to every timestep of the input tensor. For example, if use *DenseLayer* as the *layer\_class*, we input (batch\_size, length, dim) and output (batch\_size , length, new\_dim).

### Parameters

- **prev\_layer** (*Layer*) – Previous layer with output size of (batch\_size, length, dim).
- **layer\_class** (a *Layer* class) – The layer class name.
- **args** (*dictionary*) – The arguments for the *layer\_class*.
- **name** (*str*) – A unique layer name.

## Examples

```

>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> batch_size = 32
>>> timestep = 20
>>> input_dim = 100
>>> x = tf.placeholder(dtype=tf.float32, shape=[batch_size, timestep, input_dim],
↳name="encode_seqs")
>>> net = tl.layers.InputLayer(x, name='input')
[TL] InputLayer input: (32, 20, 100)
>>> net = tl.layers.TimeDistributedLayer(net, layer_class=tl.layers.DenseLayer,
↳args={'n_units':50, 'name':'dense'}, name='time_dense')
[TL] TimeDistributedLayer time_dense: layer_class:DenseLayer
>>> print(net.outputs._shape)
(32, 20, 50)
>>> net.print_params(False)
[TL] param 0: (100, 50) time_dense/dense/W:0
[TL] param 1: (50,) time_dense/dense/b:0
[TL] num of params: 5050

```

## 2.8.28 Helper Functions

### Flatten tensor

`tensorlayer.layers.flatten_reshape(variable, name='flatten')`

Reshapes a high-dimension vector input.

`[batch_size, mask_row, mask_col, n_mask] → [batch_size, mask_row x mask_col x n_mask]`

#### Parameters

- **variable** (*TensorFlow variable or tensor*) – The variable or tensor to be flatten.
- **name** (*str*) – A unique layer name.

**Returns** Flatten Tensor

**Return type** Tensor

### Examples

```

>>> import tensorflow as tf
>>> import tensorlayer as tl
>>> x = tf.placeholder(tf.float32, [None, 128, 128, 3])
>>> # Convolution Layer with 32 filters and a kernel size of 5
>>> network = tf.layers.conv2d(x, 32, 5, activation=tf.nn.relu)
>>> # Max Pooling (down-sampling) with strides of 2 and kernel size of 2
>>> network = tf.layers.max_pooling2d(network, 2, 2)
>>> print(network.get_shape().as_list())
>>> [None, 62, 62, 32]
>>> network = tl.layers.flatten_reshape(network)
>>> print(network.get_shape().as_list()[1:])
>>> [None, 123008]

```

## Permanent clear existing layer names

```
tensorlayer.layers.clear_layers_name()  
DEPRECATED FUNCTION
```

**Warning: THIS FUNCTION IS DEPRECATED:** It will be removed after after 2018-06-30. *Instructions for updating:* TensorLayer relies on TensorFlow to check naming.

## Initialize RNN state

```
tensorlayer.layers.initialize_rnn_state(state, feed_dict=None)
```

Returns the initialized RNN state. The inputs are *LSTMStateTuple* or *State* of *RNNCells*, and an optional *feed\_dict*.

### Parameters

- **state** (*RNN state.*) – The TensorFlow’s RNN state.
- **feed\_dict** (*dictionary*) – Initial RNN state; if None, returns zero state.

**Returns** The TensorFlow’s RNN state.

**Return type** RNN state

## Remove repeated items in a list

```
tensorlayer.layers.list_remove_repeat(x)
```

Remove the repeated items in a list, and return the processed list. You may need it to create merged layer like Concat, Elementwise and etc.

**Parameters** **x** (*list*) – Input

**Returns** A list that after removing it’s repeated items

**Return type** list

## Examples

```
>>> l = [2, 3, 4, 2, 3]  
>>> l = list_remove_repeat(l)  
[2, 3, 4]
```

## Merge networks attributes

```
tensorlayer.layers.merge_networks(layers=None)
```

Merge all parameters, layers and dropout probabilities to a *Layer*. The output of return network is the first network in the list.

**Parameters** **layers** (list of *Layer*) – Merge all parameters, layers and dropout probabilities to the first layer in the list.

**Returns** The network after merging all parameters, layers and dropout probabilities to the first network in the list.

Return type *Layer*

## Examples

```
>>> import tensorlayer as tl
>>> n1 = ...
>>> n2 = ...
>>> n1 = tl.layers.merge_networks([n1, n2])
```

## 2.9 API - Models

TensorLayer provides many pretrained models, you can easily use the whole or a part of the pretrained models via these APIs.

<code>VGG16(x[, end_with, reuse])</code>	Pre-trained VGG-16 model.
<code>VGG19(x[, end_with, reuse])</code>	Pre-trained VGG-19 model.
<code>SqueezeNetV1(x[, end_with, is_train, reuse])</code>	Pre-trained SqueezeNetV1 model.
<code>MobileNetV1(x[, end_with, is_train, reuse])</code>	Pre-trained MobileNetV1 model.

### 2.9.1 VGG16

**class** `tensorlayer.models.VGG16` (*x*, *end\_with*='fc3\_relu', *reuse*=None)  
Pre-trained VGG-16 model.

#### Parameters

- **x** (*placeholder*) – shape [None, 224, 224, 3], value range [0, 1].
- **end\_with** (*str*) – The end point of the model. Default `fc3_relu` i.e. the whole model.
- **reuse** (*boolean*) – Whether to reuse the model.

## Examples

Classify ImageNet classes with VGG16, see `tutorial_models_vgg16.py`

```
>>> x = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> # get the whole model
>>> vgg = tl.models.VGG16(x)
>>> # restore pre-trained VGG parameters
>>> sess = tf.InteractiveSession()
>>> vgg.restore_params(sess)
>>> # use for inferencing
>>> probs = tf.nn.softmax(vgg.outputs)
```

Extract features with VGG16 and Train a classifier with 100 classes

```
>>> x = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> # get VGG without the last layer
>>> vgg = tl.models.VGG16(x, end_with='fc2_relu')
>>> # add one more layer
```

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```
>>> net = tl.layers.DenseLayer(vgg, 100, name='out')
>>> # initialize all parameters
>>> sess = tf.InteractiveSession()
>>> tl.layers.initialize_global_variables(sess)
>>> # restore pre-trained VGG parameters
>>> vgg.restore_params(sess)
>>> # train your own classifier (only update the last layer)
>>> train_params = tl.layers.get_variables_with_name('out')
```

### Reuse model

```
>>> x1 = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> x2 = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> # get VGG without the last layer
>>> vgg1 = tl.models.VGG16(x1, end_with='fc2_relu')
>>> # reuse the parameters of vgg1 with different input
>>> vgg2 = tl.models.VGG16(x2, end_with='fc2_relu', reuse=True)
>>> # restore pre-trained VGG parameters (as they share parameters, we don't need_
↳to restore vgg2)
>>> sess = tf.InteractiveSession()
>>> vgg1.restore_params(sess)
```

## 2.9.2 VGG19

**class** tensorlayer.models.VGG19(x, end\_with='fc3\_relu', reuse=None)

Pre-trained VGG-19 model.

### Parameters

- **x** (*placeholder*) – shape [None, 224, 224, 3], value range [0, 1].
- **end\_with** (*str*) – The end point of the model. Default fc3\_relu i.e. the whole model.
- **reuse** (*boolean*) – Whether to reuse the model.

### Examples

Classify ImageNet classes with VGG19, see [tutorial\\_models\\_vgg19.py](#)

```
>>> x = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> # get the whole model
>>> vgg = tl.models.VGG19(x)
>>> # restore pre-trained VGG parameters
>>> sess = tf.InteractiveSession()
>>> vgg.restore_params(sess)
>>> # use for inferencing
>>> probs = tf.nn.softmax(vgg.outputs)
```

Extract features with VGG19 and Train a classifier with 100 classes

```
>>> x = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> # get VGG without the last layer
>>> vgg = tl.models.VGG19(x, end_with='fc2_relu')
>>> # add one more layer
>>> net = tl.layers.DenseLayer(vgg, 100, name='out')
```

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```
>>> # initialize all parameters
>>> sess = tf.InteractiveSession()
>>> tl.layers.initialize_global_variables(sess)
>>> # restore pre-trained VGG parameters
>>> vgg.restore_params(sess)
>>> # train your own classifier (only update the last layer)
>>> train_params = tl.layers.get_variables_with_name('out')
```

#### Reuse model

```
>>> x1 = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> x2 = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> # get VGG without the last layer
>>> vgg1 = tl.models.VGG19(x1, end_with='fc2_relu')
>>> # reuse the parameters of vgg1 with different input
>>> vgg2 = tl.models.VGG19(x2, end_with='fc2_relu', reuse=True)
>>> # restore pre-trained VGG parameters (as they share parameters, we don't need
↳to restore vgg2)
>>> sess = tf.InteractiveSession()
>>> vgg1.restore_params(sess)
```

## 2.9.3 SqueezeNetV1

**class** tensorlayer.models.**SqueezeNetV1** (*x*, *end\_with*='output', *is\_train*=False, *reuse*=None)

Pre-trained SqueezeNetV1 model.

#### Parameters

- **x** (*placeholder*) – shape [None, 224, 224, 3], value range [0, 255].
- **end\_with** (*str*) – The end point of the model [input, fire2, fire3 ... fire9, output]. Default output i.e. the whole model.
- **is\_train** (*boolean*) – Whether the model is used for training i.e. enable dropout.
- **reuse** (*boolean*) – Whether to reuse the model.

#### Examples

Classify ImageNet classes, see [tutorial\\_models\\_squeezenetv1.py](#)

```
>>> x = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> # get the whole model
>>> net = tl.models.SqueezeNetV1(x)
>>> # restore pre-trained parameters
>>> sess = tf.InteractiveSession()
>>> net.restore_params(sess)
>>> # use for inferencing
>>> probs = tf.nn.softmax(net.outputs)
```

Extract features and Train a classifier with 100 classes

```
>>> x = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> # get model without the last layer
>>> cnn = tl.models.SqueezeNetV1(x, end_with='fire9')
```

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```

>>> # add one more layer
>>> net = Conv2d(cnn, 100, (1, 1), (1, 1), padding='VALID', name='output')
>>> net = GlobalMeanPool2d(net)
>>> # initialize all parameters
>>> sess = tf.InteractiveSession()
>>> tl.layers.initialize_global_variables(sess)
>>> # restore pre-trained parameters
>>> cnn.restore_params(sess)
>>> # train your own classifier (only update the last layer)
>>> train_params = tl.layers.get_variables_with_name('output')

```

#### Reuse model

```

>>> x1 = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> x2 = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> # get model without the last layer
>>> net1 = tl.models.SqueezeNetV1(x1, end_with='fire9')
>>> # reuse the parameters with different input
>>> net2 = tl.models.SqueezeNetV1(x2, end_with='fire9', reuse=True)
>>> # restore pre-trained parameters (as they share parameters, we don't need to
↳ restore net2)
>>> sess = tf.InteractiveSession()
>>> net1.restore_params(sess)

```

## 2.9.4 MobileNetV1

**class** `tensorlayer.models.MobileNetV1` (*x*, *end\_with='out'*, *is\_train=False*, *reuse=None*)  
 Pre-trained MobileNetV1 model.

#### Parameters

- **x** (*placeholder*) – shape [None, 224, 224, 3], value range [0, 1].
- **end\_with** (*str*) – The end point of the model [conv, depth1, depth2 ... depth13, globalmeanpool, out]. Default out i.e. the whole model.
- **is\_train** (*boolean*) – Whether the model is used for training i.e. enable dropout.
- **reuse** (*boolean*) – Whether to reuse the model.

#### Examples

Classify ImageNet classes, see `tutorial_models_mobilenetv1.py`

```

>>> x = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> # get the whole model
>>> net = tl.models.MobileNetV1(x)
>>> # restore pre-trained parameters
>>> sess = tf.InteractiveSession()
>>> net.restore_params(sess)
>>> # use for inferencing
>>> probs = tf.nn.softmax(net.outputs)

```

Extract features and Train a classifier with 100 classes



```

>>> x = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> # get model without the last layer
>>> cnn = tl.models.MobileNetV1(x, end_with='reshape')
>>> # add one more layer
>>> net = Conv2d(cnn, 100, (1, 1), (1, 1), name='out')
>>> net = FlattenLayer(net, name='flatten')
>>> # initialize all parameters
>>> sess = tf.InteractiveSession()
>>> tl.layers.initialize_global_variables(sess)
>>> # restore pre-trained parameters
>>> cnn.restore_params(sess)
>>> # train your own classifier (only update the last layer)
>>> train_params = tl.layers.get_variables_with_name('out')

```

#### Reuse model

```

>>> x1 = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> x2 = tf.placeholder(tf.float32, [None, 224, 224, 3])
>>> # get model without the last layer
>>> net1 = tl.models.MobileNetV1(x1, end_with='reshape')
>>> # reuse the parameters with different input
>>> net2 = tl.models.MobileNetV1(x2, end_with='reshape', reuse=True)
>>> # restore pre-trained parameters (as they share parameters, we don't need to
↪ restore net2)
>>> sess = tf.InteractiveSession()
>>> net1.restore_params(sess)

```

## 2.10 API - Natural Language Processing

Natural Language Processing and Word Representation.

<code>generate_skip_gram_batch(data, batch_size, ...)</code>	Generate a training batch for the Skip-Gram model.
<code>sample([a, temperature])</code>	Sample an index from a probability array.
<code>sample_top([a, top_k])</code>	Sample from <code>top_k</code> probabilities.
<code>SimpleVocabulary(vocab, unk_id)</code>	Simple vocabulary wrapper, see <code>create_vocab()</code> .
<code>Vocabulary(vocab_file[, start_word, ...])</code>	Create Vocabulary class from a given vocabulary and its id-word, word-id convert.
<code>process_sentence(sentence[, start_word, ...])</code>	Seperate a sentence string into a list of string words, add <code>start_word</code> and <code>end_word</code> , see <code>create_vocab()</code> and <code>tutorial_tfrecord3.py</code> .
<code>create_vocab(sentences, word_counts_output_file)</code>	Creates the vocabulary of word to word_id.
<code>simple_read_words([filename])</code>	Read context from file without any preprocessing.
<code>read_words([filename, replace])</code>	Read list format context from a file.
<code>read_analogies_file([eval_file, word2id])</code>	Reads through an analogy question file, return its id format.
<code>build_vocab(data)</code>	Build vocabulary.
<code>build_reverse_dictionary(word_to_id)</code>	Given a dictionary that maps word to integer id.
<code>build_words_dataset([words, ...])</code>	Build the words dictionary and replace rare words with 'UNK' token.
<code>save_vocab([count, name])</code>	Save the vocabulary to a file so the model can be reloaded.

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Table 10 – continued from previous page

<code>words_to_word_ids([data, word_to_id, unk_key])</code>	Convert a list of string (words) to IDs.
<code>word_ids_to_words(data, id_to_word)</code>	Convert a list of integer to strings (words).
<code>basic_tokenizer(sentence[, _WORD_SPLIT])</code>	Very basic tokenizer: split the sentence into a list of tokens.
<code>create_vocabulary(vocabulary_path, ...[, ...])</code>	Create vocabulary file (if it does not exist yet) from data file.
<code>initialize_vocabulary(vocabulary_path)</code>	Initialize vocabulary from file, return the <i>word_to_id</i> (dictionary) and <i>id_to_word</i> (list).
<code>sentence_to_token_ids(sentence, vocabulary)</code>	Convert a string to list of integers representing token-ids.
<code>data_to_token_ids(data_path, target_path, ...)</code>	Tokenize data file and turn into token-ids using given vocabulary file.
<code>moses_multi_bleu(hypotheses, references[, ...])</code>	Calculate the bleu score for hypotheses and references using the MOSES ulti-bleu.perl script.

### 2.10.1 Iteration function for training embedding matrix

`tensorlayer.nlp.generate_skip_gram_batch(data, batch_size, num_skips, skip_window, data_index=0)`

Generate a training batch for the Skip-Gram model.

See [Word2Vec example](#).

#### Parameters

- **data** (*list of data*) – To present context, usually a list of integers.
- **batch\_size** (*int*) – Batch size to return.
- **num\_skips** (*int*) – How many times to reuse an input to generate a label.
- **skip\_window** (*int*) – How many words to consider left and right.
- **data\_index** (*int*) – Index of the context location. This code use *data\_index* to instead of yield like `tl.iterate`.

#### Returns

- **batch** (*list of data*) – Inputs.
- **labels** (*list of data*) – Labels
- **data\_index** (*int*) – Index of the context location.

### Examples

Setting `num_skips=2`, `skip_window=1`, use the right and left words. In the same way, `num_skips=4`, `skip_window=2` means use the nearby 4 words.

```
>>> data = [1,2,3,4,5,6,7,8,9,10,11]
>>> batch, labels, data_index = tl.nlp.generate_skip_gram_batch(data=data, batch_
↪size=8, num_skips=2, skip_window=1, data_index=0)
>>> print(batch)
[2 2 3 3 4 4 5 5]
>>> print(labels)
[[3]
```

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```
[1]
[4]
[2]
[5]
[3]
[4]
[6]]
```

## 2.10.2 Sampling functions

### Simple sampling

`tensorlayer.nlp.sample` (*a=None, temperature=1.0*)

Sample an index from a probability array.

#### Parameters

- **a** (*list of float*) – List of probabilities.
- **temperature** (*float or None*) –

**The higher the more uniform. When a = [0.1, 0.2, 0.7],**

- temperature = 0.7, the distribution will be sharpen [0.05048273, 0.13588945, 0.81362782]
- temperature = 1.0, the distribution will be the same [0.1, 0.2, 0.7]
- temperature = 1.5, the distribution will be filtered [0.16008435, 0.25411807, 0.58579758]
- If None, it will be `np.argmax(a)`

#### Notes

- No matter what is the temperature and input list, the sum of all probabilities will be one. Even if input list = [1, 100, 200], the sum of all probabilities will still be one.
- For large vocabulary size, choice a higher temperature or `tl.nlp.sample_top` to avoid error.

### Sampling from top k

`tensorlayer.nlp.sample_top` (*a=None, top\_k=10*)

Sample from `top_k` probabilities.

#### Parameters

- **a** (*list of float*) – List of probabilities.
- **top\_k** (*int*) – Number of candidates to be considered.

## 2.10.3 Vector representations of words

### Simple vocabulary class

**class** `tensorlayer.nlp.SimpleVocabulary` (*vocab*, *unk\_id*)  
Simple vocabulary wrapper, see `create_vocab()`.

#### Parameters

- **vocab** (*dictionary*) – A dictionary that maps word to ID.
- **unk\_id** (*int*) – The ID for ‘unknown’ word.

### Vocabulary class

**class** `tensorlayer.nlp.Vocabulary` (*vocab\_file*, *start\_word*=’<S>’, *end\_word*=’</S>’,  
*unk\_word*=’<UNK>’, *pad\_word*=’<PAD>’)  
Create Vocabulary class from a given vocabulary and its id-word, word-id convert. See `create_vocab()` and `tutorial_tfrecord3.py`.

#### Parameters

- **vocab\_file** (*str*) – The file contains the vocabulary (can be created via `tl.nlp.create_vocab()`), where the words are the first whitespace-separated token on each line (other tokens are ignored) and the word ids are the corresponding line numbers.
- **start\_word** (*str*) – Special word denoting sentence start.
- **end\_word** (*str*) – Special word denoting sentence end.
- **unk\_word** (*str*) – Special word denoting unknown words.

#### **vocab**

*dictionary* – A dictionary that maps word to ID.

#### **reverse\_vocab**

*list of int* – A list that maps ID to word.

#### **start\_id**

*int* – For start ID.

#### **end\_id**

*int* – For end ID.

#### **unk\_id**

*int* – For unknown ID.

#### **pad\_id**

*int* – For Padding ID.

### Examples

The vocab file looks like follow, includes *start\_word* , *end\_word* ...

```
>>> a 969108
>>> <S> 586368
>>> </S> 586368
>>> . 440479
>>> on 213612
```

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```
>>> of 202290
>>> the 196219
>>> in 182598
>>> with 152984
>>> and 139109
>>> is 97322
```

## Process sentence

`tensorlayer.nlp.process_sentence(sentence, start_word='<S>', end_word='</S>')`

Separate a sentence string into a list of string words, add `start_word` and `end_word`, see `create_vocab()` and `tutorial_tfrecord3.py`.

### Parameters

- **sentence** (*str*) – A sentence.
- **start\_word** (*str* or *None*) – The start word. If *None*, no start word will be appended.
- **end\_word** (*str* or *None*) – The end word. If *None*, no end word will be appended.

**Returns** A list of strings that separated into words.

**Return type** list of str

## Examples

```
>>> c = "how are you?"
>>> c = tl.nlp.process_sentence(c)
>>> print(c)
['<S>', 'how', 'are', 'you', '?', '</S>']
```

## Notes

- You have to install the following package.
- [Installing NLTK](#)
- [Installing NLTK data](#)

## Create vocabulary

`tensorlayer.nlp.create_vocab(sentences, word_counts_output_file, min_word_count=1)`

Creates the vocabulary of word to word\_id.

See `tutorial_tfrecord3.py`.

The vocabulary is saved to disk in a text file of word counts. The id of each word in the file is its corresponding 0-based line number.

### Parameters

- **sentences** (*list of list of str*) – All sentences for creating the vocabulary.
- **word\_counts\_output\_file** (*str*) – The file name.

- **min\_word\_count** (*int*) – Minimum number of occurrences for a word.

**Returns** The simple vocabulary object, see [Vocabulary](#) for more.

**Return type** [SimpleVocabulary](#)

## Examples

### Pre-process sentences

```
>>> captions = ["one two , three", "four five five"]
>>> processed_capt = []
>>> for c in captions:
>>>     c = tl.nlp.process_sentence(c, start_word="<S>", end_word="</S>")
>>>     processed_capt.append(c)
>>> print(processed_capt)
...[['<S>', 'one', 'two', ',', 'three', '</S>'], ['<S>', 'four', 'five', 'five', '
↪</S>']]
```

### Create vocabulary

```
>>> tl.nlp.create_vocab(processed_capt, word_counts_output_file='vocab.txt', min_
↪word_count=1)
Creating vocabulary.
Total words: 8
Words in vocabulary: 8
Wrote vocabulary file: vocab.txt
```

### Get vocabulary object

```
>>> vocab = tl.nlp.Vocabulary('vocab.txt', start_word="<S>", end_word="</S>", unk_
↪word="<UNK>")
INFO:tensorflow:Initializing vocabulary from file: vocab.txt
[TL] Vocabulary from vocab.txt : <S> </S> <UNK>
vocabulary with 10 words (includes start_word, end_word, unk_word)
start_id: 2
end_id: 3
unk_id: 9
pad_id: 0
```

## 2.10.4 Read words from file

### Simple read file

`tensorlayer.nlp.simple_read_words` (*filename*='nietzsche.txt')

Read context from file without any preprocessing.

**Parameters** **filename** (*str*) – A file path (like .txt file)

**Returns** The context in a string.

**Return type** `str`

## Read file

`tensorlayer.nlp.read_words(filename='nietzsche.txt', replace=None)`

Read list format context from a file.

For customized `read_words` method, see `tutorial_generate_text.py`.

### Parameters

- **filename** (*str*) – a file path.
- **replace** (*list of str*) – replace original string by target string.

**Returns** The context in a list (split using space).

**Return type** list of str

## 2.10.5 Read analogy question file

`tensorlayer.nlp.read_analogies_file(eval_file='questions-words.txt', word2id=None)`

Reads through an analogy question file, return its id format.

### Parameters

- **eval\_file** (*str*) – The file name.
- **word2id** (*dictionary*) – a dictionary that maps word to ID.

**Returns** A `[n_examples, 4]` numpy array containing the analogy question's word IDs.

**Return type** numpy.array

## Examples

The file should be in this format

```
>>> : capital-common-countries
>>> Athens Greece Baghdad Iraq
>>> Athens Greece Bangkok Thailand
>>> Athens Greece Beijing China
>>> Athens Greece Berlin Germany
>>> Athens Greece Bern Switzerland
>>> Athens Greece Cairo Egypt
>>> Athens Greece Canberra Australia
>>> Athens Greece Hanoi Vietnam
>>> Athens Greece Havana Cuba
```

Get the tokenized analogy question data

```
>>> words = tl.files.load_matt_mahoney_text8_dataset()
>>> data, count, dictionary, reverse_dictionary = tl.nlp.build_words_
↳ dataset(words, vocabulary_size, True)
>>> analogy_questions = tl.nlp.read_analogies_file(eval_file='questions-words.txt
↳ ', word2id=dictionary)
>>> print(analogy_questions)
[[ 3068 1248 7161 1581]
 [ 3068 1248 28683 5642]
 [ 3068 1248 3878 486]
 ...]
```

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```
[ 1216  4309 19982 25506]
[ 1216  4309  3194  8650]
[ 1216  4309   140   312]]
```

## 2.10.6 Build vocabulary, word dictionary and word tokenization

### Build dictionary from word to id

`tensorlayer.nlp.build_vocab(data)`

Build vocabulary.

Given the context in list format. Return the vocabulary, which is a dictionary for word to id. e.g. { 'campbell': 2587, 'atlantic': 2247, 'aoun': 6746 .... }

**Parameters** `data` (*list of str*) – The context in list format

**Returns** that maps word to unique ID. e.g. { 'campbell': 2587, 'atlantic': 2247, 'aoun': 6746 .... }

**Return type** dictionary

### References

- [tensorflow.models.rnn.ptb.reader](#)

### Examples

```
>>> data_path = os.getcwd() + '/simple-examples/data'
>>> train_path = os.path.join(data_path, "ptb.train.txt")
>>> word_to_id = build_vocab(read_txt_words(train_path))
```

### Build dictionary from id to word

`tensorlayer.nlp.build_reverse_dictionary(word_to_id)`

Given a dictionary that maps word to integer id. Returns a reverse dictionary that maps a id to word.

**Parameters** `word_to_id` (*dictionary*) – that maps word to ID.

**Returns** A dictionary that maps IDs to words.

**Return type** dictionary

### Build dictionaries for id to word etc

`tensorlayer.nlp.build_words_dataset(words=None, vocabulary_size=50000, printable=True, unk_key='UNK')`

Build the words dictionary and replace rare words with 'UNK' token. The most common word has the smallest integer id.

**Parameters**

- **words** (*list of str or byte*) – The context in list format. You may need to do preprocessing on the words, such as lower case, remove marks etc.



- **vocabulary\_size** (*int*) – The maximum vocabulary size, limiting the vocabulary size. Then the script replaces rare words with ‘UNK’ token.
- **printable** (*boolean*) – Whether to print the read vocabulary size of the given words.
- **unk\_key** (*str*) – Represent the unknown words.

#### Returns

- **data** (*list of int*) – The context in a list of ID.
- **count** (*list of tuple and list*) –

##### Pair words and IDs.

- count[0] is a list : the number of rare words
- count[1:] are tuples : the number of occurrence of each word
- e.g. [['UNK', 418391], (b'the', 1061396), (b'of', 593677), (b'and', 416629), (b'one', 411764)]
- **dictionary** (*dictionary*) – It is *word\_to\_id* that maps word to ID.
- **reverse\_dictionary** (*a dictionary*) – It is *id\_to\_word* that maps ID to word.

#### Examples

```
>>> words = tl.files.load_matt_mahoney_text8_dataset()
>>> vocabulary_size = 50000
>>> data, count, dictionary, reverse_dictionary = tl.nlp.build_words_
↳dataset(words, vocabulary_size)
```

#### References

- [tensorflow/examples/tutorials/word2vec/word2vec\\_basic.py](https://github.com/tensorflow/tensorflow/blob/master/tensorflow/examples/tutorials/word2vec/word2vec_basic.py)

#### Save vocabulary

`tensorlayer.nlp.save_vocab(count=None, name='vocab.txt')`

Save the vocabulary to a file so the model can be reloaded.

**Parameters** **count** (*a list of tuple and list*) – count[0] is a list : the number of rare words, count[1:] are tuples : the number of occurrence of each word, e.g. [['UNK', 418391], (b'the', 1061396), (b'of', 593677), (b'and', 416629), (b'one', 411764)]

#### Examples

```
>>> words = tl.files.load_matt_mahoney_text8_dataset()
>>> vocabulary_size = 50000
>>> data, count, dictionary, reverse_dictionary = tl.nlp.build_words_
↳dataset(words, vocabulary_size, True)
>>> tl.nlp.save_vocab(count, name='vocab_text8.txt')
>>> vocab_text8.txt
UNK 418391
```

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```
the 1061396
of 593677
and 416629
one 411764
in 372201
a 325873
to 316376
```

## 2.10.7 Convert words to IDs and IDs to words

These functions can be done by `Vocabulary` class.

### List of Words to IDs

`tensorlayer.nlp.words_to_word_ids` (*data=None, word\_to\_id=None, unk\_key='UNK'*)

Convert a list of string (words) to IDs.

#### Parameters

- **data** (*list of string or byte*) – The context in list format
- **word\_to\_id** (*a dictionary*) – that maps word to ID.
- **unk\_key** (*str*) – Represent the unknown words.

**Returns** A list of IDs to represent the context.

**Return type** list of int

### Examples

```
>>> words = tl.files.load_matt_mahoney_text8_dataset()
>>> vocabulary_size = 50000
>>> data, count, dictionary, reverse_dictionary = tl.nlp.build_words_
↳dataset(words, vocabulary_size, True)
>>> context = [b'hello', b'how', b'are', b'you']
>>> ids = tl.nlp.words_to_word_ids(words, dictionary)
>>> context = tl.nlp.word_ids_to_words(ids, reverse_dictionary)
>>> print(ids)
[6434, 311, 26, 207]
>>> print(context)
[b'hello', b'how', b'are', b'you']
```

### References

- `tensorflow.models.rnn.ptb.reader`

### List of IDs to Words

`tensorlayer.nlp.word_ids_to_words` (*data, id\_to\_word*)

Convert a list of integer to strings (words).

**Parameters**

- **data** (*list of int*) – The context in list format.
- **id\_to\_word** (*dictionary*) – a dictionary that maps ID to word.

**Returns** A list of string or byte to represent the context.

**Return type** list of str

**Examples**

```
>>> see ``tl.nlp.words_to_word_ids``
```

## 2.10.8 Functions for translation

**Word Tokenization**

`tensorlayer.nlp.basic_tokenizer(sentence, _WORD_SPLIT=re.compile(b'[,!?"\':;>()]'))`

Very basic tokenizer: split the sentence into a list of tokens.

**Parameters**

- **sentence** (*tensorflow.python.platform.gfile.GFile Object*) –
- **\_WORD\_SPLIT** (*regular expression for word splitting.*) –

**Examples**

```
>>> see create_vocabulary
>>> from tensorflow.python.platform import gfile
>>> train_path = "wmt/giga-fren.release2"
>>> with gfile.GFile(train_path + ".en", mode="rb") as f:
>>>     for line in f:
>>>         tokens = tl.nlp.basic_tokenizer(line)
>>>         tl.logging.info(tokens)
>>>         exit()
[b'Changing', b'Lives', b'|', b'Changing', b'Society', b'|', b'How',
 b'It', b'Works', b'|', b'Technology', b'Drives', b'Change', b'Home',
 b'|', b'Concepts', b'|', b'Teachers', b'|', b'Search', b'|', b'Overview',
 b'|', b'Credits', b'|', b'HHCC', b'Web', b'|', b'Reference', b'|',
 b'Feedback', b'Virtual', b'Museum', b'of', b'Canada', b'Home', b'Page']
```

**References**

- Code from `/tensorflow/models/rnn/translation/data_utils.py`

**Create or read vocabulary**

`tensorlayer.nlp.create_vocabulary(vocabulary_path, data_path, max_vocabulary_size, tokenizer=None, normalize_digits=True, _DIGIT_RE=re.compile(b'\d'), _START_VOCAB=None)`

Create vocabulary file (if it does not exist yet) from data file.

Data file is assumed to contain one sentence per line. Each sentence is tokenized and digits are normalized (if `normalize_digits` is set). Vocabulary contains the most-frequent tokens up to `max_vocabulary_size`. We write it to `vocabulary_path` in a one-token-per-line format, so that later token in the first line gets `id=0`, second line gets `id=1`, and so on.

#### Parameters

- **vocabulary\_path** (*str*) – Path where the vocabulary will be created.
- **data\_path** (*str*) – Data file that will be used to create vocabulary.
- **max\_vocabulary\_size** (*int*) – Limit on the size of the created vocabulary.
- **tokenizer** (*function*) – A function to use to tokenize each data sentence. If `None`, `basic_tokenizer` will be used.
- **normalize\_digits** (*boolean*) – If true, all digits are replaced by 0.
- **\_DIGIT\_RE** (*regular expression function*) – Default is `re.compile(br"\d")`.
- **\_START\_VOCAB** (*list of str*) – The pad, go, eos and unk token, default is `[b"_PAD", b"_GO", b"_EOS", b"_UNK"]`.

#### References

- Code from `/tensorflow/models/rnn/translation/data_utils.py`

`tensorlayer.nlp.initialize_vocabulary(vocabulary_path)`

Initialize vocabulary from file, return the `word_to_id` (dictionary) and `id_to_word` (list).

We assume the vocabulary is stored one-item-per-line, so a file will result in a vocabulary `{"dog": 0, "cat": 1}`, and this function will also return the reversed-vocabulary `["dog", "cat"]`.

**Parameters** **vocabulary\_path** (*str*) – Path to the file containing the vocabulary.

#### Returns

- **vocab** (*dictionary*) – a dictionary that maps word to ID.
- **rev\_vocab** (*list of int*) – a list that maps ID to word.

#### Examples

```
>>> Assume 'test' contains
dog
cat
bird
>>> vocab, rev_vocab = tl.nlp.initialize_vocabulary("test")
>>> print(vocab)
>>> {b'cat': 1, b'dog': 0, b'bird': 2}
>>> print(rev_vocab)
>>> [b'dog', b'cat', b'bird']
```

**Raises** `ValueError` : if the provided `vocabulary_path` does not exist.

## Convert words to IDs and IDs to words

```
tensorlayer.nlp.sentence_to_token_ids(sentence, vocabulary, tokenizer=None,
                                       normalize_digits=True, UNK_ID=3,
                                       _DIGIT_RE=re.compile(b'\\d'))
```

Convert a string to list of integers representing token-ids.

For example, a sentence “I have a dog” may become tokenized into [“I”, “have”, “a”, “dog”] and with vocabulary {“I”: 1, “have”: 2, “a”: 4, “dog”: 7} this function will return [1, 2, 4, 7].

### Parameters

- **sentence** (*tensorflow.python.platform.gfile.GFile Object*) – The sentence in bytes format to convert to token-ids, see `basic_tokenizer()` and `data_to_token_ids()`.
- **vocabulary** (*dictionary*) – Mapping tokens to integers.
- **tokenizer** (*function*) – A function to use to tokenize each sentence. If None, `basic_tokenizer` will be used.
- **normalize\_digits** (*boolean*) – If true, all digits are replaced by 0.

**Returns** The token-ids for the sentence.

**Return type** list of int

```
tensorlayer.nlp.data_to_token_ids(data_path, target_path, vocabulary_path, tok-
                                enizer=None, normalize_digits=True, UNK_ID=3,
                                _DIGIT_RE=re.compile(b'\\d'))
```

Tokenize data file and turn into token-ids using given vocabulary file.

This function loads data line-by-line from `data_path`, calls the above `sentence_to_token_ids`, and saves the result to `target_path`. See comment for `sentence_to_token_ids` on the details of token-ids format.

### Parameters

- **data\_path** (*str*) – Path to the data file in one-sentence-per-line format.
- **target\_path** (*str*) – Path where the file with token-ids will be created.
- **vocabulary\_path** (*str*) – Path to the vocabulary file.
- **tokenizer** (*function*) – A function to use to tokenize each sentence. If None, `basic_tokenizer` will be used.
- **normalize\_digits** (*boolean*) – If true, all digits are replaced by 0.

## References

- Code from `/tensorflow/models/rnn/translation/data_utils.py`

## 2.10.9 Metrics

### BLEU

```
tensorlayer.nlp.moses_multi_bleu(hypotheses, references, lowercase=False)
```

Calculate the bleu score for hypotheses and references using the MOSES `ulti-bleu.perl` script.

### Parameters

- **hypotheses** (*numpy.array.string*) – A numpy array of strings where each string is a single example.
- **references** (*numpy.array.string*) – A numpy array of strings where each string is a single example.
- **lowercase** (*boolean*) – If True, pass the “-lc” flag to the multi-bleu script

## Examples

```
>>> hypotheses = ["a bird is flying on the sky"]
>>> references = ["two birds are flying on the sky", "a bird is on the top of the_
↪tree", "an airplane is on the sky",]
>>> score = tl.nlp.moses_multi_bleu(hypotheses, references)
```

**Returns** The BLEU score

**Return type** float

## References

- [Google/seq2seq/metric/bleu](#)

## 2.11 API - Optimizers

TensorLayer provides rich layer implementations trailed for various benchmarks and domain-specific problems. In addition, we also support transparent access to native TensorFlow parameters. For example, we provide not only layers for local response normalization, but also layers that allow user to apply `tf.nn.lrn` on `network.outputs`. More functions can be found in [TensorFlow API](#).

TensorLayer provides simple API and tools to ease research, development and reduce the time to production. Therefore, we provide the latest state of the art optimizers that work with Tensorflow.

### 2.11.1 Optimizers List

---

<code>AMSGrad([learning_rate, beta1, beta2, ...])</code>	Implementation of the AMSGrad optimization algorithm.
--	---

---

### 2.11.2 AMSGrad Optimizer

```
class tensorlayer.optimizers.AMSGrad(learning_rate=0.01,      beta1=0.9,      beta2=0.99,
                                     epsilon=1e-08,          use_locking=False,
                                     name='AMSGrad')
```

Implementation of the AMSGrad optimization algorithm.

See: [On the Convergence of Adam and Beyond](#) - [Reddi et al., 2018].

#### Parameters

- **learning\_rate** (*float*) – A Tensor or a floating point value. The learning rate.
- **beta1** (*float*) – A float value or a constant float tensor. The exponential decay rate for

the 1st moment estimates.

- **beta2** (*float*) – A float value or a constant float tensor. The exponential decay rate for the 2nd moment estimates.
- **epsilon** (*float*) – A small constant for numerical stability. This epsilon is “epsilon hat” in the Kingma and Ba paper (in the formula just before Section 2.1), not the epsilon in Algorithm 1 of the paper.
- **use\_locking** (*bool*) – If True use locks for update operations.
- **name** (*str*) – Optional name for the operations created when applying gradients. Defaults to “AMSGrad”.

## 2.12 API - Reinforcement Learning

Reinforcement Learning.

<code>discount_episode_rewards(rewards, gamma, mode)</code>	Take 1D float array of rewards and compute discounted rewards for an episode.
<code>cross_entropy_reward_loss(logits, actions, ...)</code>	Calculate the loss for Policy Gradient Network.
<code>log_weight(probs, weights[, name])</code>	Log weight.
<code>choice_action_by_probs([probs, action_list])</code>	Choice and return an an action by given the action probability distribution.

### 2.12.1 Reward functions

`tensorlayer.rein.discount_episode_rewards (rewards=None, gamma=0.99, mode=0)`

Take 1D float array of rewards and compute discounted rewards for an episode. When encount a non-zero value, consider as the end a of an episode.

#### Parameters

- **rewards** (*list*) – List of rewards
- **gamma** (*float*) – Discounted factor
- **mode** (*int*) –

**Mode for computing the discount rewards.**

- If mode == 0, reset the discount process when encount a non-zero reward (Ping-pong game).
- If mode == 1, would not reset the discount process.

**Returns** The discounted rewards.

**Return type** list of float

#### Examples

```
>>> rewards = np.asarray([0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1])
>>> gamma = 0.9
```

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```

>>> discount_rewards = tl.rein.discount_episode_rewards(rewards, gamma)
>>> print(discount_rewards)
[ 0.72899997  0.81          0.89999998  1.          0.72899997  0.81
 0.89999998  1.          0.72899997  0.81          0.89999998  1.          ]
>>> discount_rewards = tl.rein.discount_episode_rewards(rewards, gamma, mode=1)
>>> print(discount_rewards)
[ 1.52110755  1.69011939  1.87791049  2.08656716  1.20729685  1.34144104
 1.49048996  1.65610003  0.72899997  0.81          0.89999998  1.          ]

```

## 2.12.2 Cost functions

### Weighted Cross Entropy

`tensorlayer.rein.cross_entropy_reward_loss` (*logits, actions, rewards, name=None*)

Calculate the loss for Policy Gradient Network.

#### Parameters

- **logits** (*tensor*) – The network outputs without softmax. This function implements softmax inside.
- **actions** (*tensor or placeholder*) – The agent actions.
- **rewards** (*tensor or placeholder*) – The rewards.

**Returns** The TensorFlow loss function.

**Return type** Tensor

#### Examples

```

>>> states_batch_pl = tf.placeholder(tf.float32, shape=[None, D])
>>> network = InputLayer(states_batch_pl, name='input')
>>> network = DenseLayer(network, n_units=H, act=tf.nn.relu, name='relu1')
>>> network = DenseLayer(network, n_units=3, name='out')
>>> probs = network.outputs
>>> sampling_prob = tf.nn.softmax(probs)
>>> actions_batch_pl = tf.placeholder(tf.int32, shape=[None])
>>> discount_rewards_batch_pl = tf.placeholder(tf.float32, shape=[None])
>>> loss = tl.rein.cross_entropy_reward_loss(probs, actions_batch_pl, discount_
↪ rewards_batch_pl)
>>> train_op = tf.train.RMSPropOptimizer(learning_rate, decay_rate).minimize(loss)

```

### Log weight

`tensorlayer.rein.log_weight` (*probs, weights, name='log\_weight'*)

Log weight.

#### Parameters

- **probs** (*tensor*) – If it is a network output, usually we should scale it to [0, 1] via softmax.
- **weights** (*tensor*) – The weights.

**Returns** The Tensor after applying the log weighted expression.



**Return type** Tensor

### 2.12.3 Sampling functions

`tensorlayer.rein.choice_action_by_probs(probs=(0.5, 0.5), action_list=None)`

Choice and return an an action by given the action probability distribution.

**Parameters**

- **probs** (*list of float.*) – The probability distribution of all actions.
- **action\_list** (*None or a list of int or others*) – A list of action in integer, string or others. If None, returns an integer range between 0 and `len(probs)-1`.

**Returns** The chosen action.

**Return type** float int or str

#### Examples

```
>>> for _ in range(5):
>>>     a = choice_action_by_probs([0.2, 0.4, 0.4])
>>>     print(a)
0
1
1
2
1
>>> for _ in range(3):
>>>     a = choice_action_by_probs([0.5, 0.5], ['a', 'b'])
>>>     print(a)
a
b
b
```

## 2.13 API - Utility

<code>fit(sess, network, train_op, cost, X_train, ...)</code>	Training a given non time-series network by the given cost function, training data, batch_size, n_epoch etc.
<code>test(sess, network, acc, X_test, y_test, x, ...)</code>	Test a given non time-series network by the given test data and metric.
<code>predict(sess, network, X, x, y_op[, batch_size])</code>	Return the predict results of given non time-series network.
<code>evaluation([y_test, y_predict, n_classes])</code>	Input the predicted results, targets results and the number of class, return the confusion matrix, F1-score of each class, accuracy and macro F1-score.
<code>class_balancing_oversample([X_train, ...])</code>	Input the features and labels, return the features and labels after oversampling.
<code>get_random_int([min_v, max_v, number, seed])</code>	Return a list of random integer by the given range and quantity.

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Table 13 – continued from previous page

<code>dict_to_one(dp_dict)</code>	Input a dictionary, return a dictionary that all items are set to one.
<code>list_string_to_dict(string)</code>	Inputs <code>['a', 'b', 'c']</code> , returns <code>{'a': 0, 'b': 1, 'c': 2}</code> .
<code>flatten_list(list_of_list)</code>	Input a list of list, return a list that all items are in a list.
<code>exit_tensorflow([sess, port])</code>	Close TensorFlow session, TensorBoard and Nvidia-process if available.
<code>open_tensorboard([log_dir, port])</code>	Open Tensorboard.
<code>clear_all_placeholder_variables([printable])</code>	Clears all the placeholder variables of keep prob, including keeping probabilities of all dropout, denoising, dropconnect etc.
<code>set_gpu_fraction([gpu_fraction])</code>	Set the GPU memory fraction for the application.

## 2.13.1 Training, testing and predicting

### Training

```
tensorlayer.utils.fit(sess, network, train_op, cost, X_train, y_train, x, y_, acc=None,
                      batch_size=100, n_epoch=100, print_freq=5, X_val=None, y_val=None,
                      eval_train=True, tensorboard_dir=None, tensorboard_epoch_freq=5, tensor-
                      board_weight_histograms=True, tensorboard_graph_vis=True)
```

Training a given non time-series network by the given cost function, training data, batch\_size, n\_epoch etc.

- MNIST example click [here](#).
- In order to control the training details, the authors HIGHLY recommend `tl.iterate` see two MNIST examples [1](#), [2](#).

#### Parameters

- **sess** (*Session*) – TensorFlow Session.
- **network** (*TensorLayer layer*) – the network to be trained.
- **train\_op** (*TensorFlow optimizer*) – The optimizer for training e.g. `tf.train.AdamOptimizer`.
- **X\_train** (*numpy.array*) – The input of training data
- **y\_train** (*numpy.array*) – The target of training data
- **x** (*placeholder*) – For inputs.
- **y** (*placeholder*) – For targets.
- **acc** (*TensorFlow expression or None*) – Metric for accuracy or others. If None, would not print the information.
- **batch\_size** (*int*) – The batch size for training and evaluating.
- **n\_epoch** (*int*) – The number of training epochs.
- **print\_freq** (*int*) – Print the training information every `print_freq` epochs.
- **X\_val** (*numpy.array or None*) – The input of validation data. If None, would not perform validation.
- **y\_val** (*numpy.array or None*) – The target of validation data. If None, would not perform validation.

- **eval\_train** (*boolean*) – Whether to evaluate the model during training. If `X_val` and `y_val` are not `None`, it reflects whether to evaluate the model on training data.
- **tensorboard\_dir** (*string*) – path to log dir, if set, summary data will be stored to the `tensorboard_dir/` directory for visualization with tensorboard. (default `None`) Also runs `tl.layers.initialize_global_variables(sess)` internally in `fit()` to setup the summary nodes.
- **tensorboard\_epoch\_freq** (*int*) – How many epochs between storing tensorboard checkpoint for visualization to `log/` directory (default 5).
- **tensorboard\_weight\_histograms** (*boolean*) – If `True` updates tensorboard data in the `logs/` directory for visualization of the weight histograms every `tensorboard_epoch_freq` epoch (default `True`).
- **tensorboard\_graph\_vis** (*boolean*) – If `True` stores the graph in the tensorboard summaries saved to `log/` (default `True`).

## Examples

See `tutorial_mnist_simple.py`

```
>>> tl.utils.fit(sess, network, train_op, cost, X_train, y_train, x, y_,
...             acc=acc, batch_size=500, n_epoch=200, print_freq=5,
...             X_val=X_val, y_val=y_val, eval_train=False)
>>> tl.utils.fit(sess, network, train_op, cost, X_train, y_train, x, y_,
...             acc=acc, batch_size=500, n_epoch=200, print_freq=5,
...             X_val=X_val, y_val=y_val, eval_train=False,
...             tensorboard=True, tensorboard_weight_histograms=True, tensorboard_
↪graph_vis=True)
```

## Notes

If `tensorboard_dir` not `None`, the `global_variables_initializer` will be run inside the `fit` function in order to initialize the automatically generated summary nodes used for tensorboard visualization, thus `tf.global_variables_initializer().run()` before the `fit()` call will be undefined.

## Evaluation

`tensorlayer.utils.test` (*sess, network, acc, X\_test, y\_test, x, y\_, batch\_size, cost=None*)

Test a given non time-series network by the given test data and metric.

### Parameters

- **sess** (*Session*) – TensorFlow session.
- **network** (*TensorLayer layer*) – The network.
- **acc** (*TensorFlow expression or None*) –  
Metric for accuracy or others.  
– If `None`, would not print the information.
- **X\_test** (*numpy.array*) – The input of testing data.
- **y\_test** (*numpy array*) – The target of testing data
- **x** (*placeholder*) – For inputs.

- **y** (*placeholder*) – For targets.
- **batch\_size** (*int or None*) – The batch size for testing, when dataset is large, we should use minibatche for testing; if dataset is small, we can set it to None.
- **cost** (*TensorFlow expression or None*) – Metric for cost or others. If None, would not print the information.

## Examples

See `tutorial_mnist_simple.py`

```
>>> tl.utils.test(sess, network, acc, X_test, y_test, x, y_, batch_size=None, ↵
↵cost=cost)
```

## Prediction

`tensorlayer.utils.predict` (*sess, network, X, x, y\_op, batch\_size=None*)

Return the predict results of given non time-series network.

### Parameters

- **sess** (*Session*) – TensorFlow Session.
- **network** (*TensorLayer layer*) – The network.
- **X** (*numpy.array*) – The inputs.
- **x** (*placeholder*) – For inputs.
- **y\_op** (*placeholder*) – The argmax expression of softmax outputs.
- **batch\_size** (*int or None*) – The batch size for prediction, when dataset is large, we should use minibatche for prediction; if dataset is small, we can set it to None.

## Examples

See `tutorial_mnist_simple.py`

```
>>> y = network.outputs
>>> y_op = tf.argmax(tf.nn.softmax(y), 1)
>>> print(tl.utils.predict(sess, network, X_test, x, y_op))
```

## 2.13.2 Evaluation functions

`tensorlayer.utils.evaluation` (*y\_test=None, y\_predict=None, n\_classes=None*)

Input the predicted results, targets results and the number of class, return the confusion matrix, F1-score of each class, accuracy and macro F1-score.

### Parameters

- **y\_test** (*list*) – The target results
- **y\_predict** (*list*) – The predicted results
- **n\_classes** (*int*) – The number of classes

## Examples

```
>>> c_mat, fl, acc, fl_macro = tl.utils.evaluation(y_test, y_predict, n_classes)
```

### 2.13.3 Class balancing functions

`tensorlayer.utils.class_balancing_oversample` (*X\_train=None, y\_train=None, printable=True*)

Input the features and labels, return the features and labels after oversampling.

#### Parameters

- **X\_train** (*numpy.array*) – The inputs.
- **y\_train** (*numpy.array*) – The targets.

## Examples

One X

```
>>> X_train, y_train = class_balancing_oversample(X_train, y_train,
↪printable=True)
```

Two X

```
>>> X, y = tl.utils.class_balancing_oversample(X_train=np.hstack((X1, X2)), y_
↪train=y, printable=False)
>>> X1 = X[:, 0:5]
>>> X2 = X[:, 5:]
```

### 2.13.4 Random functions

`tensorlayer.utils.get_random_int` (*min\_v=0, max\_v=10, number=5, seed=None*)

Return a list of random integer by the given range and quantity.

#### Parameters

- **min\_v** (*number*) – The minimum value.
- **max\_v** (*number*) – The maximum value.
- **number** (*int*) – Number of value.
- **seed** (*int or None*) – The seed for random.

## Examples

```
>>> r = get_random_int(min_v=0, max_v=10, number=5)
[10, 2, 3, 3, 7]
```

## 2.13.5 Dictionary and list

### Set all items in dictionary to one

`tensorlayer.utils.dict_to_one(dp_dict)`

Input a dictionary, return a dictionary that all items are set to one.

Used for disable dropout, dropconnect layer and so on.

**Parameters** `dp_dict` (*dictionary*) – The dictionary contains key and number, e.g. keeping probabilities.

### Examples

```
>>> dp_dict = dict_to_one( network.all_drop )
>>> dp_dict = dict_to_one( network.all_drop )
>>> feed_dict.update(dp_dict)
```

### Convert list of string to dictionary

`tensorlayer.utils.list_string_to_dict(string)`

Inputs ['a', 'b', 'c'], returns {'a': 0, 'b': 1, 'c': 2}.

### Flatten a list

`tensorlayer.utils.flatten_list(list_of_list)`

Input a list of list, return a list that all items are in a list.

**Parameters** `list_of_list` (*a list of list*) –

### Examples

```
>>> tl.utils.flatten_list([[1, 2, 3],[4, 5],[6]])
[1, 2, 3, 4, 5, 6]
```

## 2.13.6 Close TF session and associated processes

`tensorlayer.utils.exit_tensorflow(sess=None, port=6006)`

Close TensorFlow session, TensorBoard and Nvidia-process if available.

**Parameters**

- **sess** (*Session*) – TensorFlow Session.
- **tb\_port** (*int*) – TensorBoard port you want to close, 6006 as default.

## 2.13.7 Open TensorBoard

`tensorlayer.utils.open_tensorboard(log_dir='/tmp/tensorflow', port=6006)`  
Open Tensorboard.

### Parameters

- **log\_dir** (*str*) – Directory where your tensorboard logs are saved
- **port** (*int*) – TensorBoard port you want to open, 6006 is tensorboard default

## 2.13.8 Clear TensorFlow placeholder

`tensorlayer.utils.clear_all_placeholder_variables(printable=True)`  
Clears all the placeholder variables of keep prob, including keeping probabilities of all dropout, denoising, dropconnect etc.

**Parameters** **printable** (*boolean*) – If True, print all deleted variables.

## 2.13.9 Set GPU functions

`tensorlayer.utils.set_gpu_fraction(gpu_fraction=0.3)`  
Set the GPU memory fraction for the application.

**Parameters** **gpu\_fraction** (*float*) – Fraction of GPU memory, (0 ~ 1]

### References

- [TensorFlow using GPU](#)

## 2.14 API - Visualization

TensorFlow provides [TensorBoard](#) to visualize the model, activations etc. Here we provide more functions for data visualization.

<code>read_image(image[, path])</code>	Read one image.
<code>read_images(img_list[, path, n_threads, ...])</code>	Returns all images in list by given path and name of each image file.
<code>save_image(image[, image_path])</code>	Save a image.
<code>save_images(images, size[, image_path])</code>	Save multiple images into one single image.
<code>draw_boxes_and_labels_to_image(image, ...[, ...])</code>	Draw bboxes and class labels on image.
<code>draw_mpii_pose_to_image(image, poses[, ...])</code>	Draw people(s) into image using MPII dataset format as input, return or save the result image.
<code>draw_weights([W, second, saveable, shape, ...])</code>	Visualize every columns of the weight matrix to a group of Greyscale img.
<code>CNN2d([CNN, second, saveable, name, fig_idx])</code>	Display a group of RGB or Greyscale CNN masks.
<code>frame([I, second, saveable, name, cmap, fig_idx])</code>	Display a frame.
<code>images2d([images, second, saveable, name, ...])</code>	Display a group of RGB or Greyscale images.
<code>t_sne_embedding(embeddings, reverse_dictionary)</code>	Visualize the embeddings by using t-SNE.

## 2.14.1 Save and read images

### Read one image

`tensorlayer.visualize.read_image(image, path="")`

Read one image.

#### Parameters

- **image** (*str*) – The image file name.
- **path** (*str*) – The image folder path.

**Returns** The image.

**Return type** `numpy.array`

### Read multiple images

`tensorlayer.visualize.read_images(img_list, path="", n_threads=10, printable=True)`

Returns all images in list by given path and name of each image file.

#### Parameters

- **img\_list** (*list of str*) – The image file names.
- **path** (*str*) – The image folder path.
- **n\_threads** (*int*) – The number of threads to read image.
- **printable** (*boolean*) – Whether to print information when reading images.

**Returns** The images.

**Return type** list of `numpy.array`

### Save one image

`tensorlayer.visualize.save_image(image, image_path='_temp.png')`

Save a image.

#### Parameters

- **image** (*numpy array*) – [w, h, c]
- **image\_path** (*str*) – path

### Save multiple images

`tensorlayer.visualize.save_images(images, size, image_path='_temp.png')`

Save multiple images into one single image.

#### Parameters

- **images** (*numpy array*) – (batch, w, h, c)
- **size** (*list of 2 ints*) – row and column number. number of images should be equal or less than `size[0] * size[1]`
- **image\_path** (*str*) – save path



## Examples

```
>>> import numpy as np
>>> import tensorlayer as tl
>>> images = np.random.rand(64, 100, 100, 3)
>>> tl.visualize.save_images(images, [8, 8], 'temp.png')
```

## Save image for object detection

```
tensorlayer.visualize.draw_boxes_and_labels_to_image(image, classes, coords, scores,
                                                    classes_list, is_center=True,
                                                    is_rescale=True,
                                                    save_name=None)
```

Draw bboxes and class labels on image. Return or save the image with bboxes, example in the docs of `tl.prepro`.

### Parameters

- **image** (*numpy.array*) – The RGB image [height, width, channel].
- **classes** (*list of int*) – A list of class ID (int).
- **coords** (*list of int*) –  
 A list of list for coordinates.
  - Should be [x, y, x2, y2] (up-left and botton-right format)
  - If [x\_center, y\_center, w, h] (set `is_center` to True).
- **scores** (*list of float*) – A list of score (float). (Optional)
- **classes\_list** (*list of str*) – for converting ID to string on image.
- **is\_center** (*boolean*) –

Whether the coordinates is [x\_center, y\_center, w, h]

- If coordinates are [x\_center, y\_center, w, h], set it to True for converting it to [x, y, x2, y2] (up-left and botton-right) internally.
- If coordinates are [x1, x2, y1, y2], set it to False.

- **is\_rescale** (*boolean*) –

Whether to rescale the coordinates from pixel-unit format to ratio format.

- If True, the input coordinates are the portion of width and high, this API will scale the coordinates to pixel unit internally.
- If False, feed the coordinates with pixel unit format.

- **save\_name** (*None or str*) – The name of image file (i.e. image.png), if None, not to save image.

**Returns** The saved image.

**Return type** `numpy.array`

## References

- OpenCV rectangle and putText.
- [scikit-image](#).

## Save image for pose estimation (MPII)

`tensorlayer.visualize.draw_mpii_pose_to_image(image, poses, save_name='image.png')`

Draw people(s) into image using MPII dataset format as input, return or save the result image.

This is an experimental API, can be changed in the future.

### Parameters

- **image** (*numpy.array*) – The RGB image [height, width, channel].
- **poses** (*list of dict*) – The people(s) annotation in MPII format, see `tl.files.load_mpii_pose_dataset`.
- **save\_name** (*None or str*) – The name of image file (i.e. image.png), if None, not to save image.

**Returns** The saved image.

**Return type** `numpy.array`

## Examples

```
>>> import pprint
>>> import tensorlayer as tl
>>> img_train_list, ann_train_list, img_test_list, ann_test_list = tl.files.load_
↳ mpii_pose_dataset()
>>> image = tl.vis.read_image(img_train_list[0])
>>> tl.vis.draw_mpii_pose_to_image(image, ann_train_list[0], 'image.png')
>>> pprint.pprint(ann_train_list[0])
```

## References

- [MPII Keypoints and ID](#)

## 2.14.2 Visualize model parameters

### Visualize CNN 2d filter

`tensorlayer.visualize.CNN2d(CNN=None, second=10, saveable=True, name='cnn', fig_idx=3119362)`

Display a group of RGB or Greyscale CNN masks.

### Parameters

- **CNN** (*numpy.array*) – The image. e.g: 64 5x5 RGB images can be (5, 5, 3, 64).
- **second** (*int*) – The display second(s) for the image(s), if saveable is False.
- **saveable** (*boolean*) – Save or plot the figure.

- **name** (*str*) – A name to save the image, if saveable is True.
- **fig\_idx** (*int*) – The matplotlib figure index.

## Examples

```
>>> tl.visualize.CNN2d(network.all_params[0].eval(), second=10, saveable=True,
↳name='cnn1_mnist', fig_idx=2012)
```

## Visualize weights

```
tensorlayer.visualize.draw_weights(W=None, second=10, saveable=True, shape=None,
name='mnist', fig_idx=2396512)
```

Visualize every columns of the weight matrix to a group of Greyscale img.

### Parameters

- **W** (*numpy.array*) – The weight matrix
- **second** (*int*) – The display second(s) for the image(s), if saveable is False.
- **saveable** (*boolean*) – Save or plot the figure.
- **shape** (*a list with 2 int or None*) – The shape of feature image, MNIST is [28, 80].
- **name** (*a string*) – A name to save the image, if saveable is True.
- **fig\_idx** (*int*) – matplotlib figure index.

## Examples

```
>>> tl.visualize.draw_weights(network.all_params[0].eval(), second=10,
↳saveable=True, name='weight_of_1st_layer', fig_idx=2012)
```

## 2.14.3 Visualize images

### Image by matplotlib

```
tensorlayer.visualize.frame(I=None, second=5, saveable=True, name='frame', cmap=None,
fig_idx=12836)
```

Display a frame. Make sure OpenAI Gym render() is disable before using it.

### Parameters

- **I** (*numpy.array*) – The image.
- **second** (*int*) – The display second(s) for the image(s), if saveable is False.
- **saveable** (*boolean*) – Save or plot the figure.
- **name** (*str*) – A name to save the image, if saveable is True.
- **cmap** (*None or str*) – 'gray' for greyscale, None for default, etc.
- **fig\_idx** (*int*) – matplotlib figure index.

## Examples

```
>>> env = gym.make("Pong-v0")
>>> observation = env.reset()
>>> tl.visualize.frame(observation)
```

## Images by matplotlib

`tensorlayer.visualize.images2d(images=None, second=10, saveable=True, name='images', dtype=None, fig_idx=3119362)`

Display a group of RGB or Greyscale images.

### Parameters

- **images** (*numpy.array*) – The images.
- **second** (*int*) – The display second(s) for the image(s), if saveable is False.
- **saveable** (*boolean*) – Save or plot the figure.
- **name** (*str*) – A name to save the image, if saveable is True.
- **dtype** (*None or numpy data type*) – The data type for displaying the images.
- **fig\_idx** (*int*) – matplotlib figure index.

## Examples

```
>>> X_train, y_train, X_test, y_test = tl.files.load_cifar10_dataset(shape=(-1, 32, 32, 3), plotable=False)
>>> tl.visualize.images2d(X_train[0:100, :, :, :], second=10, saveable=False, name='cifar10', dtype=np.uint8, fig_idx=20212)
```

## 2.14.4 Visualize embeddings

`tensorlayer.visualize.tsne_embedding(embeddings, reverse_dictionary, plot_only=500, second=5, saveable=False, name='tsne', fig_idx=9862)`

Visualize the embeddings by using t-SNE.

### Parameters

- **embeddings** (*numpy.array*) – The embedding matrix.
- **reverse\_dictionary** (*dictionary*) – id\_to\_word, mapping id to unique word.
- **plot\_only** (*int*) – The number of examples to plot, choice the most common words.
- **second** (*int*) – The display second(s) for the image(s), if saveable is False.
- **saveable** (*boolean*) – Save or plot the figure.
- **name** (*str*) – A name to save the image, if saveable is True.
- **fig\_idx** (*int*) – matplotlib figure index.

## Examples

```
>>> see 'tutorial_word2vec_basic.py'
>>> final_embeddings = normalized_embeddings.eval()
>>> tl.visualize.tsne_embedding(final_embeddings, labels, reverse_dictionary,
...                             plot_only=500, second=5, saveable=False, name='tsne')
```

## 2.15 API - Database

This is the alpha version of database management system. If you have any trouble, please ask for help at [tensorlayer@gmail.com](mailto:tensorlayer@gmail.com).

### 2.15.1 Why Database

TensorLayer is designed for real world production, capable of large scale machine learning applications. TensorLayer database is introduced to address the many data management challenges in the large scale machine learning projects, such as:

1. Finding training data from an enterprise data warehouse.
2. Loading large datasets that are beyond the storage limitation of one computer.
3. Managing different models with version control, and comparing them(e.g. accuracy).
4. Automating the process of training, evaluating and deploying machine learning models.

With the TensorLayer system, we introduce this database technology to address the challenges above.

The database management system is designed with the following three principles in mind.

### Everything is Data

Data warehouses can store and capture the entire machine learning development process. The data can be categorized as:

1. Dataset: This includes all the data used for training, validation and prediction. The labels can be manually specified or generated by model prediction.
2. Model architecture: The database includes a table that stores different model architectures, enabling users to reuse the many model development works.
3. Model parameters: This database stores all the model parameters of each epoch in the training step.
4. Tasks: A project usually include many small tasks. Each task contains the necessary information such as hyper-parameters for training or validation. For a training task, typical information includes training data, the model parameter, the model architecture, how many epochs the training task has. Validation, testing and inference are also supported by the task system.
5. Loggings: The logs store all the metrics of each machine learning model, such as the time stamp, loss and accuracy of each batch or epoch.

TensorLayer database in principle is a keyword based search engine. Each model, parameter, or training data is assigned many tags. The storage system organizes data into two layers: the index layer, and the blob layer. The index layer stores all the tags and references to the blob storage. The index layer is implemented based on NoSQL document database such as MongoDB. The blob layer stores videos, medical images or label masks in large chunk size, which

is usually implemented based on a file system. Our database is based on MongoDB. The blob system is based on the GridFS while the indexes are stored as documents.

### Everything is identified by Query

Within the database framework, any entity within the data warehouse, such as the data, model or tasks is specified by the database query language. As a reference, the query is more space efficient for storage and it can specify multiple objects in a concise way. Another advantage of such a design is enabling a highly flexible software system. Many system can be implemented by simply rewriting different components, with many new applications can be implemented just by update the query without modification of any application code.

## 2.15.2 Preparation

In principle, the database can be implemented by any document oriented NoSQL database system. The existing implementation is based on MongoDB. Further implementations on other databases will be released depending on the progress. It will be straightforward to port our database system to Google Cloud, AWS and Azure. The following tutorials are based on the MongoDB implementation.

### Installing and running MongoDB

The installation instruction of MongoDB can be found at [MongoDB Docs](#). There are also many MongoDB services from Amazon or GCP, such as Mongo Atlas from MongoDB User can also use docker, which is a powerful tool for [deploying software](#) . After installing MongoDB, a MongoDB management tool with graphic user interface will be extremely useful. Users can also install Studio3T(MongoChef), which is powerful user interface tool for MongoDB and is free for non-commercial use [studio3t](#).

## 2.15.3 Tutorials

### Connect to the database

Similar with MongoDB management tools, IP and port number are required for connecting to the database. To distinguish the different projects, the database instances have a `project_name` argument. In the following example, we connect to MongoDB on a local machine with the IP `localhost`, and port 27017 (this is the default port number of MongoDB).

```
db = tl.db.TensorHub(ip='localhost', port=27017, dbname='temp',
                    username=None, password='password', project_name='tutorial')
```

### Dataset management

You can save a dataset into the database and allow all machines to access it. Apart from the dataset key, you can also insert a custom argument such as version and description, for better managing the datasets. Note that, all saving functions will automatically save a timestamp, allowing you to load staff (data, model, task) using the timestamp.

```
db.save_dataset(dataset=[X_train, y_train, X_test, y_test], dataset_name='mnist',
               ↳description='this is a tutorial')
```

After saving the dataset, others can access the dataset as followed:

```
dataset = db.find_dataset('mnist')
dataset = db.find_dataset('mnist', version='1.0')
```

If you have multiple datasets that use the same dataset key, you can get all of them as followed:

```
datasets = db.find_all_datasets('mnist')
```

## Model management

Save model architecture and parameters into database. The model architecture is represented by a TL graph, and the parameters are stored as a list of array.

```
db.save_model(net, accuracy=0.8, loss=2.3, name='second_model')
```

After saving the model into database, we can load it as follow:

```
net = db.find_model(sess=sess, accuracy=0.8, loss=2.3)
```

If there are many models, you can use MongoDB's 'sort' method to find the model you want. To get the newest or oldest model, you can sort by time:

```
## newest model

net = db.find_model(sess=sess, sort=[("time", pymongo.DESCENDING)])
net = db.find_model(sess=sess, sort=[("time", -1)])

## oldest model

net = db.find_model(sess=sess, sort=[("time", pymongo.ASCENDING)])
net = db.find_model(sess=sess, sort=[("time", 1)])
```

If you save the model along with accuracy, you can get the model with the best accuracy as followed:

```
net = db.find_model(sess=sess, sort=[("test_accuracy", -1)])
```

To delete all models in a project:

```
db.delete_model()
```

If you want to specify which model you want to delete, you need to put arguments inside.

## Event / Logging management

Save training log:

```
db.save_training_log(accuracy=0.33)
db.save_training_log(accuracy=0.44)
```

Delete logs that match the requirement:

```
db.delete_training_log(accuracy=0.33)
```

Delete all logging of this project:

```
db.delete_training_log()
db.delete_validation_log()
db.delete_testing_log()
```

## Task distribution

A project usually consists of many tasks such as hyper parameter selection. To make it easier, we can distribute these tasks to several GPU servers. A task consists of a task script, hyper parameters, desired result and a status.

A task distributor can push both dataset and tasks into a database, allowing task runners on GPU servers to pull and run. The following is an example that pushes 3 tasks with different hyper parameters.

```
## save dataset into database, then allow other servers to use it
X_train, y_train, X_val, y_val, X_test, y_test = tl.files.load_mnist_dataset(shape=(-
↳1, 784))
db.save_dataset((X_train, y_train, X_val, y_val, X_test, y_test), 'mnist',
↳description='handwriting digit')

## push tasks into database, then allow other servers pull tasks to run
db.create_task(
    task_name='mnist', script='task_script.py', hyper_parameters=dict(n_units1=800, n_
↳units2=800),
    saved_result_keys=['test_accuracy'], description='800-800'
)

db.create_task(
    task_name='mnist', script='task_script.py', hyper_parameters=dict(n_units1=600, n_
↳units2=600),
    saved_result_keys=['test_accuracy'], description='600-600'
)

db.create_task(
    task_name='mnist', script='task_script.py', hyper_parameters=dict(n_units1=400, n_
↳units2=400),
    saved_result_keys=['test_accuracy'], description='400-400'
)

## wait for tasks to finish
while db.check_unfinished_task(task_name='mnist'):
    print("waiting runners to finish the tasks")
    time.sleep(1)

## you can get the model and result from database and do some analysis at the end
```

The task runners on GPU servers can monitor the database, and run the tasks immediately when they are made available. In the task script, we can save the final model and results to the database, this allows task distributors to get the desired model and results.

```
## monitors the database and pull tasks to run
while True:
    print("waiting task from distributor")
    db.run_task(task_name='mnist', sort= [("time", -1)])
    time.sleep(1)
```



## Example codes

See [here](#).

### 2.15.4 TensorHub API

```
class tensorlayer.db.TensorHub(ip='localhost', port=27017, dbname='dbname', user-
                               name=None, password='password', project_name=None)
```

It is a MongoDB based manager that help you to manage data, network architecture, parameters and logging.

#### Parameters

- **ip** (*str*) – Localhost or IP address.
- **port** (*int*) – Port number.
- **dbname** (*str*) – Database name.
- **username** (*str or None*) – User name, set to None if you do not need authentication.
- **password** (*str*) – Password.
- **project\_name** (*str or None*) – Experiment key for this entire project, similar with the repository name of Github.

**ip, port, dbname and other input parameters**

*see above* – See above.

**project\_name**

*str* – The given project name, if no given, set to the script name.

**db**

*mongodb client* – See pymongo.MongoClient.

**check\_unfinished\_task** (*task\_name=None, \*\*kwargs*)

Finds and runs a pending task.

#### Parameters

- **task\_name** (*str*) – The task name.
- **kwargs** (*other parameters*) – Users customized parameters such as description, version number.

## Examples

Wait until all tasks finish in user's local console

```
>>> while not db.check_unfinished_task():
>>>     time.sleep(1)
>>> print("all tasks finished")
>>> sess = tf.InteractiveSession()
>>> net = db.find_top_model(sess=sess, sort=[("test_accuracy", -1)])
>>> print("the best accuracy {} is from model {}".format(net._test_accuracy,
↵net._name))
```

**Returns boolean**

**Return type** True for success, False for fail.

**create\_task** (*task\_name=None, script=None, hyper\_parameters=None, saved\_result\_keys=None, \*\*kwargs*)

Uploads a task to the database, timestamp will be added automatically.

#### Parameters

- **task\_name** (*str*) – The task name.
- **script** (*str*) – File name of the python script.
- **hyper\_parameters** (*dictionary*) – The hyper parameters pass into the script.
- **saved\_result\_keys** (*list of str*) – The keys of the task results to keep in the database when the task finishes.
- **kwargs** (*other parameters*) – Users customized parameters such as description, version number.

#### Examples

Uploads a task >>> db.create\_task(task\_name='mnist', script='example/tutorial\_mnist\_simple.py', description='simple tutorial')

Finds and runs the latest task >>> db.run\_top\_task(sess=sess, sort=[("time", pymongo.DESCENDING)])  
>>> db.run\_top\_task(sess=sess, sort=[("time", -1)])

Finds and runs the oldest task >>> db.run\_top\_task(sess=sess, sort=[("time", pymongo.ASCENDING)])  
>>> db.run\_top\_task(sess=sess, sort=[("time", 1)])

**delete\_datasets** (*\*\*kwargs*)

Delete datasets.

**Parameters** **kwargs** (*logging information*) – Find items to delete, leave it empty to delete all log.

**delete\_model** (*\*\*kwargs*)

Delete model.

**Parameters** **kwargs** (*logging information*) – Find items to delete, leave it empty to delete all log.

**delete\_tasks** (*\*\*kwargs*)

Delete tasks.

**Parameters** **kwargs** (*logging information*) – Find items to delete, leave it empty to delete all log.

#### Examples

```
>>> db.delete_tasks()
```

**delete\_testing\_log** (*\*\*kwargs*)

Deletes testing log.

**Parameters** **kwargs** (*logging information*) – Find items to delete, leave it empty to delete all log.

## Examples

- see `save_training_log`.

**delete\_training\_log** (*\*\*kwargs*)

Deletes training log.

**Parameters** **kwargs** (*logging information*) – Find items to delete, leave it empty to delete all log.

## Examples

Save training log >>> `db.save_training_log(accuracy=0.33)` >>> `db.save_training_log(accuracy=0.44)`

Delete logs that match the requirement >>> `db.delete_training_log(accuracy=0.33)`

Delete all logs >>> `db.delete_training_log()`

**delete\_validation\_log** (*\*\*kwargs*)

Deletes validation log.

**Parameters** **kwargs** (*logging information*) – Find items to delete, leave it empty to delete all log.

## Examples

- see `save_training_log`.

**find\_datasets** (*dataset\_name=None, \*\*kwargs*)

Finds and returns all datasets from the database which matches the requirement. In some case, the data in a dataset can be stored separately for better management.

### Parameters

- **dataset\_name** (*str*) – The name/key of dataset.
- **kwargs** (*other events*) – Other events, such as description, author and etc (optional).

### Returns params

**Return type** the parameters, return False if nothing found.

**find\_top\_dataset** (*dataset\_name=None, sort=None, \*\*kwargs*)

Finds and returns a dataset from the database which matches the requirement.

### Parameters

- **dataset\_name** (*str*) – The name of dataset.
- **sort** (*List of tuple*) – PyMongo sort comment, search “PyMongo find one sorting” and [collection level operations](#) for more details.
- **kwargs** (*other events*) – Other events, such as description, author and etc (optional).

## Examples

Save dataset >>> db.save\_dataset([X\_train, y\_train, X\_test, y\_test], 'mnist', description='this is a tutorial')

Get dataset >>> dataset = db.find\_top\_dataset('mnist') >>> datasets = db.find\_datasets('mnist')

**Returns dataset** – Return False if nothing found.

**Return type** the dataset or False

**find\_top\_model** (*sess*, *sort=None*, *model\_name='model'*, *\*\*kwargs*)

Finds and returns a model architecture and its parameters from the database which matches the requirement.

### Parameters

- **sess** (*Session*) – TensorFlow session.
- **sort** (*List of tuple*) – PyMongo sort comment, search “PyMongo find one sorting” and [collection level operations](#) for more details.
- **model\_name** (*str or None*) – The name/key of model.
- **kwargs** (*other events*) – Other events, such as name, accuracy, loss, step number and etc (optinal).

## Examples

- see `save_model`.

**Returns network** – Note that, the returned network contains all information of the document (record), e.g. if you saved accuracy in the document, you can get the accuracy by using `net._accuracy`.

**Return type** TensorLayer layer

**run\_top\_task** (*task\_name=None*, *sort=None*, *\*\*kwargs*)

Finds and runs a pending task that in the first of the sorting list.

### Parameters

- **task\_name** (*str*) – The task name.
- **sort** (*List of tuple*) – PyMongo sort comment, search “PyMongo find one sorting” and [collection level operations](#) for more details.
- **kwargs** (*other parameters*) – Users customized parameters such as description, version number.

## Examples

Monitors the database and pull tasks to run >>> while True: >>> print(“waiting task from distributor”)  
>>> db.run\_top\_task(task\_name='mnist', sort=[(“time”, -1)]) >>> time.sleep(1)

**Returns boolean**

**Return type** True for success, False for fail.

**save\_dataset** (*dataset=None*, *dataset\_name=None*, *\*\*kwargs*)

Saves one dataset into database, timestamp will be added automatically.

**Parameters**

- **dataset** (*any type*) – The dataset you want to store.
- **dataset\_name** (*str*) – The name of dataset.
- **kwargs** (*other events*) – Other events, such as description, author and etc (optinal).

**Examples**

Save dataset >>> db.save\_dataset([X\_train, y\_train, X\_test, y\_test], 'mnist', description='this is a tutorial')

Get dataset >>> dataset = db.find\_top\_dataset('mnist')

**Returns boolean**

**Return type** Return True if save success, otherwise, return False.

**save\_model** (*network=None, model\_name='model', \*\*kwargs*)

Save model architecture and parameters into database, timestamp will be added automatically.

**Parameters**

- **network** (*TensorLayer layer*) – TensorLayer layer instance.
- **model\_name** (*str*) – The name/key of model.
- **kwargs** (*other events*) – Other events, such as name, accuracy, loss, step number and etc (optinal).

**Examples**

Save model architecture and parameters into database. >>> db.save\_model(net, accuracy=0.8, loss=2.3, name='second\_model')

Load one model with parameters from database (run this in other script) >>> net = db.find\_top\_model(sess=sess, accuracy=0.8, loss=2.3)

Find and load the latest model. >>> net = db.find\_top\_model(sess=sess, sort=[("time", pymongo.DESCENDING)]) >>> net = db.find\_top\_model(sess=sess, sort=[("time", -1)])

Find and load the oldest model. >>> net = db.find\_top\_model(sess=sess, sort=[("time", pymongo.ASCENDING)]) >>> net = db.find\_top\_model(sess=sess, sort=[("time", 1)])

Get model information >>> net.\_accuracy ... 0.8

**Returns boolean**

**Return type** True for success, False for fail.

**save\_testing\_log** (*\*\*kwargs*)

Saves the testing log, timestamp will be added automatically.

**Parameters** **kwargs** (*logging information*) – Events, such as accuracy, loss, step number and etc.

**Examples**

```
>>> db.save_testing_log(accuracy=0.33, loss=0.98)
```

**save\_training\_log** (*\*\*kwargs*)

Saves the training log, timestamp will be added automatically.

**Parameters** **kwargs** (*logging information*) – Events, such as accuracy, loss, step number and etc.

### Examples

```
>>> db.save_training_log(accuracy=0.33, loss=0.98)
```

**save\_validation\_log** (*\*\*kwargs*)

Saves the validation log, timestamp will be added automatically.

**Parameters** **kwargs** (*logging information*) – Events, such as accuracy, loss, step number and etc.

### Examples

```
>>> db.save_validation_log(accuracy=0.33, loss=0.98)
```

---

## Command-line Reference

---

TensorLayer provides a handy command-line tool *tl* to perform some common tasks.

### 3.1 CLI - Command Line Interface

The `tensorlayer.cli` module provides a command-line tool for some common tasks.

#### 3.1.1 `tl train`

(Alpha release - usage might change later)

The `tensorlayer.cli.train` module provides the `tl train` subcommand. It helps the user bootstrap a TensorFlow/TensorLayer program for distributed training using multiple GPU cards or CPUs on a computer.

You need to first setup the `CUDA_VISIBLE_DEVICES` to tell `tl train` which GPUs are available. If the `CUDA_VISIBLE_DEVICES` is not given, `tl train` would try best to discover all available GPUs.

In distribute training, each TensorFlow program needs a `TF_CONFIG` environment variable to describe the cluster. It also needs a master daemon to monitor all trainers. `tl train` is responsible for automatically managing these two tasks.

#### Usage

`tl train [-h] [-p NUM_PSS] [-c CPU_TRAINERS] <file> [args [args ...]]`

```
# example of using GPU 0 and 1 for training mnist
CUDA_VISIBLE_DEVICES="0,1"
tl train example/tutorial_mnist_distributed.py

# example of using CPU trainers for inception v3
tl train -c 16 example/tutorial_imagenet_inceptionV3_distributed.py
```

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```
# example of using GPU trainers for inception v3 with customized arguments
# as CUDA_VISIBLE_DEVICES is not given, tl would try to discover all available GPUs
tl train example/tutorial_imagenet_inceptionV3_distributed.py -- --batch_size 16
```

## Command-line Arguments

- `file`: python file path.
- `NUM_PSS` : The number of parameter servers.
- `CPU_TRAINERS`: The number of CPU trainers.  
It is recommended that `NUM_PSS + CPU_TRAINERS <= cpu count`
- `args`: Any parameter after `--` would be passed to the python program.

## Notes

A parallel training program would require multiple parameter servers to help parallel trainers to exchange intermediate gradients. The best number of parameter servers is often proportional to the size of your model as well as the number of CPUs available. You can control the number of parameter servers using the `-p` parameter.

If you have a single computer with massive CPUs, you can use the `-c` parameter to enable CPU-only parallel training. The reason we are not supporting GPU-CPU co-training is because GPU and CPU are running at different speeds. Using them together in training would incur stragglers.



## CHAPTER 4

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