TensorFlow and Keras

CMPT 498/820 Machine Learning
Tutorial 8

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1 TensorFlow

TensorFlow is an interface for expressing machine learning algorithms, and an implementation for executing such algorithms (Abadi et al., 2015).

- Represents computations as **graphs**
- Nodes in the graph are called **ops**
- Edges are tensors
- Represents data as **tensors**
- A tensor is an n-dimensional array with a rank, shape and type.
- For example [batch, height, width, channels]
- Executes graphs in the context of **sessions**
- A session places the graph ops onto devices such as CPUs/GPUs etc.
- Maintains state with **variables**
- Typically represent the parameters of a statistical model as a set of variables
- Uses **feeds** and **fetches** to get data into and out of arbitrary operations.

1.1 TensorFlow Example I

```
In [1]: %matplotlib inline
        import tensorflow as tf

        # Define two constants
        matrix1 = tf.constant([[3., 3.]])
        matrix2 = tf.constant([[2.],[2.]])

        # Define a matmul operation
        product = tf.matmul(matrix1, matrix2)

        # Launch the default graph.
        sess = tf.Session()

        # Run the matmul operation
        result = sess.run(product)
        print(result)
```

```
        # Close the Session.
        sess.close()
```

```
[[ 12.]]
```

1.2 TensorFlow Example II

```
In [2]: state = tf.Variable(0.0, name="counter")
        inc = tf.placeholder(tf.float32)
        new_value = tf.add(state, inc)
        update = tf.assign(state, new_value)
        init_op = tf.initialize_all_variables()
        # Launch the graph
        with tf.Session() as sess:
            with tf.device("/gpu:0"):
                # Run the init op
                sess.run(init_op)
                # Run the op that updates state
                for _ in range(3):
                    sess.run([update],feed_dict={inc:0.5})
                    print(sess.run(state))
```

```
0.5
1.0
1.5
```

1.3 Autoencoder in TensorFlow

```
In [3]: import tensorflow as tf
        import numpy as np
        import matplotlib.pyplot as plt
```

Import data

```
In [4]: from tensorflow.examples.tutorials.mnist import input_data
        mnist = input_data.read_data_sets("/tmp/data/", one_hot=True)
```

```
Extracting /tmp/data/train-images-idx3-ubyte.gz
Extracting /tmp/data/train-labels-idx1-ubyte.gz
Extracting /tmp/data/t10k-images-idx3-ubyte.gz
Extracting /tmp/data/t10k-labels-idx1-ubyte.gz
```

Hyperparameters

```
In [5]: # Parameters
        learning_rate = 0.05
        training_epochs = 30
        batch_size = 64
        display_step = 10
        examples_to_show = 10

        # Network Parameters
        n_hidden_1 = 64 # 1st layer num features
        n_input = 784 # MNIST data input (img shape: 28*28)
```

Construct the graph

```
In [6]: # tf Graph input (only pictures)
        X = tf.placeholder("float", [None, n_input])

        weights = {
            'encoder_h1': tf.Variable(tf.random_normal([n_input, n_hidden_1])),
            'decoder_h1': tf.Variable(tf.random_normal([n_hidden_1, n_input])),

        }
        biases = {
            'encoder_b1': tf.Variable(tf.random_normal([n_hidden_1])),
            'decoder_b1': tf.Variable(tf.random_normal([n_input])),

        }


        # Building the encoder
        def encoder(x):
            # Encoder Hidden layer with sigmoid activation #1
            layer_1 = tf.nn.sigmoid(tf.add(tf.matmul(x, weights['encoder_h1']),
                                           biases['encoder_b1']))
            return layer_1


        # Building the decoder
        def decoder(x):
            # Encoder Hidden layer with sigmoid activation #1
            layer_1 = tf.nn.sigmoid(tf.add(tf.matmul(x, weights['decoder_h1']),
                                           biases['decoder_b1']))
            return layer_1

        # Construct model
        encoder_op = encoder(X)
        decoder_op = decoder(encoder_op)
```

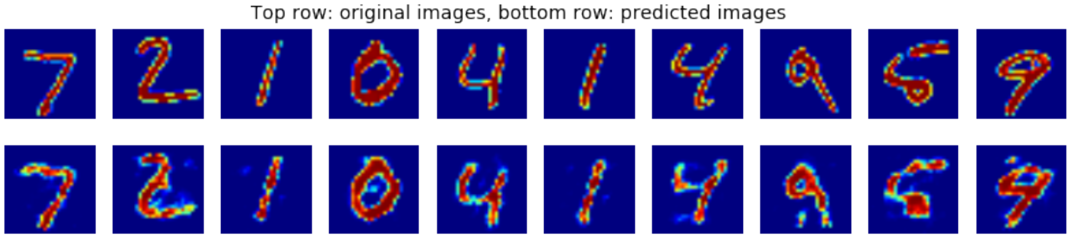
```
# Prediction
y_pred = decoder_op
# Targets (Labels) are the input data.
y_true = X
# Define loss and optimizer, minimize the squared error
cost = tf.reduce_mean(tf.pow(y_true - y_pred, 2))

# Create an optimizer with the desired parameters.
optimizer = tf.train.RMSPropOptimizer(learning_rate).minimize(cost)


# Initializing the variables
init = tf.initialize_all_variables()
```

Execute the graph

```
In [7]: # Launch the graph
        with tf.Session() as sess:
            sess.run(init)
            total_batch = int(mnist.train.num_examples/batch_size)
            # Training cycle
            for epoch in range(training_epochs):
                # Loop over all batches
                for i in range(total_batch):
                    batch_xs, batch_ys = mnist.train.next_batch(batch_size)
                    # Run optimization op (backprop) and cost op (to get loss value
                    _, c = sess.run([optimizer, cost], feed_dict={X: batch_xs})


                # Display logs per epoch step
                if epoch % display_step == 0:
                    print("Epoch:", '%04d' % (epoch+1),
                          "cost=", "{:.9f}".format(c))

            print("Optimization Finished!")

            # Applying encode and decode over test set
            encode_decode = sess.run(
                y_pred, feed_dict={X: mnist.test.images[:examples_to_show]})
            # Compare original images with their reconstructions
            f, a = plt.subplots(2, 10,frameon=False, figsize=(10, 2))
            f.suptitle('Top row: original images, bottom row: predicted images')
            for i in range(examples_to_show):
                a[0][i].imshow(np.reshape(mnist.test.images[i], (28, 28)))
                a[1][i].imshow(np.reshape(encode_decode[i], (28, 28)))
                a[0][i].axis('off')
                a[1][i].axis('off')
```

```
            plt.draw()
```

```
Epoch: 0001 cost= 0.064531557
Epoch: 0011 cost= 0.028448787
Epoch: 0021 cost= 0.023096683
Optimization Finished!
```



2 Keras

Keras is a high-level library that can utilize TensorFlow or Theano as its backend. Here we train a simple deep NN on the MNIST dataset.

Imports

```
In [8]: import numpy as np
        np.random.seed(1337)  # for reproducibility

        from keras.datasets import mnist
        from keras.models import Sequential
        from keras.layers.core import Dense, Dropout, Activation
        from keras.optimizers import SGD, Adam, RMSprop
        from keras.callbacks import TensorBoard
        from keras.utils import np_utils
```

```
Using TensorFlow backend.
```

Hyperparameters

```
In [9]: batch_size = 128
        nb_classes = 10
        nb_epoch = 20
```

Preprocessing

```
In [10]: # the data, shuffled and split between train and test sets
         (X_train, y_train), (X_test, y_test) = mnist.load_data()

         X_train = X_train.reshape(60000, 784)
         X_test = X_test.reshape(10000, 784)
         X_train = X_train.astype('float32')
         X_test = X_test.astype('float32')
         X_train /= 255
         X_test /= 255
         print(X_train.shape[0], 'train samples')
         print(X_test.shape[0], 'test samples')

         # convert class vectors to binary class matrices
         Y_train = np_utils.to_categorical(y_train, nb_classes)
         Y_test = np_utils.to_categorical(y_test, nb_classes)
```

```
60000 train samples
10000 test samples
```

Model Creation

```
In [11]: model = Sequential()
         model.add(Dense(512, input_shape=(784,)))
         model.add(Activation('relu'))
         model.add(Dropout(0.2))
         model.add(Dense(512))
         model.add(Activation('relu'))
         model.add(Dropout(0.2))
         model.add(Dense(10))
         model.add(Activation('softmax'))
```

```
In [12]: model.compile(loss='categorical_crossentropy',
                       optimizer=RMSprop(),
                       metrics=['accuracy'])
```

Train and Evaluate

```
In [13]: history = model.fit(X_train, Y_train,
                             batch_size=batch_size, nb_epoch=nb_epoch,
                             verbose=0, validation_data=(X_test, Y_test),
                             callbacks=[TensorBoard(log_dir='./logs',
                                                    histogram_freq=0,
                                                    write_graph=True,
                                                    write_images=False)])
         score = model.evaluate(X_test, Y_test, verbose=0)
         print('Test score:', score[0])
         print('Test accuracy:', score[1])
```

```
Test score: 0.109998893419
Test accuracy: 0.9841
```

Go to a terminal and type

```
tensorboard --logdir=./logs
```

then open the address given by the above command (usually localhost:6006) using Google Chrome.