# Deep Learning 182, HW #1

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## 1 Network architecture

In our graph we used convolutional layers. The input image is of size 28*28.

```
new_input = tf.reshape(input_images, [-1, 28, 28, 1])
```

We defined the following hidden layers:

1. Convolutional Layer 1:
   We used 32 filters, each filter is a kernel of size 5*5. Each neuron in this layer is a result (scalar) of a convolution of each kernel centered on one neuron in the input layer. Thus, this layer consists of 28*28*32 neurons. We then compute the activation function relu on the result of each neuron:

```
    conv1 = tf.layers.conv2d(
            inputs=new_input,
            filters=32,
            kernel_size=[5, 5],
            padding="same",
            activation=tf.nn.relu)
```

2. Pooling Layer 1:
   Here we reduce the spatial size of the conv. layer by using a Max Pooling filter of size 2*2 and apply the maximum value of each 2*2 sized part of the image (Convolutional Layer 1). After this step we will have 14*14*32 neurons.:

```
pool1 = tf.layers.max_pooling2d(inputs=conv1, pool_size=[2, 2], strides=2)
```

3. Convolutional Layer 2:
   Here we used 64 filters, each filter is a kernel of size 5*5:

```
  conv2 = tf.layers.conv2d(
        inputs=pool1,
        filters=64,
        kernel_size=[5, 5],
        padding="same",
        activation=tf.nn.relu)
```

4. Pooling Layer 2:
   After this step we will have 7*7*64 neurons:

```
        pool2 = tf.layers.max_pooling2d(inputs=conv2, pool_size=[2, 2], strides=2)
```

5. Reshaping:

```
            pool2_flat = tf.reshape(pool2, [-1, 7 * 7 * 64])
```

6. Dense:
   This layer is fully connected: we picked 1024 neurons in this layer that are fully connected to the neurons from the previous layer (”Pooling Layer 2”):

```
            dense = tf.layers.dense(inputs=pool2_flat, units=1024, activation=tf.nn
    .relu)
```

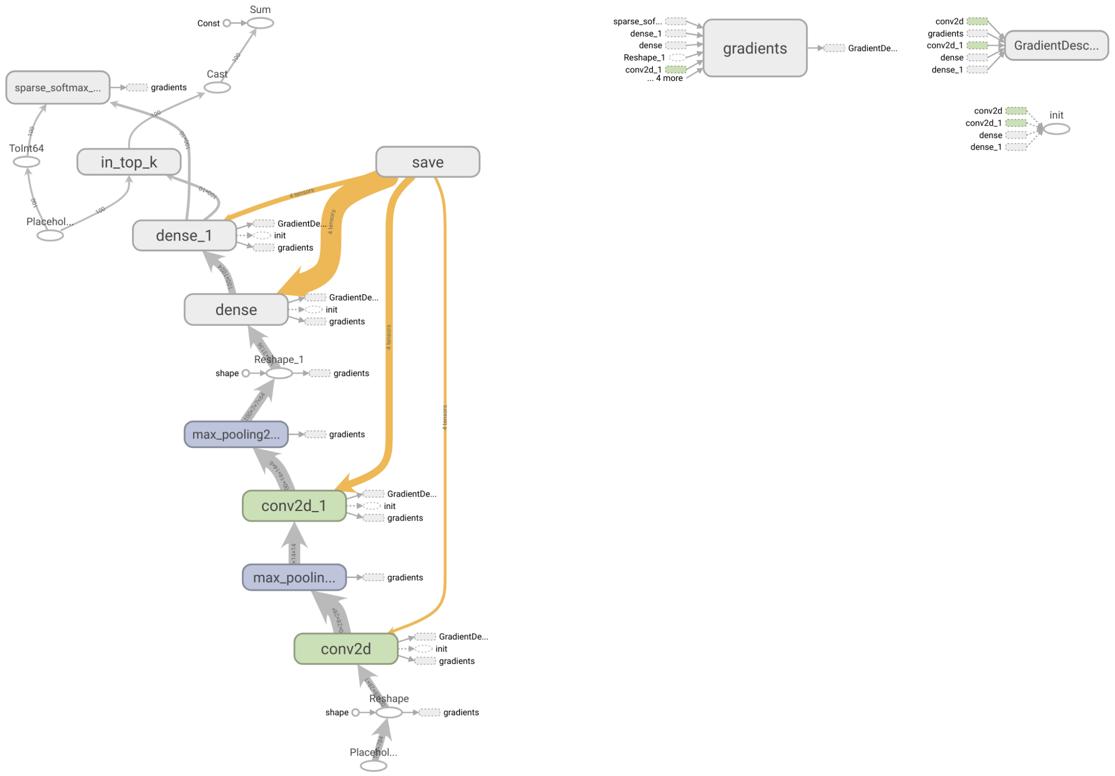
7. Dropout: Method to reduce overfitting. At each training stage, individual nodes are either ”dropped out” of the net or kept.

```
     dropout = tf.layers.dropout(inputs=dense, rate=0.2)
```

8. Output:
   The output layer is 10 neurons, each neuron is a classifier for one digit. This layer is full connected to the previous layer:

```
     logits = tf.layers.dense(inputs=dropout, units=10)
```

Figure 1: Architecture Description Graph



## 2 Results

At first we started with 32 filters in the second convolutional layer, we saw that increasing the number of filters to 64 improve our results.
Another improvement was made by adding the drop-out layer.
Below are the script results after running with 100 batches and 4000 steps to run the trainer, reaching precision of 0.97:

Training Data Eval:
Num examples: 55000 Num correct: 53798 Precision @ 1: 0.9781
Validation Data Eval:
Num examples: 5000 Num correct: 4896 Precision @ 1: 0.9792
Test Data Eval:
Num examples: 10000 Num correct: 9778 Precision @ 1: 0.9778

Figure 2: Loss Function Graph

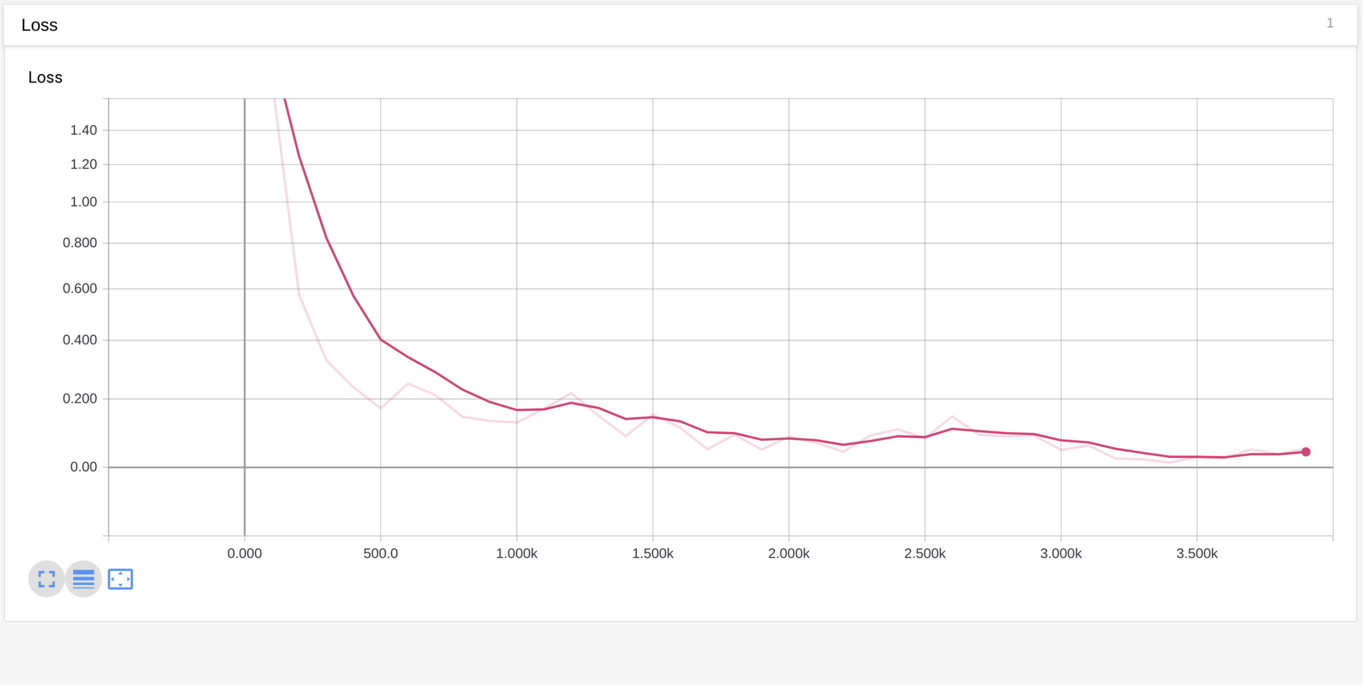
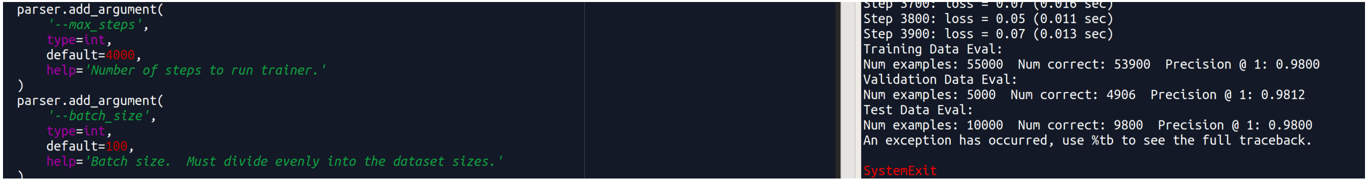


Figure 3: Console results and parameters:



```
parser.add_argument(
    '--max_steps',
    type=int,
    default=4000,
    help='Number of steps to run trainer.'
)
parser.add_argument(
    '--batch_size',
    type=int,
    default=100,
    help='Batch size.  Must divide evenly into the dataset sizes.'
)
```

```
Step 3700: loss = 0.07 (0.016 sec)
Step 3800: loss = 0.05 (0.011 sec)
Step 3900: loss = 0.07 (0.013 sec)
Training Data Eval:
Num examples: 55000  Num correct: 53900  Precision @ 1: 0.9800
Validation Data Eval:
Num examples: 5000  Num correct: 4906  Precision @ 1: 0.9812
Test Data Eval:
Num examples: 10000  Num correct: 9800  Precision @ 1: 0.9800
An exception has occurred, use %tb to see the full traceback.

SystemExit
```