LabMNIST_Final-v2

May 14, 2018

In [1]:
```
#  MNIST tutorial (handwritten printed digits recognition tutorial)
#  modified from
#  https://elitedatascience.com/keras-tutorial-deep-learning-in-python
#  for SDSC SI2017

# ----------- IMPORT STATEMENTS ---------------
import numpy as np
np.random.seed(1)  # for reproducibility

from keras.models import Sequential               #Sequential models are the standard st
from keras.layers import Dense, Dropout, Activation, Flatten   #These are core layer spe
from keras.layers import Convolution2D, MaxPooling2D           #These are convolution la
from keras.utils import np_utils                          #Some utilities
from keras import optimizers                              #For training algorithm
#-------------------------------------------
print('import done')
```

```
Using TensorFlow backend.
```

```
import done
```

In [2]:
```
#--------------- LOAD and PREPARE DATA STATEMENTS ----------------
# Load some numpy arrays that have the MNIST data
#  (these are subsets extracted from the MNIST data set in Keras)
X_train=np.load('X_train5k.npy')
Y_train=np.load('Y_train5k.npy')
X_test =np.load('X_test.npy')
Y_test =np.load('Y_test.npy')

print(X_train.shape)     #review the dimensions Note python3 uses print(X..) python 2 us

#save a few training images with the label in the file name
from PIL import Image
for i in range(0,3):
   im = Image.fromarray(X_train[i,:,:])
   im.save("Xtrain_num"+str(i)+"_cat_"+str(Y_train[i])+".jpeg")
print('img load done')
```

```
(5000, 28, 28)
img load done
```

In [3]:
```
# --------- Reshape input data ------------
#  b/c Keras expects N-3D images (ie 4D matrix)
X_train = X_train.reshape(X_train.shape[0], 1, 28, 28)
X_test  = X_test.reshape(X_test.shape[0],   1, 28, 28)

#To confirm, we can print X_train's dimensions again:
print(X_train.shape)

#convert and put into 0-1 range
X_train  = X_train.astype('float32')
X_test   = X_test.astype('float32')
X_train /= 255
X_test  /= 255

# Convert 1-dimensional class arrays to 10-dimensional class matrices
Y_train = np_utils.to_categorical(Y_train, 10)
Y_test  = np_utils.to_categorical(Y_test,  10)

# ------------- End loading and preparing data --------------
np.amax(X_train)   #this gets the max value over a flattened numpy array
print('prep done')
```

```
(5000, 1, 28, 28)
prep done
```

In [4]:
```
# --------------Set up Model ---------------------
mymodel = Sequential()

numfilters = 16
#add convolution layer of 32 or 16 or __ filters, 3x3 each,   After a first run, try 9x9
#     input shape for 1 image, channels refers to color dimension of input image
mymodel.add(Convolution2D(numfilters, (9,9),strides=1,  data_format="channels_first",act

#mymodel.add(Convolution2D(numfilters, (9,9),strides=1,  data_format="channels_first",ac

print('modeldef and first conv layer done')
```

```
modeldef and first conv layer done
```

In [5]:
```
mymodel.layers[0].output # use this to check sizes of output
```

Out[5]:
```
<tf.Tensor 'conv2d_1/Relu:0' shape=(?, 16, 20, 20) dtype=float32>
```

```
In [6]: #-----------------Now add more Convolution layers
        mymodel.add(Convolution2D(numfilters, (3, 3), activation='relu'))
        mymodel.add(MaxPooling2D(pool_size=(2,2))) #get Max over 2D region,and slide

        #optional?
        mymodel.add(Dropout(0.25))

        mymodel.add(Flatten())            #reorganize 2DxFilters output into 1D

In [7]: mymodel.layers[2].output   #size of output layer for max pooling

Out[7]: <tf.Tensor 'max_pooling2d_1/MaxPool:0' shape=(?, 7, 9, 16) dtype=float32>

In [8]: #----------------Now add final classification layers
        mymodel.add(Dense(128, activation='relu'))  #enter number of hidden units (no good rule,
        mymodel.add(Dropout(0.5))
        mymodel.add(Dense(10, activation='softmax'))
        print('assemble model done')

assemble model done


In [9]: # --------- Now assemble (ie compile TensorFlow commands) and run -----
        mymodel.compile(loss='categorical_crossentropy',
                        optimizer='sgd',
                        metrics=['accuracy'])

In [10]: #------------ Now Run Training
         mymodel.fit(X_train, Y_train,
                     batch_size=32, epochs=15, verbose=1)  #batch up 32 examples before adjusting
                                                           #sweep through training data 'epochs' t

Epoch 1/15
5000/5000 [==============================] - 2s - loss: 2.1984 - acc: 0.2242
Epoch 2/15
5000/5000 [==============================] - 1s - loss: 1.5009 - acc: 0.5256
Epoch 3/15
5000/5000 [==============================] - 1s - loss: 0.8799 - acc: 0.7184
Epoch 4/15
5000/5000 [==============================] - 1s - loss: 0.6578 - acc: 0.8010
Epoch 5/15
5000/5000 [==============================] - 1s - loss: 0.5520 - acc: 0.8254
Epoch 6/15
5000/5000 [==============================] - 2s - loss: 0.4583 - acc: 0.8592
Epoch 7/15
5000/5000 [==============================] - 1s - loss: 0.4203 - acc: 0.8750
Epoch 8/15
5000/5000 [==============================] - 2s - loss: 0.3909 - acc: 0.8814
Epoch 9/15
```

```
5000/5000 [==============================] - 1s - loss: 0.3473 - acc: 0.8952
Epoch 10/15
5000/5000 [==============================] - 1s - loss: 0.3234 - acc: 0.9074
Epoch 11/15
5000/5000 [==============================] - 2s - loss: 0.3069 - acc: 0.9106
Epoch 12/15
5000/5000 [==============================] - 2s - loss: 0.2947 - acc: 0.9150
Epoch 13/15
5000/5000 [==============================] - 2s - loss: 0.2769 - acc: 0.9196
Epoch 14/15
5000/5000 [==============================] - 1s - loss: 0.2597 - acc: 0.9260
Epoch 15/15
5000/5000 [==============================] - 1s - loss: 0.2493 - acc: 0.9284
```

```
Out[10]: <keras.callbacks.History at 0x2b3c982c95c0>
```

```
In [11]: #--------- Get overall prediction score
         trainscore = mymodel.evaluate(X_train, Y_train, verbose=1) # get overal score
         testscore  = mymodel.evaluate(X_test, Y_test, verbose=1) # get overal score
         #somepred  = mymodel.predict(X_test,verbose=0)           # get predicted labels
         print(trainscore)
         print(testscore)
```

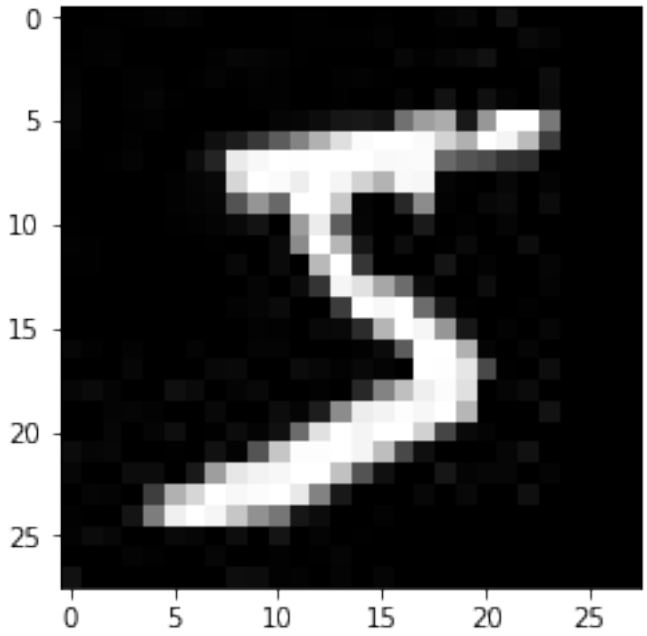
```
 9920/10000 [============================>.] - ETA: 0s[0.13141486806869507, 0.96399999999999997]
[0.16991045740135013, 0.94799999999999995]
```

```
In [12]: #-----------Optional: View some of the output
         #print(somepred[1:3])
         #Notice each row is 10 elements, each element is a prediction of the number labels
         print(Y_test[1:3])
```

```
[[ 0.  0.  1.  0.  0.  0.  0.  0.  0.  0.]
 [ 0.  1.  0.  0.  0.  0.  0.  0.  0.  0.]]
```

```
In [13]: #To view a sample image
         import matplotlib.pyplot as plt      #These provide matlab type of plotting functions
         import matplotlib.image as mpimg

         img_filename = "Xtrain_num0_cat_5.jpeg" #% scriptDir
         im = mpimg.imread(img_filename)
         plt.figure()
         plt.imshow(im,'gray')
         plt.show()
         print('im loaded')
```

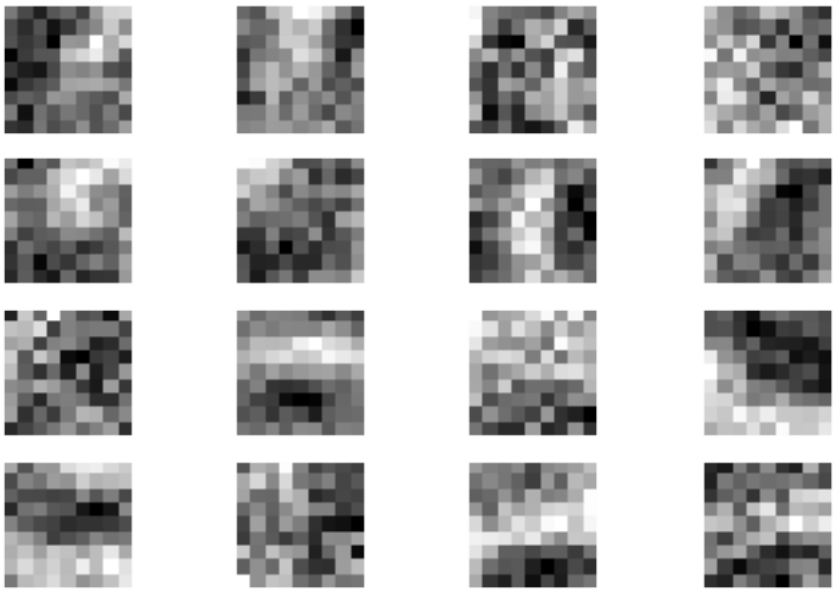



```
im loaded
```

In [14]:
```
# ------------ GET WEIGHTS From Convolution Layer and make mosaic image
Wlist   =mymodel.layers[0].get_weights()
W3D     =np.squeeze(Wlist[0])
W3D.shape
W3Dchan =W3D.swapaxes(1,2).swapaxes(0,1)  #get 32 as 1st dimension

Wmin       =np.amin(W3Dchan)
Wmax       =np.amax(W3Dchan-Wmin)
Wsc        =np.int_(255*(W3Dchan-Wmin)/Wmax)
ncol =4
nrow =np.ceil(numfilters/ncol)
print(nrow)
plt.figure()
for i in range(Wsc.shape[0]):
   plt.subplot(nrow,ncol,i+1)
   plt.imshow(Wsc[i],'gray')
   plt.axis('off')
#plt.savefig("test.png", bbox_inches='tight')
plt.show()
print('done plotting weights mosaic')
```

```
4.0
```



```
done plotting weights mosaic
```

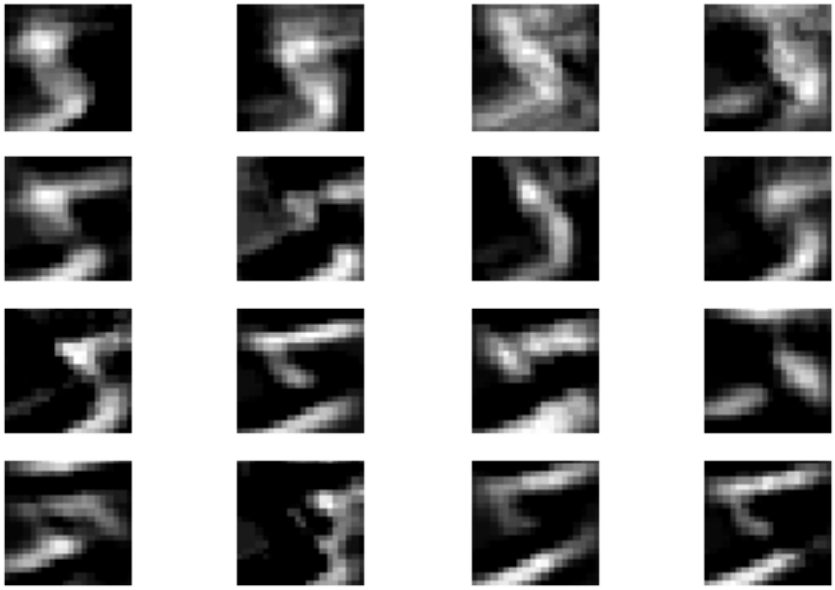
```
In [15]: #  ---------------- NOW Visualize the activations for the first training example ------
         from keras import backend as K    #backend is tensorflow

         get_layer_output = K.function([mymodel.layers[0].input],[mymodel.layers[0].output]) #se
         x                = np.expand_dims(X_train[0],0)           #set up a 4D input of 1 image
         layer_output     = get_layer_output([x])[0]  #get output using K.function

         layer_output.shape    #check output shape and use it in next cell, first dimension is n
```

```
Out[15]: (1, 16, 20, 20)
```

```
In [16]: # --- Now output a mosaic
         layeroutput3D      = np.squeeze(layer_output)
         ncol =4
         nrow =np.ceil(numfilters/ncol)
         plt.figure()
         for i in range(layeroutput3D.shape[0]):
            plt.subplot(nrow,ncol,i+1)
            plt.imshow(layeroutput3D[i],'gray')
            plt.axis('off')
         #plt.savefig("test.png", bbox_inches='tight')
         plt.show()
         print('done plotting layer activation output mosaic')
```



```
done plotting layer activation output mosaic
```