Classify Handwritten digits (MNIST) using MLP

In [1]:

```
from IPython.display import Image, SVG
import matplotlib.pyplot as plt

%matplotlib inline

import numpy as np
import keras
from keras.datasets import mnist
from keras.utils import np_utils
from keras.models import Sequential
from keras.layers import Dense

from keras.utils.vis_utils import model_to_dot
```

```
Using TensorFlow backend.
C:\Users\Vihan\anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:516: Future
Warning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future versio
n of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint8 = np.dtype([("qint8", np.int8, 1)])
C:\Users\Vihan\anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:517: Future
Warning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future versio
n of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_quint8 = np.dtype([("quint8", np.uint8, 1)])
C:\Users\Vihan\anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:518: Future
Warning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future versio
n of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint16 = np.dtype([("qint16", np.int16, 1)])
C:\Users\Vihan\anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:519: Future
Warning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future versio
n of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_quint16 = np.dtype([("quint16", np.uint16, 1)])
C:\Users\Vihan\anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:520: Future
Warning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future versio
n of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint32 = np.dtype([("qint32", np.int32, 1)])
C:\Users\Vihan\anaconda3\lib\site-packages\tensorflow\python\framework\dtypes.py:525: Future
Warning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future versio
n of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])
C:\Users\Vihan\anaconda3\lib\site-packages\tensorboard\compat\tensorflow_stub\dtypes.py:541:
FutureWarning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint8 = np.dtype([("qint8", np.int8, 1)])
C:\Users\Vihan\anaconda3\lib\site-packages\tensorboard\compat\tensorflow_stub\dtypes.py:542:
FutureWarning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_quint8 = np.dtype([("quint8", np.uint8, 1)])
C:\Users\Vihan\anaconda3\lib\site-packages\tensorboard\compat\tensorflow_stub\dtypes.py:543:
FutureWarning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint16 = np.dtype([("qint16", np.int16, 1)])
C:\Users\Vihan\anaconda3\lib\site-packages\tensorboard\compat\tensorflow_stub\dtypes.py:544:
FutureWarning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_quint16 = np.dtype([("quint16", np.uint16, 1)])
C:\Users\Vihan\anaconda3\lib\site-packages\tensorboard\compat\tensorflow_stub\dtypes.py:545:
FutureWarning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  _np_qint32 = np.dtype([("qint32", np.int32, 1)])
```

```
C:\Users\Vihan\anaconda3\lib\site-packages\tensorboard\compat\tensorflow_stub\dtypes.py:550:
FutureWarning: Passing (type, 1) or '1type' as a synonym of type is deprecated; in a future
version of numpy, it will be understood as (type, (1,)) / '(1,)type'.
  np_resource = np.dtype([("resource", np.ubyte, 1)])
```

Data Loading and Preprocessing

In [2]:

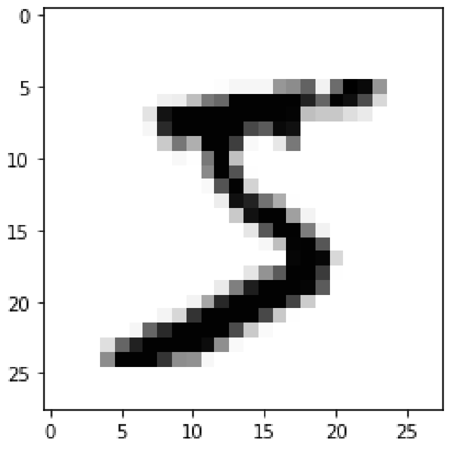
```
# Loads the training and test data sets
(X_train, y_train), (X_test, y_test) = mnist.load_data()
```

In [3]:

```
first_image = X_train[0, :, :]
```

In [4]:

```
# To interpret the values as a 28x28 image, we need to reshape
# the numpy array, which is one dimensional.
plt.imshow(first_image, cmap=plt.cm.Greys);
```



In [5]:

```
num_classes = len(np.unique(y_train))
num_classes
```

Out[5]:

```
10
```

In [6]:

```
# 60K training 28 x 28 (pixel) images
X_train.shape
```

Out[6]:

```
(60000, 28, 28)
```

In [7]:

```
# 10K test 28 x 28 (pixel) images
X_test.shape
```

Out[7]:

```
(10000, 28, 28)
```

In [8]:

```
input_dim = np.prod(X_train.shape[1:])
input_dim
```

Out[8]:

```
784
```

In [9]:

```
# The training and test data sets are integers, ranging from 0 to 255.
# We reshape the training and test data sets to be matrices with 784 (= 28 * 28) features.
X_train = X_train.reshape(60000, input_dim).astype('float32')
X_test = X_test.reshape(10000, input_dim).astype('float32')
```

In [10]:

```
# Scales the training and test data to range between 0 and 1.
max_value = X_train.max()
X_train /= max_value
X_test /= max_value
```

In [11]:

```
# The training and test labels are integers from 0 to 9 indicating the class label
(y_train, y_test)
```

Out[11]:

```
(array([5, 0, 4, ..., 5, 6, 8], dtype=uint8),
 array([7, 2, 1, ..., 4, 5, 6], dtype=uint8))
```

In [12]:

```
# We convert the class labels to binary class matrices
y_train = np_utils.to_categorical(y_train, num_classes)
y_test = np_utils.to_categorical(y_test, num_classes)
```

Multilayer Perceptron

Technically, we're building a perceptron with one hidden layer.

In [13]:

```
model = Sequential()
model.add(Dense(512, activation='relu', input_shape=(input_dim,)))
model.add(Dense(num_classes, activation='softmax'))
```

Different Ways to Summarize Model

In [14]:

```
model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
dense_1 (Dense)              (None, 512)               401920    
_________________________________________________________________
dense_2 (Dense)              (None, 10)                5130      
=================================================================
Total params: 407,050
Trainable params: 407,050
Non-trainable params: 0
```

In [15]:

```
SVG(model_to_dot(model, show_shapes=True).create(prog='dot', format='svg'))
```

```
---------------------------------------------------------------------------
ImportError                               Traceback (most recent call last)
<ipython-input-15-b7be228d4297> in <module>
----> 1 SVG(model_to_dot(model, show_shapes=True).create(prog='dot', format='svg'))

~\anaconda3\lib\site-packages\keras\utils\vis_utils.py in model_to_dot(model, show_shapes, s
how_layer_names, rankdir, expand_nested, dpi, subgraph)
     77     from ..models import Sequential
     78 
---> 79     _check_pydot()
     80     if subgraph:
     81         dot = pydot.Cluster(style='dashed', graph_name=model.name)

~\anaconda3\lib\site-packages\keras\utils\vis_utils.py in _check_pydot()
     20     if pydot is None:
     21         raise ImportError(
---> 22             'Failed to import `pydot`. '
     23             'Please install `pydot`. '
     24             'For example with `pip install pydot`.')

ImportError: Failed to import `pydot`. Please install `pydot`. For example with `pip install
pydot`.
```

In [17]:

```
# import json
# json.loads(model.to_json())
```

Train Classifier

In [16]:

```
# Trains the model, iterating on the training data in batches of 32 in 3 epochs.
# Using the Adam optimizer.
model.compile(optimizer='adam',
              loss='categorical_crossentropy',
              metrics=['accuracy'])
model.fit(X_train, y_train, batch_size=32, epochs=3, verbose=1)
```

```
WARNING:tensorflow:From C:\Users\Vihan\anaconda3\lib\site-packages\keras\backend\tensorflow_
backend.py:422: The name tf.global_variables is deprecated. Please use tf.compat.v1.global_v
ariables instead.

Epoch 1/3
60000/60000 [==============================] - 13s 224us/step - loss: 0.2009 - accuracy: 0.9
408
Epoch 2/3
60000/60000 [==============================] - 14s 228us/step - loss: 0.0818 - accuracy: 0.9
750
Epoch 3/3
60000/60000 [==============================] - 12s 208us/step - loss: 0.0528 - accuracy: 0.9
832
```

Out[16]:

```
<keras.callbacks.callbacks.History at 0x1a25528fb48>
```

Model Evaluation

In [17]:

```
# Test accuracy is ~97%.
model.evaluate(X_test, y_test)
```

```
10000/10000 [==============================] - 0s 49us/step
```

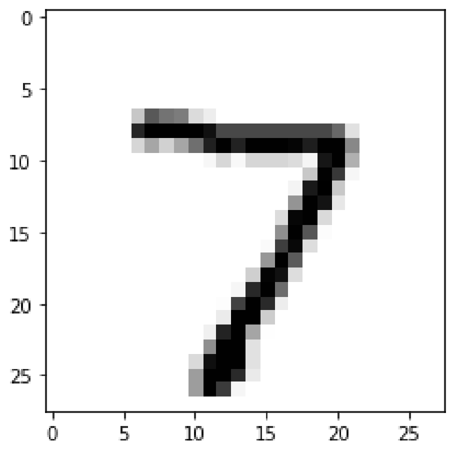
Out[17]:

```
[0.08310179765983484, 0.9757000207901001]
```

Predicting a Couple of Held-Out Images

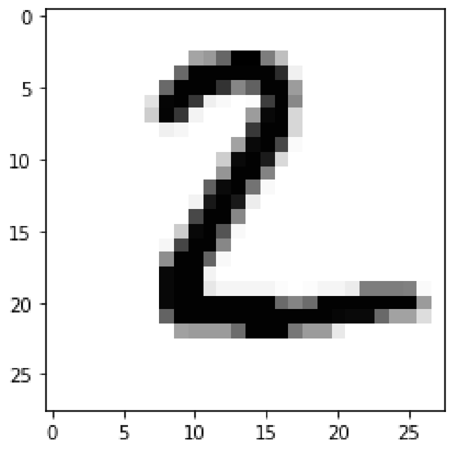
In [18]:

```
first_test_image = X_test[0, :]
plt.imshow(first_test_image.reshape(28, 28), cmap=plt.cm.Greys);
```



In [19]:

```
second_test_image = X_test[1, :]
plt.imshow(second_test_image.reshape(28, 28), cmap=plt.cm.Greys);
```



In [20]:

```
model.predict_classes(X_test[[0, 1], :])
```

Out[20]:

```
array([7, 2], dtype=int64)
```

In [ ]: