Fall 2023: CS5720

Neural Networks & Deep Learning - ICP-6

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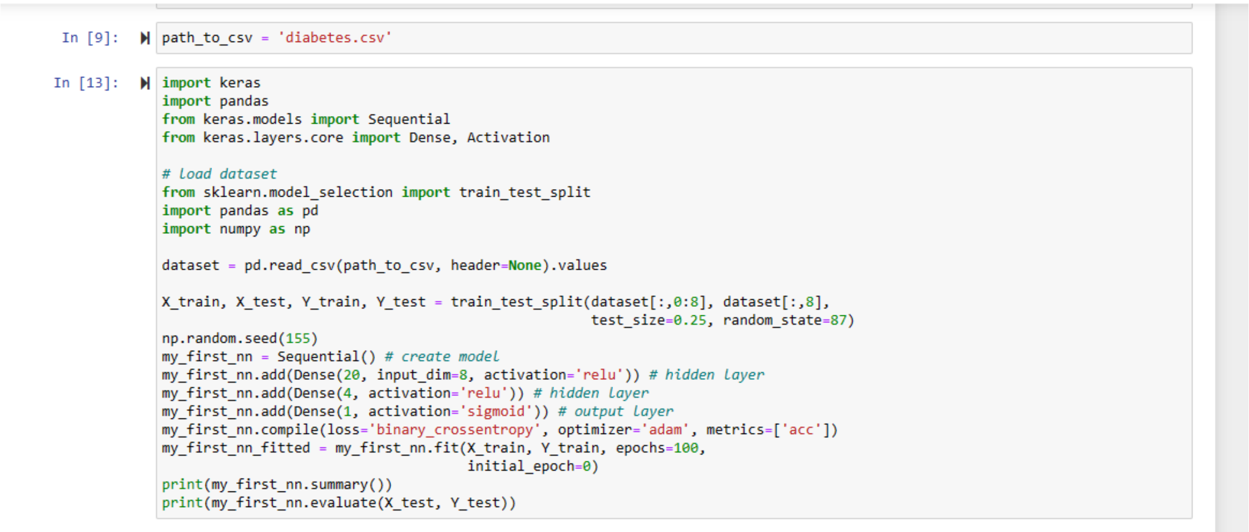
Git link: https://github.com/Mani543/Manisha_NNDL_ICP6.git

Video link:

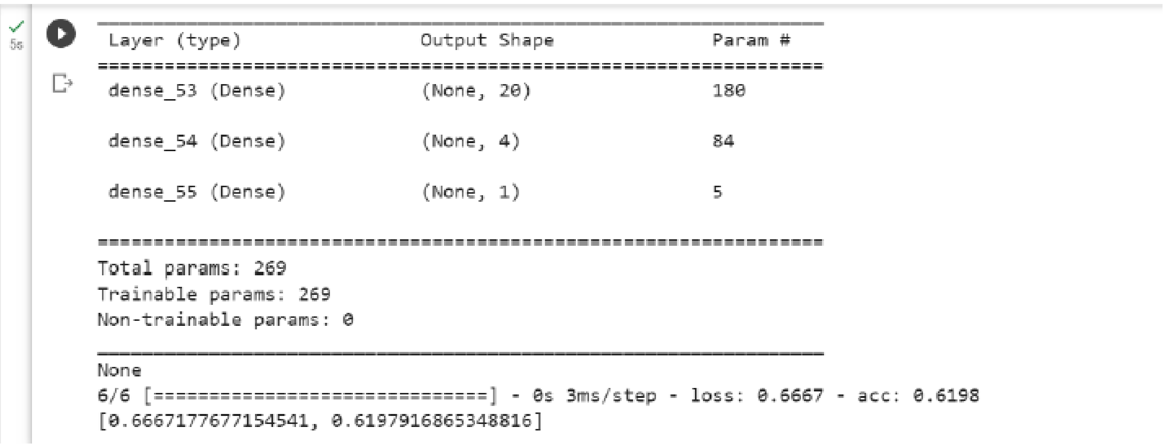
https://drive.google.com/file/d/1DeX3c_Tq28gWyl5v6JdNYzPR07bmbBv9/view?usp=sharing

In class programming:

1. Use the use case in the class: a. Add more Dense layers to the existing code and check how the accuracy changes.

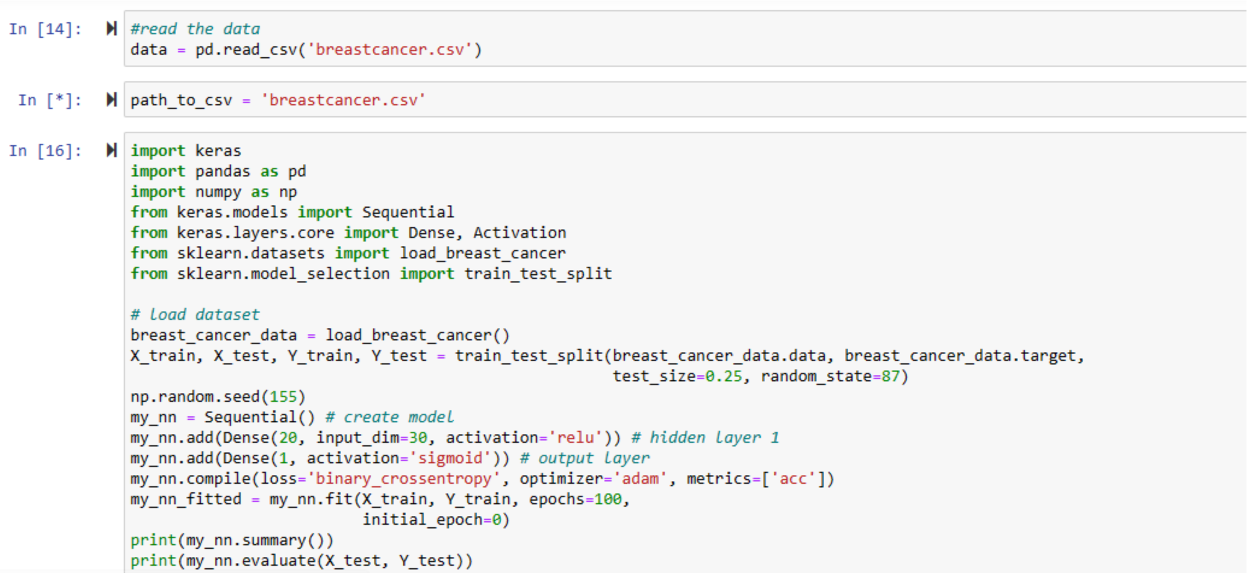


```
In [9]:  path_to_csv = 'diabetes.csv'

In [13]: import keras
         import pandas
         from keras.models import Sequential
         from keras.layers.core import Dense, Activation

         # load dataset
         from sklearn.model_selection import train_test_split
         import pandas as pd
         import numpy as np

         dataset = pd.read_csv(path_to_csv, header=None).values

         X_train, X_test, Y_train, Y_test = train_test_split(dataset[:,0:8], dataset[:,8],
                                                              test_size=0.25, random_state=87)
         np.random.seed(155)
         my_first_nn = Sequential() # create model
         my_first_nn.add(Dense(20, input_dim=8, activation='relu')) # hidden layer
         my_first_nn.add(Dense(4, activation='relu')) # hidden layer
         my_first_nn.add(Dense(1, activation='sigmoid')) # output layer
         my_first_nn.compile(loss='binary_crossentropy', optimizer='adam', metrics=['acc'])
         my_first_nn_fitted = my_first_nn.fit(X_train, Y_train, epochs=100,
                                              initial_epoch=0)
         print(my_first_nn.summary())
         print(my_first_nn.evaluate(X_test, Y_test))
```

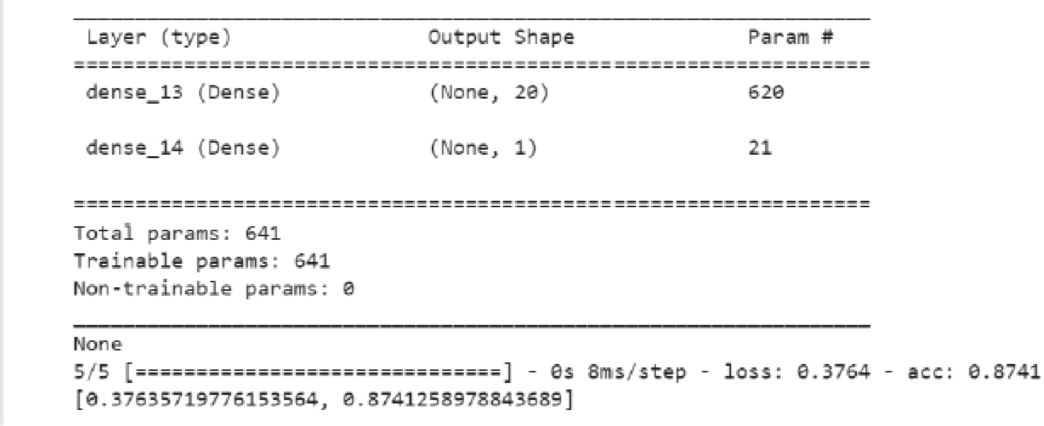


```
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_53 (Dense)            (None, 20)                180

 dense_54 (Dense)            (None, 4)                 84

 dense_55 (Dense)            (None, 1)                 5

=================================================================
Total params: 269
Trainable params: 269
Non-trainable params: 0
_________________________________________________________________
None
6/6 [==============================] - 0s 3ms/step - loss: 0.6667 - acc: 0.6198
[0.6667177677154541, 0.6197916865348816]
```

2. Change the data source to Breast Cancer dataset * available in the source code folder and make required changes. Report accuracy of the model.



```
In [14]:  #read the data
          data = pd.read_csv('breastcancer.csv')

In [*]:   path_to_csv = 'breastcancer.csv'

In [16]:  import keras
          import pandas as pd
          import numpy as np
          from keras.models import Sequential
          from keras.layers.core import Dense, Activation
          from sklearn.datasets import load_breast_cancer
          from sklearn.model_selection import train_test_split

          # load dataset
          breast_cancer_data = load_breast_cancer()
          X_train, X_test, Y_train, Y_test = train_test_split(breast_cancer_data.data, breast_cancer_data.target,
                                                              test_size=0.25, random_state=87)
          np.random.seed(155)
          my_nn = Sequential() # create model
          my_nn.add(Dense(20, input_dim=30, activation='relu')) # hidden layer 1
          my_nn.add(Dense(1, activation='sigmoid')) # output layer
          my_nn.compile(loss='binary_crossentropy', optimizer='adam', metrics=['acc'])
          my_nn_fitted = my_nn.fit(X_train, Y_train, epochs=100,
                                   initial_epoch=0)
          print(my_nn.summary())
          print(my_nn.evaluate(X_test, Y_test))
```



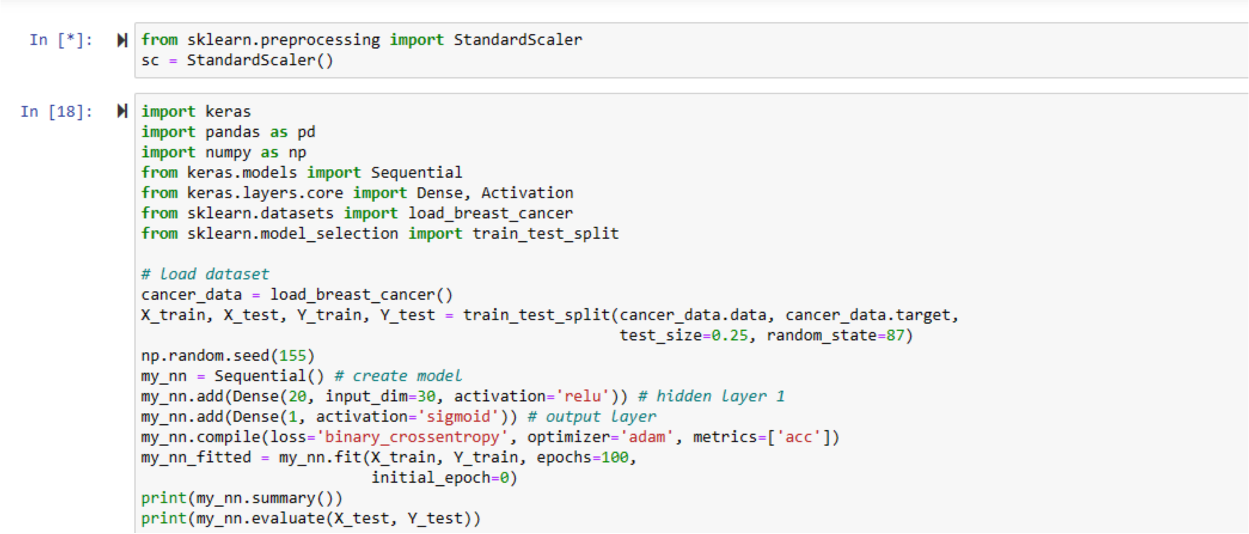
```
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_13 (Dense)            (None, 20)                620

 dense_14 (Dense)            (None, 1)                 21

=================================================================
Total params: 641
Trainable params: 641
Non-trainable params: 0
_________________________________________________________________
None
5/5 [==============================] - 0s 8ms/step - loss: 0.3764 - acc: 0.8741
[0.37635719776153564, 0.8741258978843689]
```

3. Normalize the data before feeding the data to the model and check how the normalization changes your accuracy (code given below).

from sklearn.preprocessing import StandardScaler

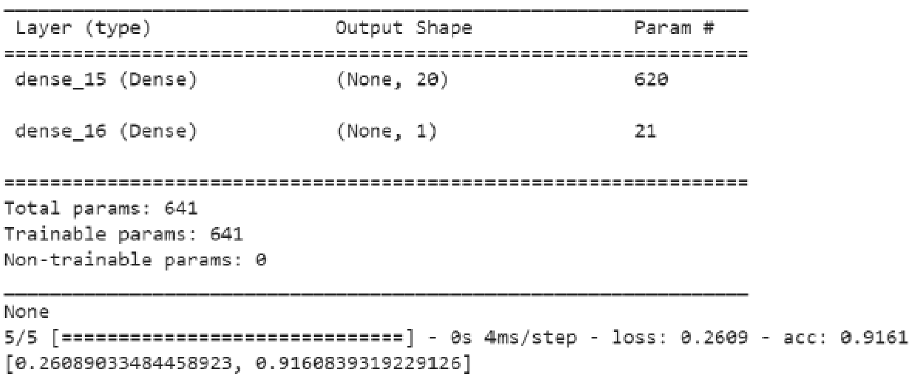
sc = StandardScaler()

Breast Cancer dataset is designated to predict if a patient has Malignant (M) or Benign = B cancer



```
In [*]:  from sklearn.preprocessing import StandardScaler
         sc = StandardScaler()
```

```
In [18]: import keras
         import pandas as pd
         import numpy as np
         from keras.models import Sequential
         from keras.layers.core import Dense, Activation
         from sklearn.datasets import load_breast_cancer
         from sklearn.model_selection import train_test_split

         # load dataset
         cancer_data = load_breast_cancer()
         X_train, X_test, Y_train, Y_test = train_test_split(cancer_data.data, cancer_data.target,
                                                             test_size=0.25, random_state=87)
         np.random.seed(155)
         my_nn = Sequential() # create model
         my_nn.add(Dense(20, input_dim=30, activation='relu')) # hidden layer 1
         my_nn.add(Dense(1, activation='sigmoid')) # output layer
         my_nn.compile(loss='binary_crossentropy', optimizer='adam', metrics=['acc'])
         my_nn_fitted = my_nn.fit(X_train, Y_train, epochs=100,
                                  initial_epoch=0)
         print(my_nn.summary())
         print(my_nn.evaluate(X_test, Y_test))
```

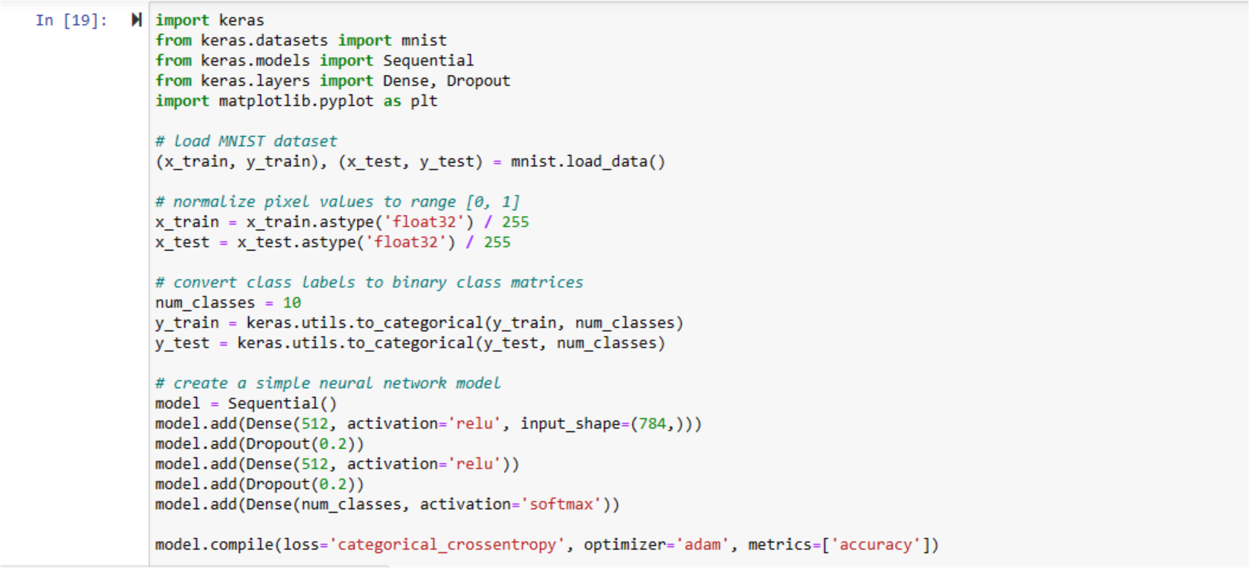


```
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_15 (Dense)            (None, 20)                620

 dense_16 (Dense)            (None, 1)                 21

=================================================================
Total params: 641
Trainable params: 641
Non-trainable params: 0
_________________________________________________________________
None
5/5 [==============================] - 0s 4ms/step - loss: 0.2609 - acc: 0.9161
[0.26089033484458923, 0.9160839319229126]
```

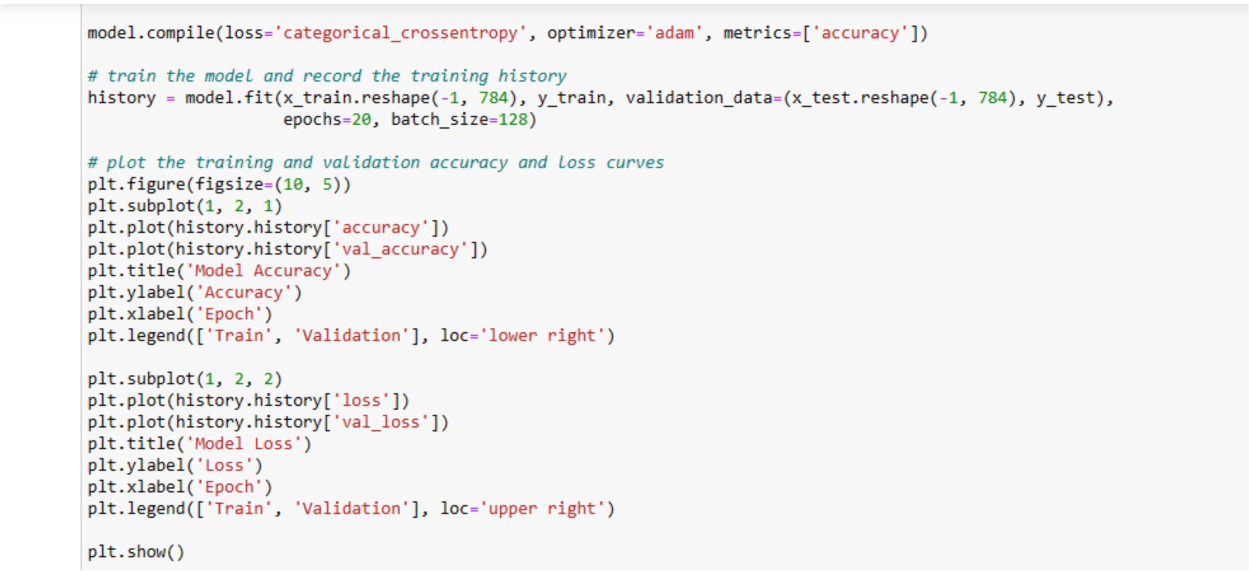
In class programming:

Use Image Classification on the handwritten digits data set (mnist)

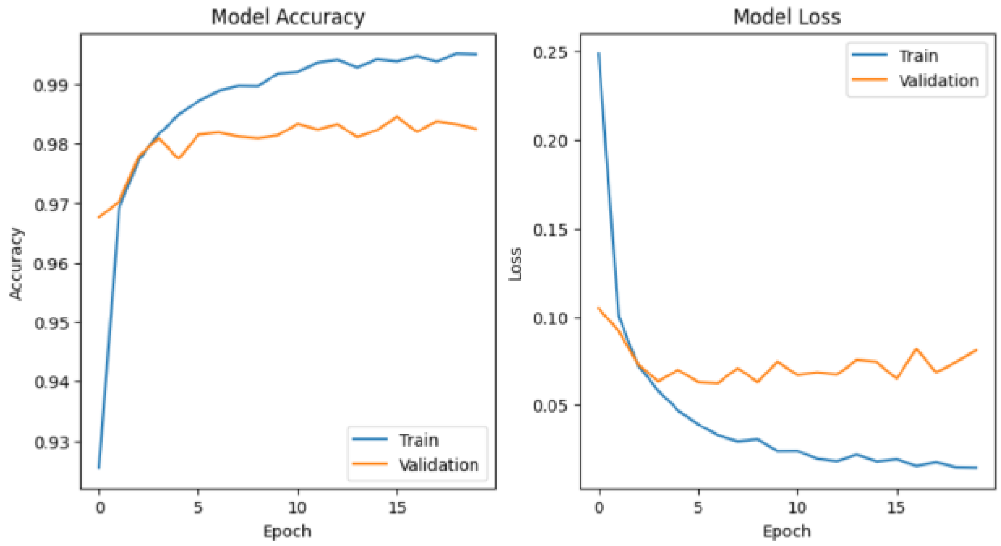
1. Plot the loss and accuracy for both training data and validation data using the history object in the source code.



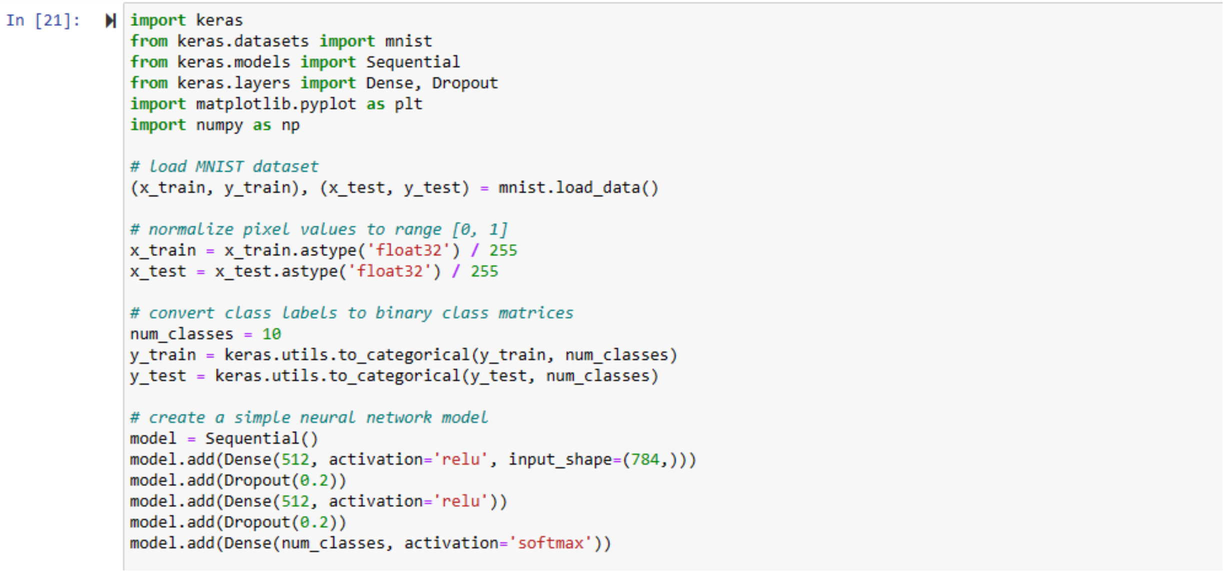
```
In [19]:  import keras
          from keras.datasets import mnist
          from keras.models import Sequential
          from keras.layers import Dense, Dropout
          import matplotlib.pyplot as plt

          # load MNIST dataset
          (x_train, y_train), (x_test, y_test) = mnist.load_data()

          # normalize pixel values to range [0, 1]
          x_train = x_train.astype('float32') / 255
          x_test = x_test.astype('float32') / 255

          # convert class labels to binary class matrices
          num_classes = 10
          y_train = keras.utils.to_categorical(y_train, num_classes)
          y_test = keras.utils.to_categorical(y_test, num_classes)

          # create a simple neural network model
          model = Sequential()
          model.add(Dense(512, activation='relu', input_shape=(784,)))
          model.add(Dropout(0.2))
          model.add(Dense(512, activation='relu'))
          model.add(Dropout(0.2))
          model.add(Dense(num_classes, activation='softmax'))

          model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
```



```
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])

# train the model and record the training history
history = model.fit(x_train.reshape(-1, 784), y_train, validation_data=(x_test.reshape(-1, 784), y_test),
                    epochs=20, batch_size=128)

# plot the training and validation accuracy and loss curves
plt.figure(figsize=(10, 5))
plt.subplot(1, 2, 1)
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='lower right')

plt.subplot(1, 2, 2)
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model Loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper right')

plt.show()
```

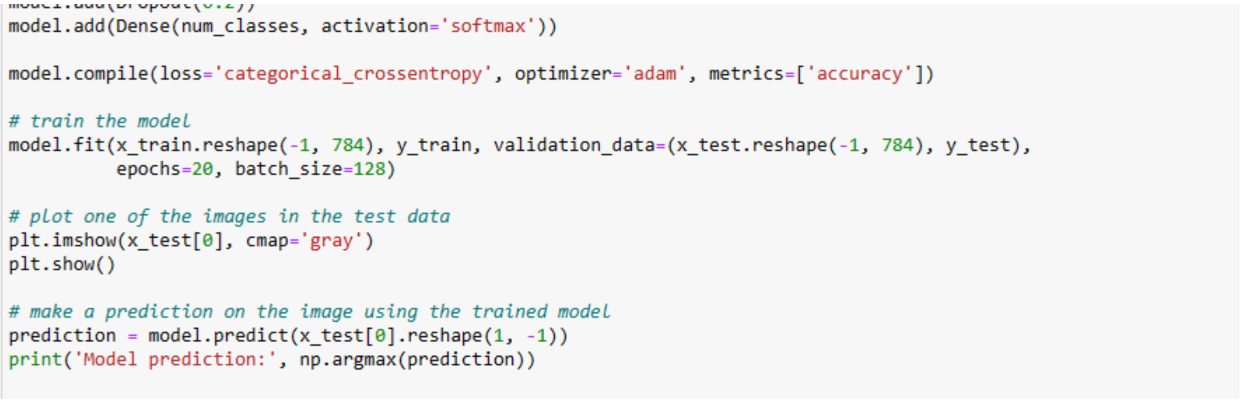


2. Plot one of the images in the test data, and then do inferencing to check what is the prediction of the model on that single image.

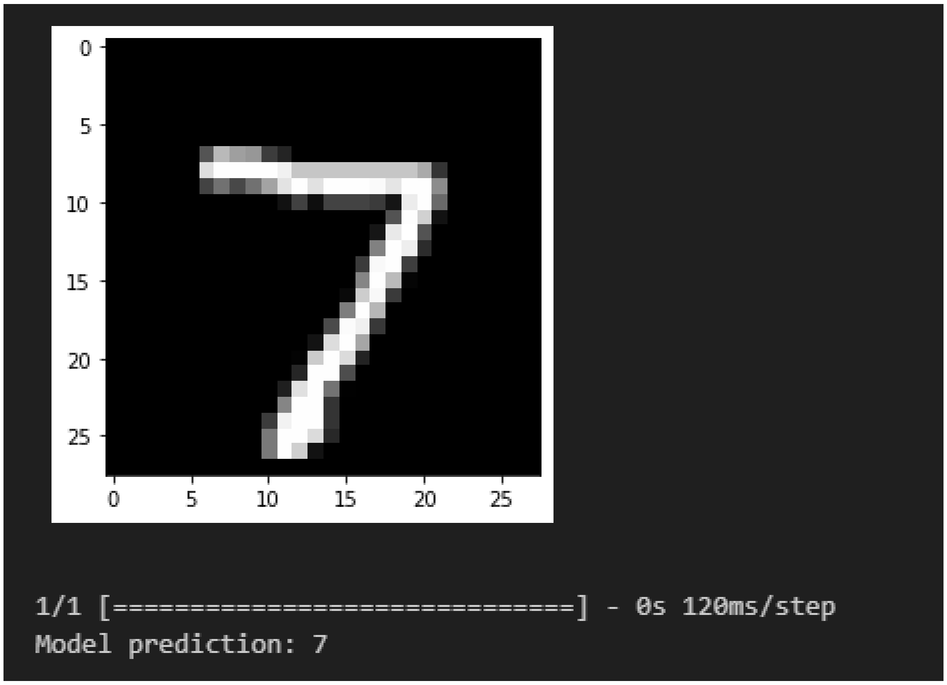


In [21]:

```
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout
import matplotlib.pyplot as plt
import numpy as np

# load MNIST dataset
(x_train, y_train), (x_test, y_test) = mnist.load_data()

# normalize pixel values to range [0, 1]
x_train = x_train.astype('float32') / 255
x_test = x_test.astype('float32') / 255

# convert class labels to binary class matrices
num_classes = 10
y_train = keras.utils.to_categorical(y_train, num_classes)
y_test = keras.utils.to_categorical(y_test, num_classes)

# create a simple neural network model
model = Sequential()
model.add(Dense(512, activation='relu', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(512, activation='relu'))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
```

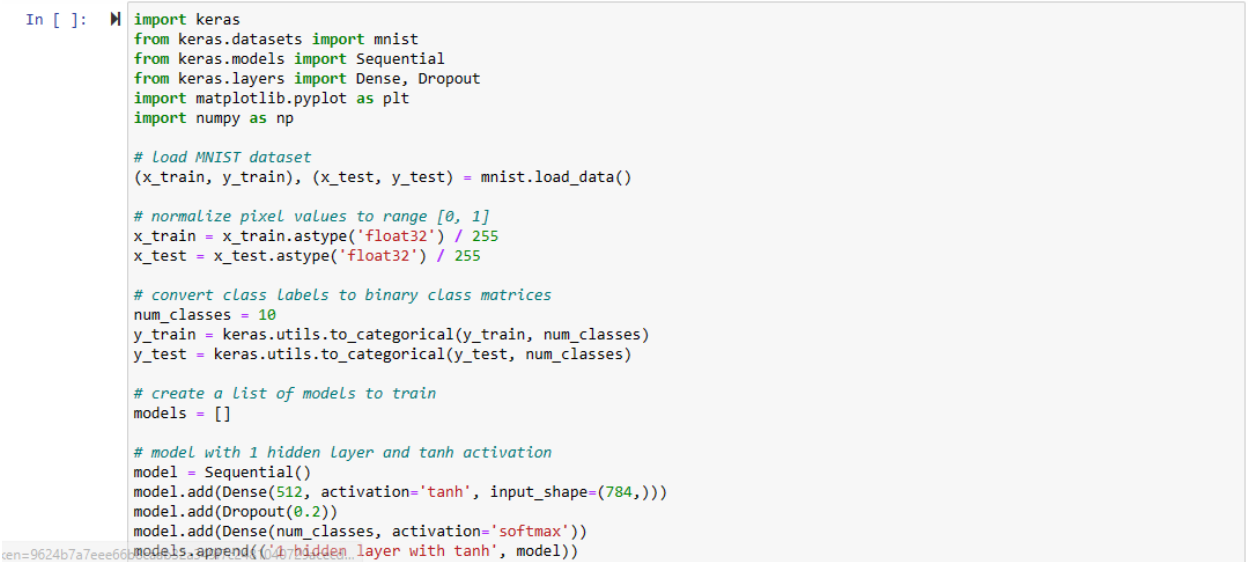


```
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))

model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])

# train the model
model.fit(x_train.reshape(-1, 784), y_train, validation_data=(x_test.reshape(-1, 784), y_test),
          epochs=20, batch_size=128)

# plot one of the images in the test data
plt.imshow(x_test[0], cmap='gray')
plt.show()

# make a prediction on the image using the trained model
prediction = model.predict(x_test[0].reshape(1, -1))
print('Model prediction:', np.argmax(prediction))
```

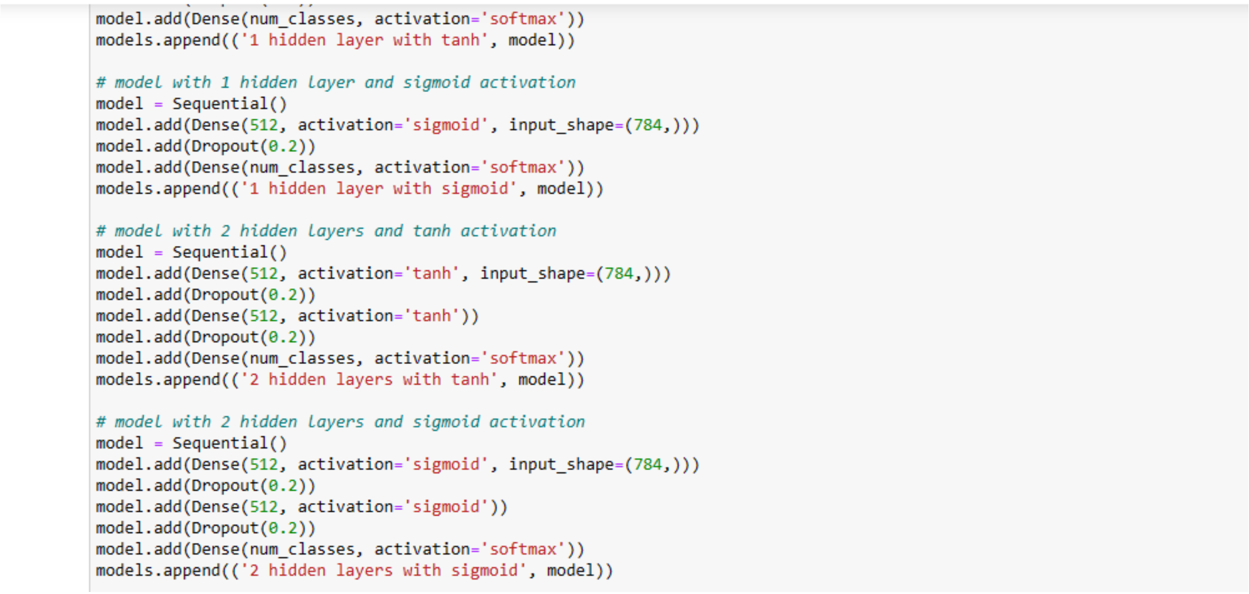


```
1/1 [==============================] - 0s 120ms/step
Model prediction: 7
```

3. We used 2 hidden layers and Relu activation. Try to change the number of hidden layer and the activation to tanh or sigmoid and see what happens.

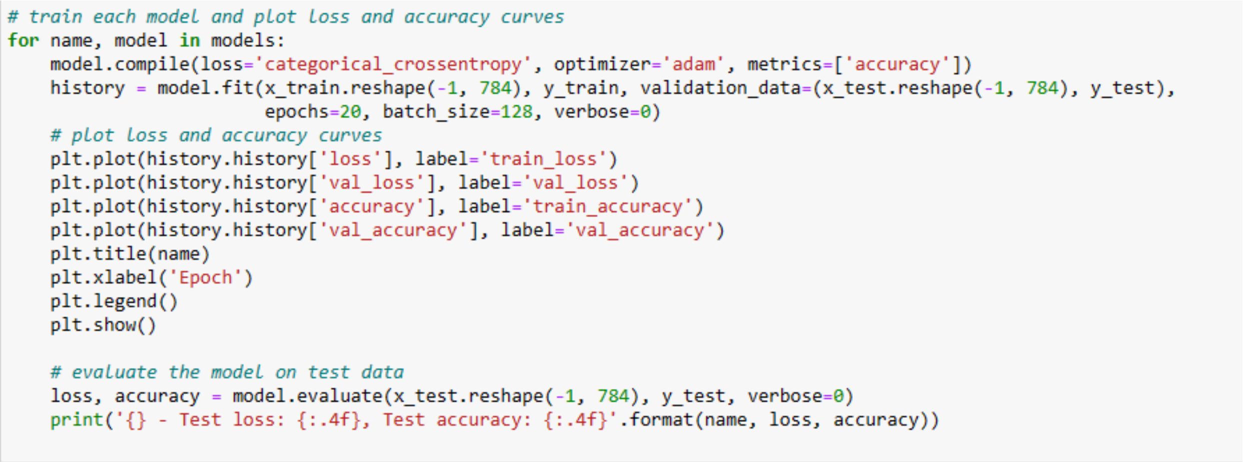


```
In [ ]:  import keras
         from keras.datasets import mnist
         from keras.models import Sequential
         from keras.layers import Dense, Dropout
         import matplotlib.pyplot as plt
         import numpy as np

         # load MNIST dataset
         (x_train, y_train), (x_test, y_test) = mnist.load_data()

         # normalize pixel values to range [0, 1]
         x_train = x_train.astype('float32') / 255
         x_test = x_test.astype('float32') / 255

         # convert class labels to binary class matrices
         num_classes = 10
         y_train = keras.utils.to_categorical(y_train, num_classes)
         y_test = keras.utils.to_categorical(y_test, num_classes)

         # create a list of models to train
         models = []

         # model with 1 hidden layer and tanh activation
         model = Sequential()
         model.add(Dense(512, activation='tanh', input_shape=(784,)))
         model.add(Dropout(0.2))
         model.add(Dense(num_classes, activation='softmax'))
         models.append(('1 hidden layer with tanh', model))
```

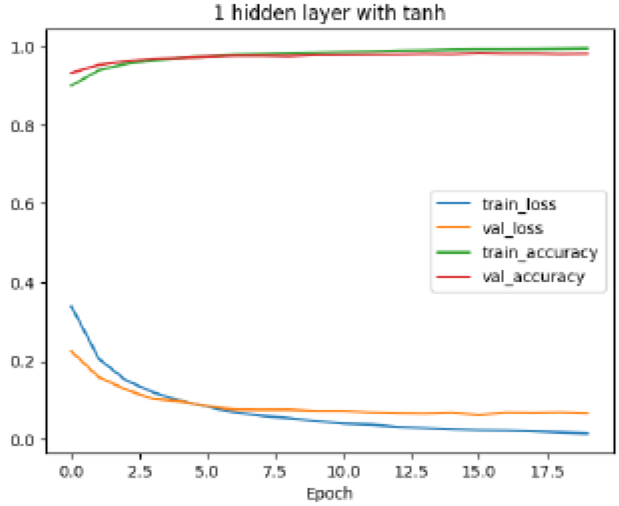


```
model.add(Dense(num_classes, activation='softmax'))
models.append(('1 hidden layer with tanh', model))
```

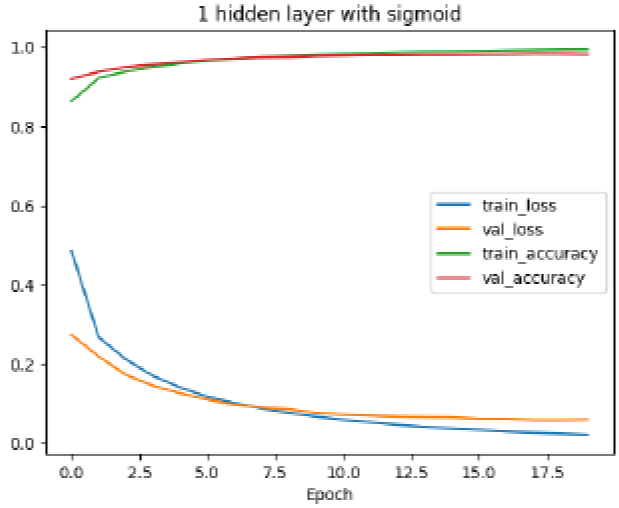
```
# model with 1 hidden layer and sigmoid activation
model = Sequential()
model.add(Dense(512, activation='sigmoid', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('1 hidden layer with sigmoid', model))

# model with 2 hidden layers and tanh activation
model = Sequential()
model.add(Dense(512, activation='tanh', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(512, activation='tanh'))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('2 hidden layers with tanh', model))

# model with 2 hidden layers and sigmoid activation
model = Sequential()
model.add(Dense(512, activation='sigmoid', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(512, activation='sigmoid'))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('2 hidden layers with sigmoid', model))
```



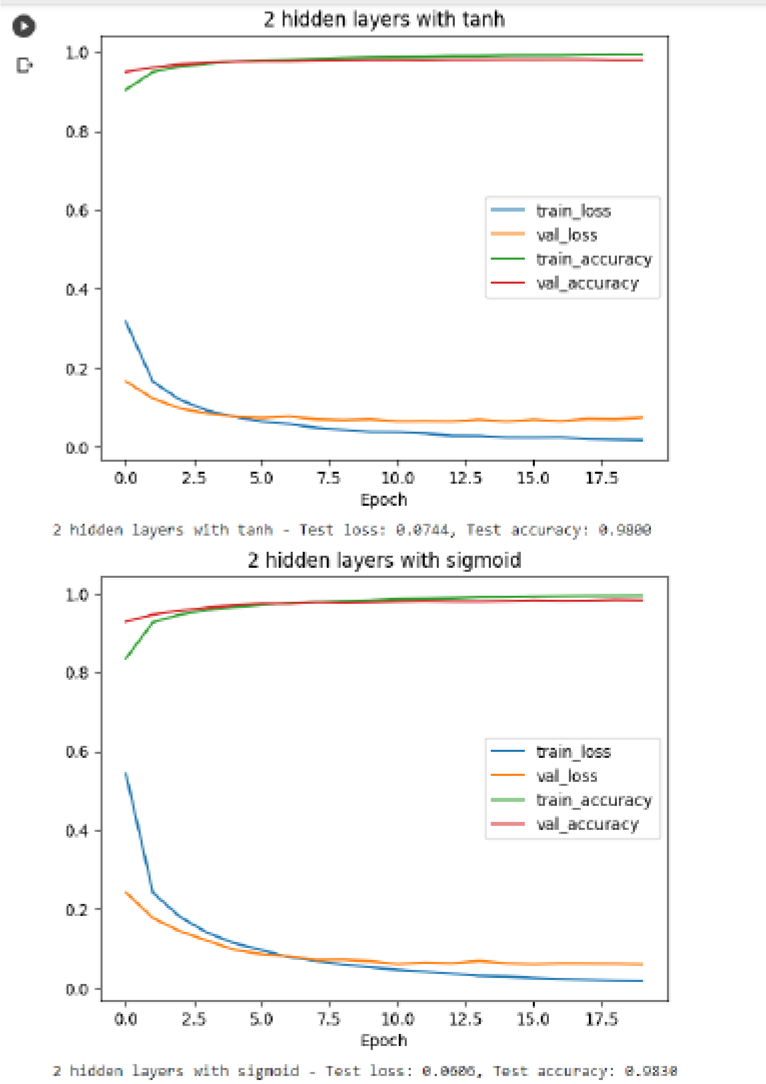
```
# train each model and plot loss and accuracy curves
for name, model in models:
    model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
    history = model.fit(x_train.reshape(-1, 784), y_train, validation_data=(x_test.reshape(-1, 784), y_test),
                        epochs=20, batch_size=128, verbose=0)
    # plot loss and accuracy curves
    plt.plot(history.history['loss'], label='train_loss')
    plt.plot(history.history['val_loss'], label='val_loss')
    plt.plot(history.history['accuracy'], label='train_accuracy')
    plt.plot(history.history['val_accuracy'], label='val_accuracy')
    plt.title(name)
    plt.xlabel('Epoch')
    plt.legend()
    plt.show()

    # evaluate the model on test data
    loss, accuracy = model.evaluate(x_test.reshape(-1, 784), y_test, verbose=0)
    print('{} - Test loss: {:.4f}, Test accuracy: {:.4f}'.format(name, loss, accuracy))
```


1 hidden layer with tanh

```
1 hidden layer with tanh - Test loss: 0.0670, Test accuracy: 0.9809
```


1 hidden layer with sigmoid

```
1 hidden layer with sigmoid - Test loss: 0.0601, Test accuracy: 0.9813
```



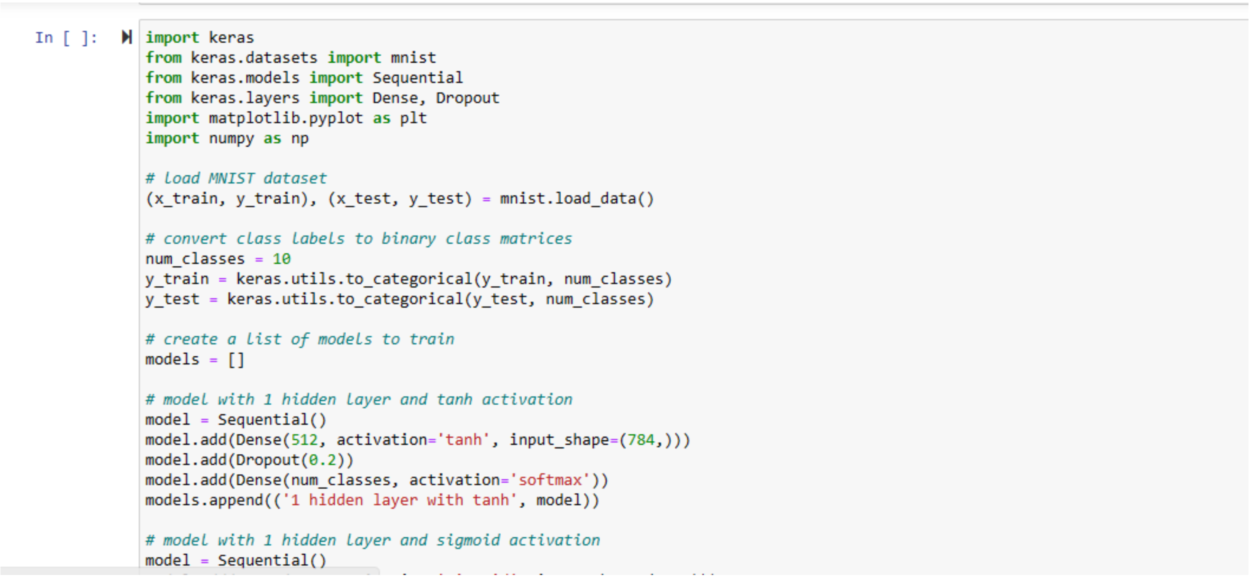
2 hidden layers with tanh

```
2 hidden layers with tanh - Test loss: 0.0744, Test accuracy: 0.9800
```

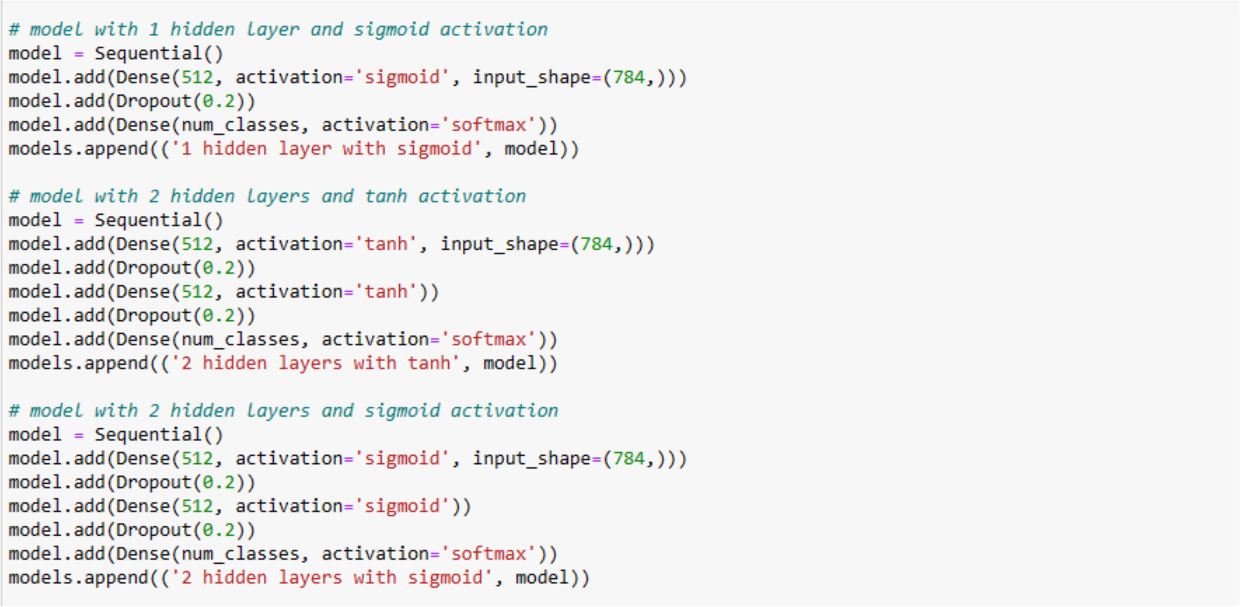
2 hidden layers with sigmoid

```
2 hidden layers with sigmoid - Test loss: 0.0606, Test accuracy: 0.9830
```

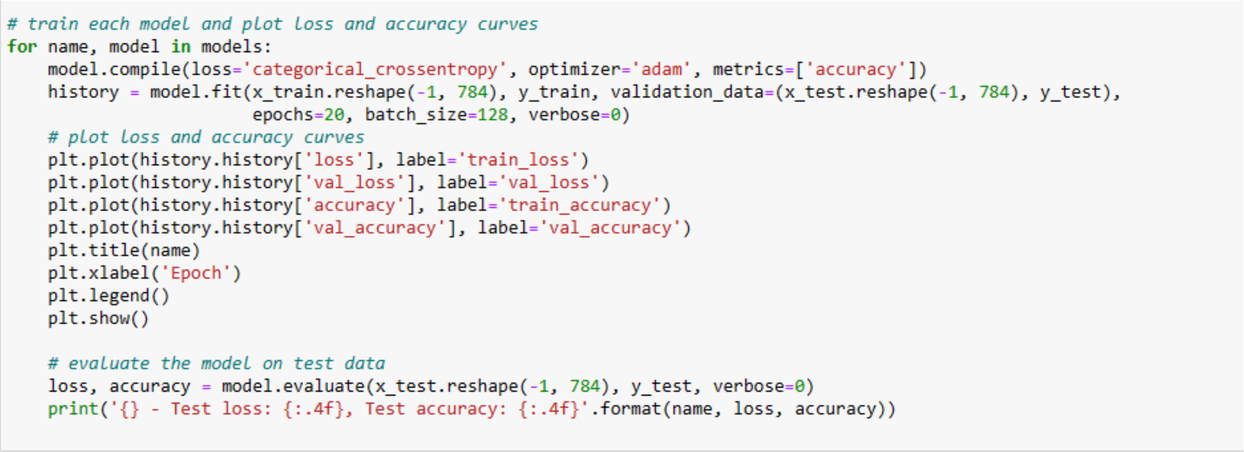
4. Run the same code without scaling the images and check the performance?



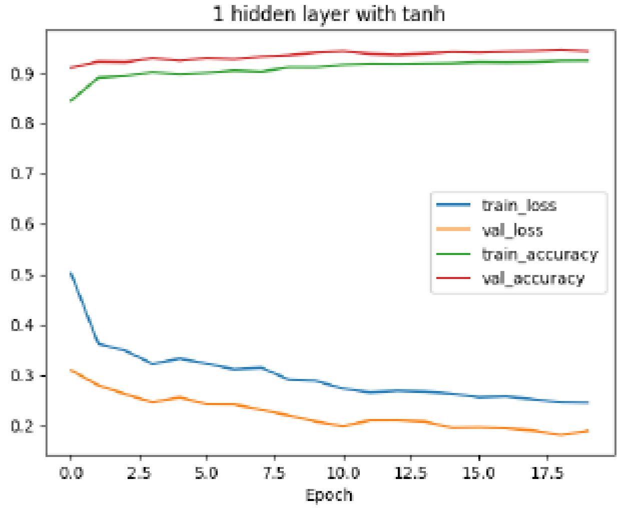
```
In [ ]:
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout
import matplotlib.pyplot as plt
import numpy as np

# load MNIST dataset
(x_train, y_train), (x_test, y_test) = mnist.load_data()

# convert class labels to binary class matrices
num_classes = 10
y_train = keras.utils.to_categorical(y_train, num_classes)
y_test = keras.utils.to_categorical(y_test, num_classes)

# create a list of models to train
models = []

# model with 1 hidden layer and tanh activation
model = Sequential()
model.add(Dense(512, activation='tanh', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('1 hidden layer with tanh', model))

# model with 1 hidden layer and sigmoid activation
model = Sequential()
```



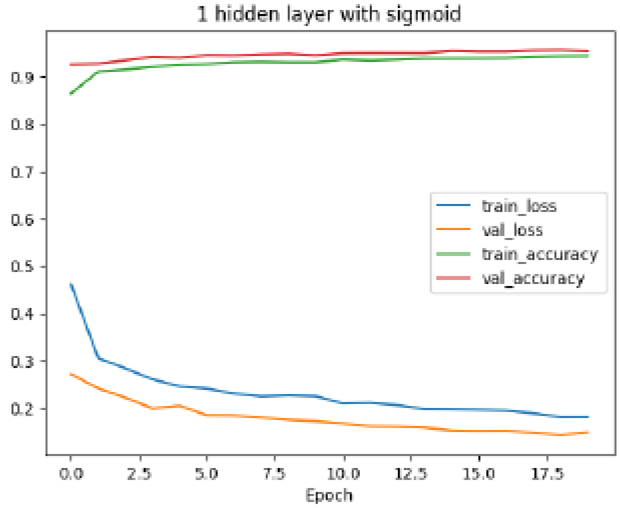
```
# model with 1 hidden layer and sigmoid activation
model = Sequential()
model.add(Dense(512, activation='sigmoid', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('1 hidden layer with sigmoid', model))

# model with 2 hidden layers and tanh activation
model = Sequential()
model.add(Dense(512, activation='tanh', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(512, activation='tanh'))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('2 hidden layers with tanh', model))

# model with 2 hidden layers and sigmoid activation
model = Sequential()
model.add(Dense(512, activation='sigmoid', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(512, activation='sigmoid'))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('2 hidden layers with sigmoid', model))
```



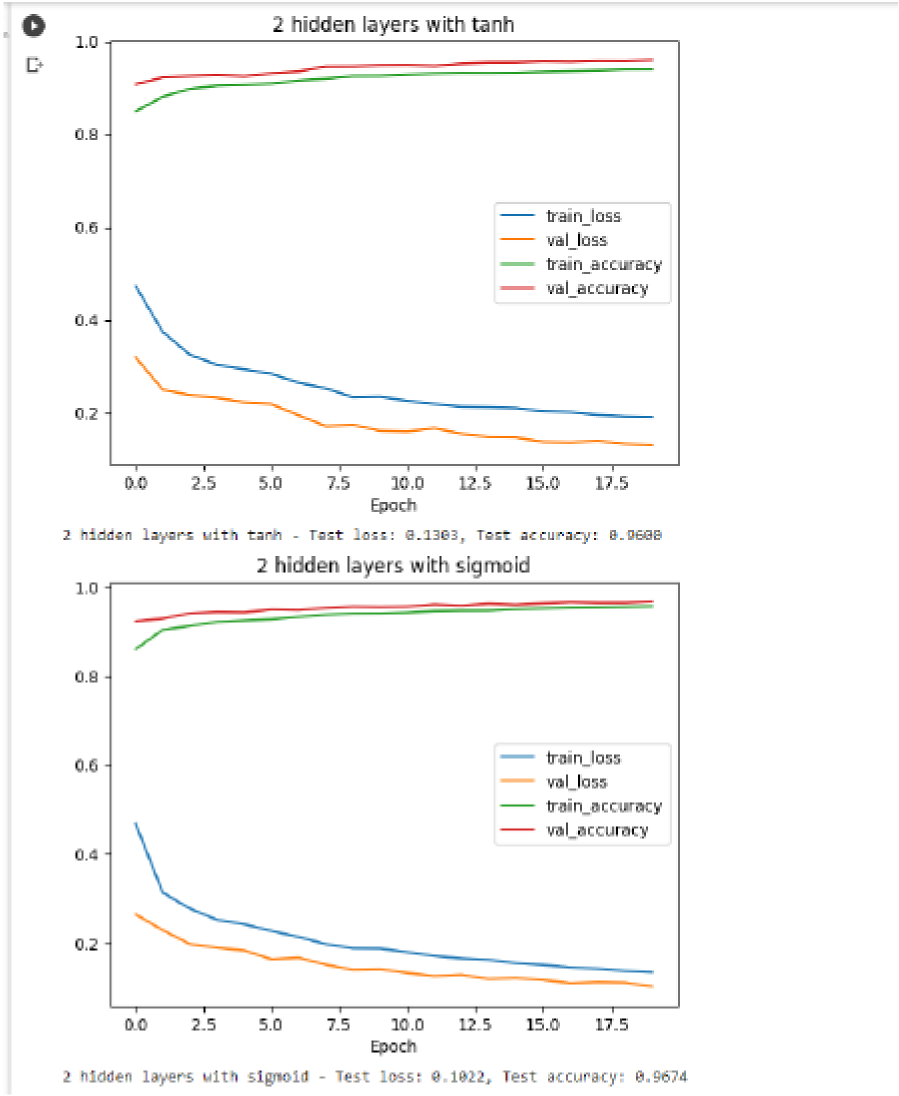
```
# train each model and plot loss and accuracy curves
for name, model in models:
    model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
    history = model.fit(x_train.reshape(-1, 784), y_train, validation_data=(x_test.reshape(-1, 784), y_test),
                        epochs=20, batch_size=128, verbose=0)
    # plot loss and accuracy curves
    plt.plot(history.history['loss'], label='train_loss')
    plt.plot(history.history['val_loss'], label='val_loss')
    plt.plot(history.history['accuracy'], label='train_accuracy')
    plt.plot(history.history['val_accuracy'], label='val_accuracy')
    plt.title(name)
    plt.xlabel('Epoch')
    plt.legend()
    plt.show()

    # evaluate the model on test data
    loss, accuracy = model.evaluate(x_test.reshape(-1, 784), y_test, verbose=0)
    print('{} - Test loss: {:.4f}, Test accuracy: {:.4f}'.format(name, loss, accuracy))
```



```
1 hidden layer with tanh - Test loss: 0.1893, Test accuracy: 0.9424
```



```
1 hidden layer with sigmoid - Test loss: 0.1492, Test accuracy: 0.9539
```



```
2 hidden layers with tanh - Test loss: 0.1303, Test accuracy: 0.9608
```

```
2 hidden layers with sigmoid - Test loss: 0.1022, Test accuracy: 0.9674
```