Assignment-6

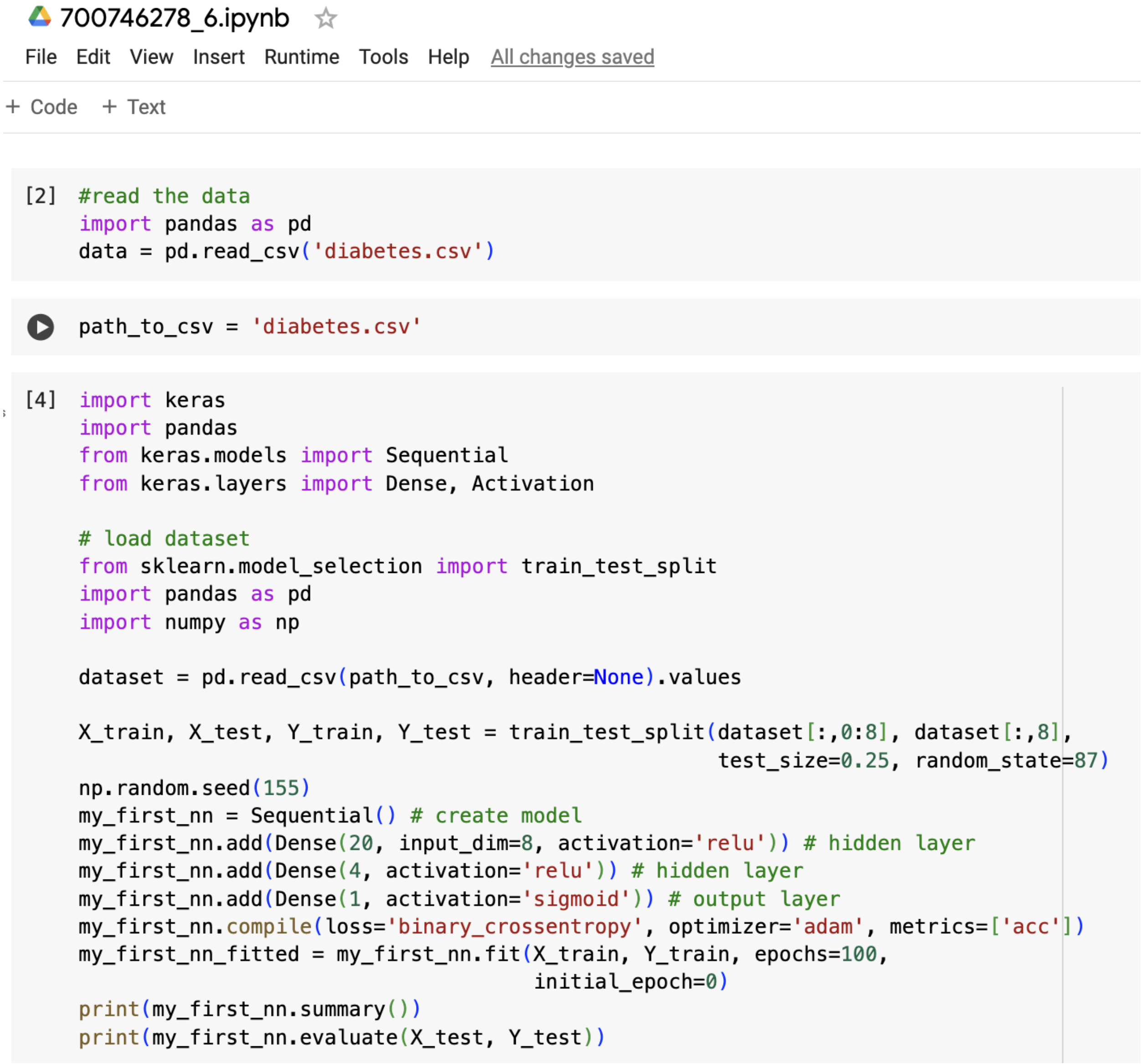
Mohith Degala

700746278

GitHub Link: https://github.com/Mohith700/Assignment_6.git

Video Link: https://drive.google.com/file/d/15ENH2OixA46nxbrpZMQ1ydIpZM8kkxk8/view?usp=sharing

1)

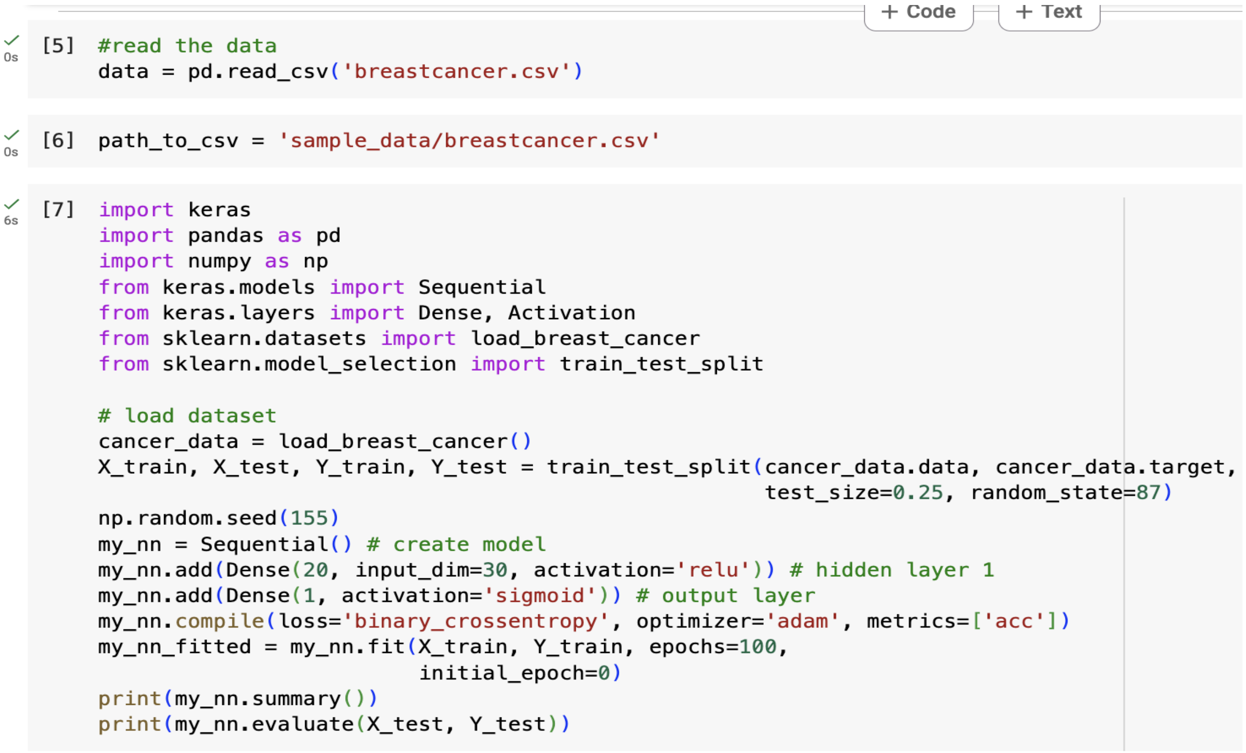


```
#read the data
import pandas as pd
data = pd.read_csv('diabetes.csv')
```

```
path_to_csv = 'diabetes.csv'
```

```
import keras
import pandas
from keras.models import Sequential
from keras.layers 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))
```

```
Epoch 1/100 18/18 [==============================] - 1s 3ms/step - loss: 28.7097 - acc: 0.3385
Epoch 2/100 18/18 [==============================] - 0s 2ms/step - loss: 19.0821 - acc: 0.3403
Epoch 3/100 18/18 [==============================] - 0s 2ms/step - loss: 9.7154 - acc: 0.3368
Epoch 4/100 18/18 [==============================] - 0s 2ms/step - loss: 3.6108 - acc: 0.4549
Epoch 5/100 18/18 [==============================] - 0s 2ms/step - loss: 1.9655 - acc: 0.6337
Epoch 6/100 18/18 [==============================] - 0s 2ms/step - loss: 1.1196 - acc: 0.6215
Epoch 7/100 18/18 [==============================] - 0s 2ms/step - loss: 0.8363 - acc: 0.6528
Epoch 8/100 18/18 [==============================] - 0s 2ms/step - loss: 0.7765 - acc: 0.6510
Epoch 9/100 18/18 [==============================] - 0s 2ms/step - loss: 0.7546 - acc: 0.6562
Epoch 10/100 18/18 [==============================] - 0s 2ms/step - loss: 0.7425 - acc: 0.6528
Epoch 11/100 18/18 [==============================] - 0s 2ms/step - loss: 0.7343 - acc: 0.6528
Epoch 12/100 18/18 [==============================] - 0s 2ms/step - loss: 0.7290 - acc: 0.6528
Epoch 13/100 18/18 [==============================] - 0s 2ms/step - loss: 0.7224 - acc: 0.6510
Epoch 14/100 18/18 [==============================] - 0s 2ms/step - loss: 0.7151 - acc: 0.6493
Epoch 15/100 18/18 [==============================] - 0s 2ms/step - loss: 0.7103 - acc: 0.6493
Epoch 16/100 18/18 [==============================] - 0s 2ms/step - loss: 0.7046 - acc: 0.6493
Epoch 17/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6995 - acc: 0.6493
Epoch 18/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6934 - acc: 0.6510
Epoch 19/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6882 - acc: 0.6510
Epoch 20/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6838 - acc: 0.6510
Epoch 21/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6804 - acc: 0.6510
Epoch 22/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6767 - acc: 0.6528
Epoch 23/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6730 - acc: 0.6528
Epoch 24/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6703 - acc: 0.6562
Epoch 25/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6684 - acc: 0.6562
Epoch 26/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6668 - acc: 0.6562
Epoch 27/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6654 - acc: 0.6562
Epoch 28/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6639 - acc: 0.6562
Epoch 29/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6629 - acc: 0.6562
Epoch 30/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6618 - acc: 0.6545
Epoch 31/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6605 - acc: 0.6562
Epoch 32/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6596 - acc: 0.6562
Epoch 33/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6582 - acc: 0.6580
Epoch 34/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6569 - acc: 0.6597
Epoch 35/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6560 - acc: 0.6597
Epoch 36/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6551 - acc: 0.6615
Epoch 37/100 18/18 [==============================] - 0s 3ms/step - loss: 0.6544 - acc: 0.6632
Epoch 38/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6537 - acc: 0.6632
Epoch 39/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6528 - acc: 0.6632
Epoch 40/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6521 - acc: 0.6632
Epoch 41/100 18/18 [==============================] - 0s 3ms/step - loss: 0.6514 - acc: 0.6632
Epoch 42/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6508 - acc: 0.6632
Epoch 43/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6503 - acc: 0.6632
Epoch 44/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6496 - acc: 0.6615
Epoch 45/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6491 - acc: 0.6615
Epoch 46/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6486 - acc: 0.6615
Epoch 47/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6481 - acc: 0.6615
Epoch 48/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6478 - acc: 0.6615
Epoch 49/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6471 - acc: 0.6615
Epoch 50/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6466 - acc: 0.6615
Epoch 51/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6463 - acc: 0.6615
Epoch 52/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6460 - acc: 0.6615
Epoch 53/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6455 - acc: 0.6615
Epoch 54/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6453 - acc: 0.6615
Epoch 55/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6448 - acc: 0.6615
Epoch 56/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6442 - acc: 0.6615
Epoch 57/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6441 - acc: 0.6615
Epoch 58/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6436 - acc: 0.6615
Epoch 59/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6433 - acc: 0.6615
Epoch 60/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6439 - acc: 0.6615
Epoch 61/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6428 - acc: 0.6615
Epoch 62/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6424 - acc: 0.6615
Epoch 63/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6423 - acc: 0.6615
Epoch 64/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6421 - acc: 0.6615
Epoch 65/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6418 - acc: 0.6615
Epoch 66/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6414 - acc: 0.6615
Epoch 67/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6414 - acc: 0.6615
Epoch 68/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6411 - acc: 0.6615
Epoch 69/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6408 - acc: 0.6615
Epoch 70/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6405 - acc: 0.6615
Epoch 71/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6404 - acc: 0.6615
Epoch 72/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6402 - acc: 0.6615
Epoch 73/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6400 - acc: 0.6615
Epoch 74/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6399 - acc: 0.6615
Epoch 75/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6397 - acc: 0.6615
Epoch 76/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6394 - acc: 0.6615
Epoch 77/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6397 - acc: 0.6615
Epoch 78/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6393 - acc: 0.6615
Epoch 79/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6391 - acc: 0.6615
Epoch 80/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6393 - acc: 0.6615
Epoch 81/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6390 - acc: 0.6615
Epoch 82/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6390 - acc: 0.6615
Epoch 83/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6389 - acc: 0.6615
Epoch 84/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6386 - acc: 0.6615
Epoch 85/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6387 - acc: 0.6615
Epoch 86/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6383 - acc: 0.6615
Epoch 87/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6381 - acc: 0.6615
Epoch 88/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6382 - acc: 0.6615
Epoch 89/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6381 - acc: 0.6615
Epoch 90/100 18/18 [==============================] - 0s 3ms/step - loss: 0.6380 - acc: 0.6615
Epoch 91/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6383 - acc: 0.6615
Epoch 92/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6377 - acc: 0.6615
Epoch 93/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6385 - acc: 0.6615
Epoch 94/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6378 - acc: 0.6615
Epoch 95/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6377 - acc: 0.6615
Epoch 96/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6375 - acc: 0.6615
Epoch 97/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6377 - acc: 0.6615
Epoch 98/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6377 - acc: 0.6615
Epoch 99/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6374 - acc: 0.6615
Epoch 100/100 18/18 [==============================] - 0s 2ms/step - loss: 0.6374 - acc: 0.6615
Model: "sequential" _________________________________________________________________ Layer
(type) Output Shape Param #
================================================================= dense (Dense)
(None, 20) 180 dense_1 (Dense) (None, 4) 84 dense_2 (Dense) (None, 1) 5
================================================================= Total params: 269
(1.05 KB) Trainable params: 269 (1.05 KB) Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________ None 6/6
[==============================] - 0s 3ms/step - loss: 0.6606 - acc: 0.6198 [0.660642683506012,
0.6197916865348816]
```



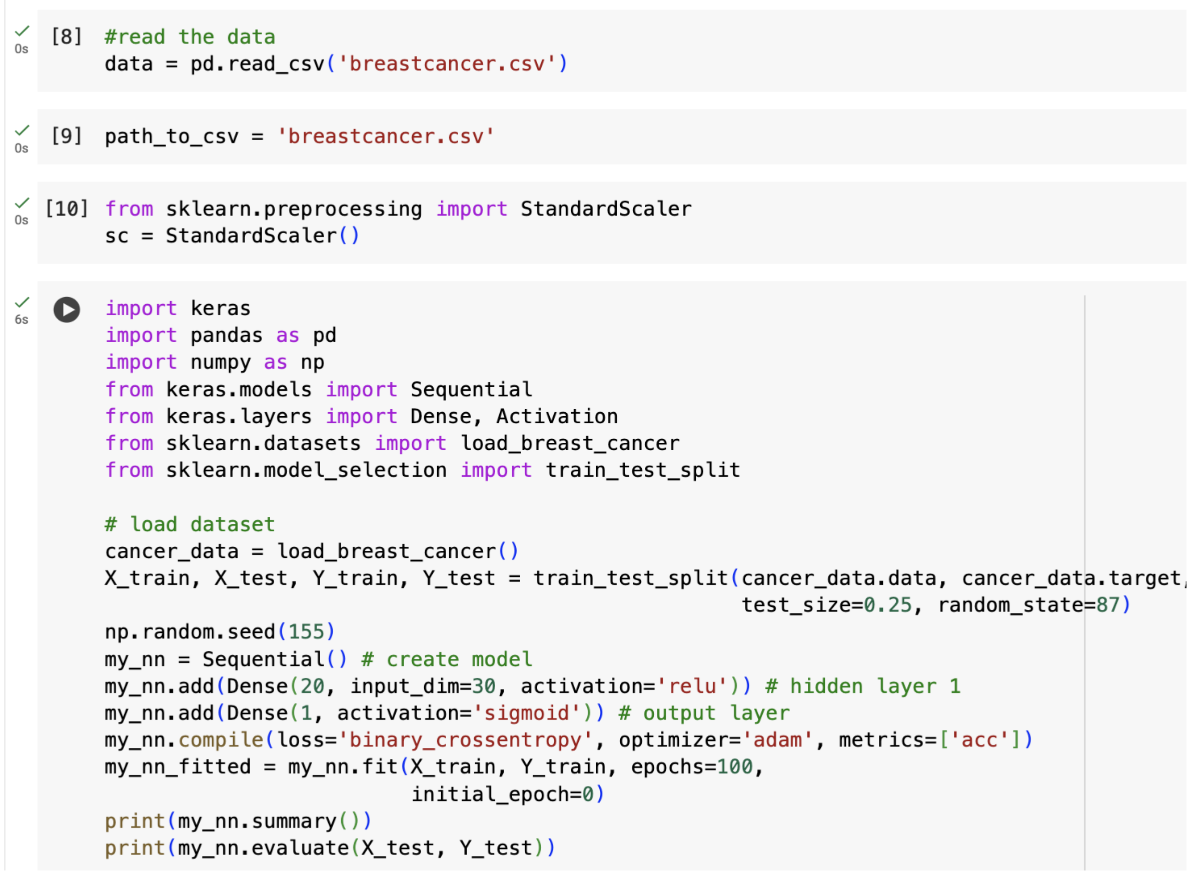
```
[5] #read the data
    data = pd.read_csv('breastcancer.csv')
```

```
[6] path_to_csv = 'sample_data/breastcancer.csv'
```

```
[7] import keras
    import pandas as pd
    import numpy as np
    from keras.models import Sequential
    from keras.layers 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))
```

```
Epoch 1/100 14/14 [==============================] - 1s 3ms/step - loss: 102.3078 - acc: 0.3803
Epoch 2/100 14/14 [==============================] - 0s 3ms/step - loss: 59.1148 - acc: 0.3803
Epoch 3/100 14/14 [==============================] - 0s 2ms/step - loss: 18.0792 - acc: 0.4601
Epoch 4/100 14/14 [==============================] - 0s 3ms/step - loss: 3.6943 - acc: 0.7394
Epoch 5/100 14/14 [==============================] - 0s 8ms/step - loss: 1.1049 - acc: 0.8005
Epoch 6/100 14/14 [==============================] - 0s 3ms/step - loss: 0.8925 - acc: 0.8451
Epoch 7/100 14/14 [==============================] - 0s 3ms/step - loss: 0.8376 - acc: 0.8498
Epoch 8/100 14/14 [==============================] - 0s 3ms/step - loss: 0.8064 - acc: 0.8427
Epoch 9/100 14/14 [==============================] - 0s 3ms/step - loss: 0.7676 - acc: 0.8545
Epoch 10/100 14/14 [==============================] - 0s 3ms/step - loss: 0.7416 - acc: 0.8615
Epoch 11/100 14/14 [==============================] - 0s 2ms/step - loss: 0.7417 - acc: 0.8474
Epoch 12/100 14/14 [==============================] - 0s 3ms/step - loss: 0.7564 - acc: 0.8779
Epoch 13/100 14/14 [==============================] - 0s 3ms/step - loss: 0.6699 - acc: 0.8568
Epoch 14/100 14/14 [==============================] - 0s 3ms/step - loss: 0.6799 - acc: 0.8545
Epoch 15/100 14/14 [==============================] - 0s 3ms/step - loss: 0.6825 - acc: 0.8732
Epoch 16/100 14/14 [==============================] - 0s 3ms/step - loss: 0.6358 - acc: 0.8756
Epoch 17/100 14/14 [==============================] - 0s 3ms/step - loss: 0.6047 - acc: 0.8732
Epoch 18/100 14/14 [==============================] - 0s 6ms/step - loss: 0.5634 - acc: 0.8803
Epoch 19/100 14/14 [==============================] - 0s 3ms/step - loss: 0.5546 - acc: 0.8756
Epoch 20/100 14/14 [==============================] - 0s 3ms/step - loss: 0.5656 - acc: 0.8803
Epoch 21/100 14/14 [==============================] - 0s 3ms/step - loss: 0.5279 - acc: 0.8873
Epoch 22/100 14/14 [==============================] - 0s 3ms/step - loss: 0.5286 - acc: 0.8850
Epoch 23/100 14/14 [==============================] - 0s 3ms/step - loss: 0.4875 - acc: 0.8756
Epoch 24/100 14/14 [==============================] - 0s 3ms/step - loss: 0.4942 - acc: 0.8967
Epoch 25/100 14/14 [==============================] - 0s 3ms/step - loss: 0.4791 - acc: 0.8873
Epoch 26/100 14/14 [==============================] - 0s 3ms/step - loss: 0.4725 - acc: 0.8897
Epoch 27/100 14/14 [==============================] - 0s 2ms/step - loss: 0.4402 - acc: 0.8897
Epoch 28/100 14/14 [==============================] - 0s 3ms/step - loss: 0.4333 - acc: 0.9038
Epoch 29/100 14/14 [==============================] - 0s 2ms/step - loss: 0.4272 - acc: 0.8944
Epoch 30/100 14/14 [==============================] - 0s 2ms/step - loss: 0.3860 - acc: 0.9108
Epoch 31/100 14/14 [==============================] - 0s 3ms/step - loss: 0.4952 - acc: 0.8920
Epoch 32/100 14/14 [==============================] - 0s 3ms/step - loss: 0.3922 - acc: 0.8991
Epoch 33/100 14/14 [==============================] - 0s 3ms/step - loss: 0.3771 - acc: 0.9085
Epoch 34/100 14/14 [==============================] - 0s 3ms/step - loss: 0.7166 - acc: 0.8592
Epoch 35/100 14/14 [==============================] - 0s 3ms/step - loss: 0.3751 - acc: 0.9108
Epoch 36/100 14/14 [==============================] - 0s 3ms/step - loss: 0.3469 - acc: 0.9014
Epoch 37/100 14/14 [==============================] - 0s 3ms/step - loss: 0.3559 - acc: 0.9038
Epoch 38/100 14/14 [==============================] - 0s 3ms/step - loss: 0.3142 - acc: 0.9108
Epoch 39/100 14/14 [==============================] - 0s 3ms/step - loss: 0.3540 - acc: 0.9061
Epoch 40/100 14/14 [==============================] - 0s 3ms/step - loss: 0.3123 - acc: 0.9061
Epoch 41/100 14/14 [==============================] - 0s 3ms/step - loss: 0.3201 - acc: 0.9108
Epoch 42/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2783 - acc: 0.9178
Epoch 43/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2841 - acc: 0.9061
Epoch 44/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2664 - acc: 0.9085
Epoch 45/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2509 - acc: 0.9155
Epoch 46/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2837 - acc: 0.9202
Epoch 47/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2776 - acc: 0.9155
Epoch 48/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2496 - acc: 0.9202
Epoch 49/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2970 - acc: 0.9202
Epoch 50/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2562 - acc: 0.9296
Epoch 51/100 14/14 [==============================] - 0s 3ms/step - loss: 0.3467 - acc: 0.9085
Epoch 52/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2634 - acc: 0.9202
Epoch 53/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2171 - acc: 0.9272
Epoch 54/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2175 - acc: 0.9249
Epoch 55/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2488 - acc: 0.9272
Epoch 56/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2668 - acc: 0.9249
Epoch 57/100 14/14 [==============================] - 0s 4ms/step - loss: 0.2485 - acc: 0.9272
Epoch 58/100 14/14 [==============================] - 0s 5ms/step - loss: 0.2832 - acc: 0.9085
Epoch 59/100 14/14 [==============================] - 0s 4ms/step - loss: 0.2214 - acc: 0.9249
Epoch 60/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2104 - acc: 0.9272
Epoch 61/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2217 - acc: 0.9296
Epoch 62/100 14/14 [==============================] - 0s 3ms/step - loss: 0.1963 - acc: 0.9296
Epoch 63/100 14/14 [==============================] - 0s 3ms/step - loss: 0.1907 - acc: 0.9437
Epoch 64/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2267 - acc: 0.9249
Epoch 65/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2001 - acc: 0.9178
Epoch 66/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1667 - acc: 0.9390
Epoch 67/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1678 - acc: 0.9296
Epoch 68/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1771 - acc: 0.9366
Epoch 69/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1519 - acc: 0.9296
Epoch 70/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1789 - acc: 0.9249
Epoch 71/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1930 - acc: 0.9366
Epoch 72/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2408 - acc: 0.9202
Epoch 73/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2966 - acc: 0.9038
Epoch 74/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2153 - acc: 0.9343
Epoch 75/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1956 - acc: 0.9390
Epoch 76/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1452 - acc: 0.9413
Epoch 77/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1679 - acc: 0.9343
Epoch 78/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1894 - acc: 0.9343
Epoch 79/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2121 - acc: 0.9296
Epoch 80/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1513 - acc: 0.9390
Epoch 81/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1422 - acc: 0.9319
Epoch 82/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1342 - acc: 0.9390
Epoch 83/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1405 - acc: 0.9413
Epoch 84/100 14/14 [==============================] - 0s 4ms/step - loss: 0.1360 - acc: 0.9413
Epoch 85/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1949 - acc: 0.9296
Epoch 86/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2018 - acc: 0.9225
Epoch 87/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1425 - acc: 0.9484
Epoch 88/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1750 - acc: 0.9390
Epoch 89/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1313 - acc: 0.9413
Epoch 90/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1288 - acc: 0.9484
Epoch 91/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1879 - acc: 0.9272
Epoch 92/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1723 - acc: 0.9531
Epoch 93/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1232 - acc: 0.9531
Epoch 94/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1199 - acc: 0.9460
Epoch 95/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1317 - acc: 0.9531
Epoch 96/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1965 - acc: 0.9178
Epoch 97/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1730 - acc: 0.9296
Epoch 98/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1797 - acc: 0.9319
Epoch 99/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1189 - acc: 0.9413
Epoch 100/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1187 - acc: 0.9507
Model: "sequential_1" _________________________________________________________________ Layer
(type) Output Shape Param #
```

=== dense_3 (Dense) (None, 20) 620 dense_4 (Dense) (None, 1) 21 === Total params: 641 (2.50 KB) Trainable params: 641 (2.50 KB) Non-trainable params: 0 (0.00 Byte) ____ None 5/5 [==============================] - 0s 3ms/step - loss: 0.1654 - acc: 0.9371 [0.16541491448879242, 0.9370629191398621]



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

```
[9]  path_to_csv = 'breastcancer.csv'
```

```
[10] from sklearn.preprocessing import StandardScaler
     sc = StandardScaler()
```

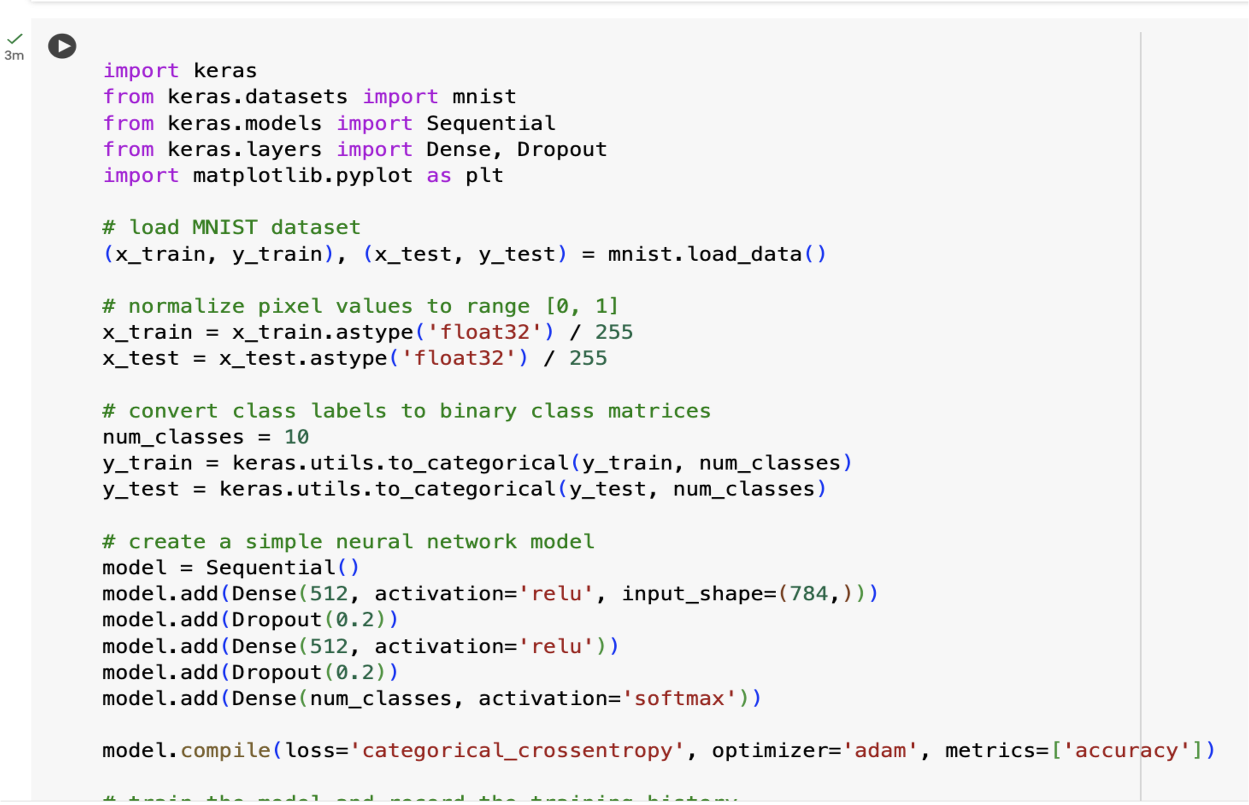
```
import keras
import pandas as pd
import numpy as np
from keras.models import Sequential
from keras.layers import Dense, Activation
from sklearn.datasets import load_breast_cancer
from sklearn.model_selection import train_test_split

# 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))
```

Epoch 1/100 14/14 [==============================] - 1s 2ms/step - loss: 160.3251 - acc: 0.6197
Epoch 2/100 14/14 [==============================] - 0s 2ms/step - loss: 114.6389 - acc: 0.6197
Epoch 3/100 14/14 [==============================] - 0s 2ms/step - loss: 72.7626 - acc: 0.6197
Epoch 4/100 14/14 [==============================] - 0s 2ms/step - loss: 31.9955 - acc: 0.5728
Epoch 5/100 14/14 [==============================] - 0s 2ms/step - loss: 10.4390 - acc: 0.2653
Epoch 6/100 14/14 [==============================] - 0s 2ms/step - loss: 8.9202 - acc: 0.2418
Epoch 7/100 14/14 [==============================] - 0s 3ms/step - loss: 6.1245 - acc: 0.1948
Epoch 8/100 14/14 [==============================] - 0s 2ms/step - loss: 3.5213 - acc: 0.2746
Epoch 9/100 14/14 [==============================] - 0s 2ms/step - loss: 1.8175 - acc: 0.4249
Epoch 10/100 14/14 [==============================] - 0s 2ms/step - loss: 1.0556 - acc: 0.6127

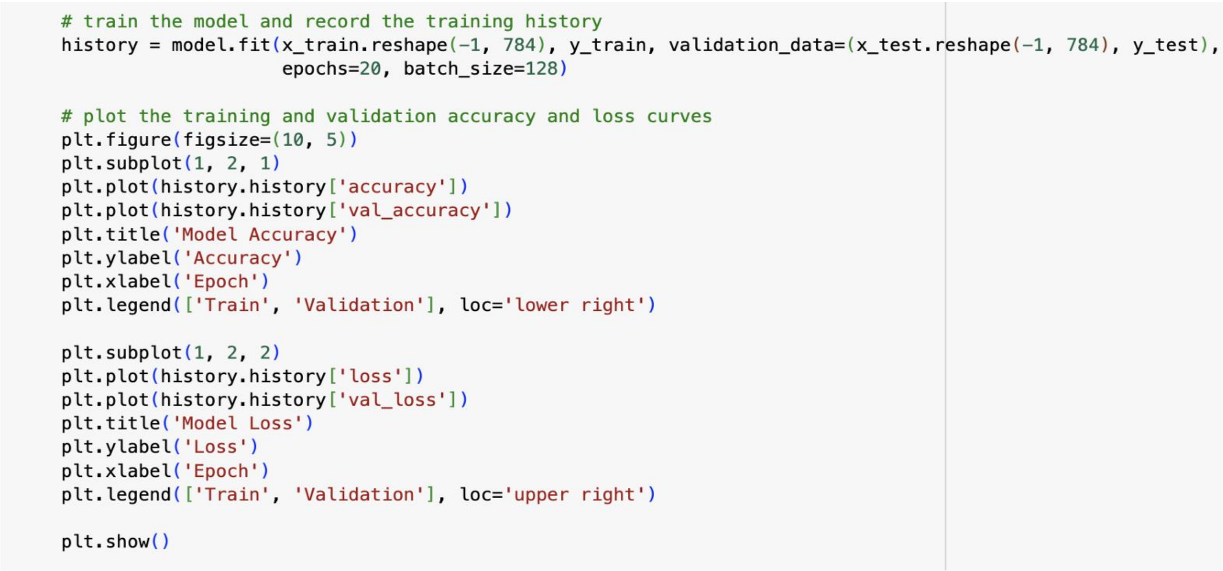
```
Epoch 11/100 14/14 [==============================] - 0s 2ms/step - loss: 0.6782 - acc: 0.7254
Epoch 12/100 14/14 [==============================] - 0s 2ms/step - loss: 0.5148 - acc: 0.7887
Epoch 13/100 14/14 [==============================] - 0s 2ms/step - loss: 0.4347 - acc: 0.8216
Epoch 14/100 14/14 [==============================] - 0s 2ms/step - loss: 0.4257 - acc: 0.8216
Epoch 15/100 14/14 [==============================] - 0s 2ms/step - loss: 0.3664 - acc: 0.8732
Epoch 16/100 14/14 [==============================] - 0s 2ms/step - loss: 0.3560 - acc: 0.8568
Epoch 17/100 14/14 [==============================] - 0s 2ms/step - loss: 0.3169 - acc: 0.8709
Epoch 18/100 14/14 [==============================] - 0s 2ms/step - loss: 0.3153 - acc: 0.8826
Epoch 19/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2856 - acc: 0.8897
Epoch 20/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2775 - acc: 0.8944
Epoch 21/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2709 - acc: 0.8967
Epoch 22/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2642 - acc: 0.9061
Epoch 23/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2543 - acc: 0.9061
Epoch 24/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2589 - acc: 0.8944
Epoch 25/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2477 - acc: 0.8991
Epoch 26/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2414 - acc: 0.9108
Epoch 27/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2447 - acc: 0.9061
Epoch 28/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2293 - acc: 0.9131
Epoch 29/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2413 - acc: 0.9085
Epoch 30/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2250 - acc: 0.9061
Epoch 31/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2217 - acc: 0.9202
Epoch 32/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2429 - acc: 0.9061
Epoch 33/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2235 - acc: 0.9178
Epoch 34/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2176 - acc: 0.9202
Epoch 35/100 14/14 [==============================] - 0s 3ms/step - loss: 0.2322 - acc: 0.9202
Epoch 36/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2222 - acc: 0.9131
Epoch 37/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2351 - acc: 0.9202
Epoch 38/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2131 - acc: 0.9131
Epoch 39/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2054 - acc: 0.9155
Epoch 40/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2411 - acc: 0.8991
Epoch 41/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2008 - acc: 0.9225
Epoch 42/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1937 - acc: 0.9202
Epoch 43/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2065 - acc: 0.9272
Epoch 44/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1985 - acc: 0.9202
Epoch 45/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1973 - acc: 0.9225
Epoch 46/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2064 - acc: 0.9085
Epoch 47/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1893 - acc: 0.9225
Epoch 48/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1881 - acc: 0.9249
Epoch 49/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1889 - acc: 0.9272
Epoch 50/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2146 - acc: 0.9155
Epoch 51/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1807 - acc: 0.9343
Epoch 52/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1863 - acc: 0.9249
Epoch 53/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2141 - acc: 0.9225
Epoch 54/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1799 - acc: 0.9272
Epoch 55/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1725 - acc: 0.9366
Epoch 56/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1869 - acc: 0.9272
Epoch 57/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1812 - acc: 0.9272
Epoch 58/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1710 - acc: 0.9319
Epoch 59/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1879 - acc: 0.9202
Epoch 60/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1745 - acc: 0.9343
Epoch 61/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1693 - acc: 0.9225
Epoch 62/100 14/14 [==============================] - 0s 4ms/step - loss: 0.1701 - acc: 0.9343
Epoch 63/100 14/14 [==============================] - 0s 3ms/step - loss: 0.1901 - acc: 0.9225
Epoch 64/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1655 - acc: 0.9343
Epoch 65/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2049 - acc: 0.9131
Epoch 66/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1975 - acc: 0.9272
Epoch 67/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1665 - acc: 0.9413
Epoch 68/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1680 - acc: 0.9390
Epoch 69/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1778 - acc: 0.9366
Epoch 70/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1947 - acc: 0.9225
Epoch 71/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2147 - acc: 0.9131
Epoch 72/100 14/14 [==============================] - 0s 2ms/step - loss: 0.3321 - acc: 0.8967
Epoch 73/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2058 - acc: 0.9202
Epoch 74/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1865 - acc: 0.9225
Epoch 75/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1576 - acc: 0.9319
Epoch 76/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1567 - acc: 0.9390
Epoch 77/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1586 - acc: 0.9319
Epoch 78/100 14/14 [==============================] - 0s 2ms/step - loss: 0.2066 - acc: 0.9155
Epoch 79/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1565 - acc: 0.9413
Epoch 80/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1486 - acc: 0.9343
Epoch 81/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1546 - acc: 0.9390
Epoch 82/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1621 - acc: 0.9366
Epoch 83/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1539 - acc: 0.9366
Epoch 84/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1622 - acc: 0.9366
Epoch 85/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1948 - acc: 0.9296
Epoch 86/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1516 - acc: 0.9366
Epoch 87/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1571 - acc: 0.9343
Epoch 88/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1403 - acc: 0.9437
Epoch 89/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1414 - acc: 0.9413
Epoch 90/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1428 - acc: 0.9437
Epoch 91/100 14/14 [==============================] - 0s 3ms/step - loss: 0.1487 - acc: 0.9343
Epoch 92/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1601 - acc: 0.9390
Epoch 93/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1767 - acc: 0.9272
Epoch 94/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1575 - acc: 0.9413
Epoch 95/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1773 - acc: 0.9272
Epoch 96/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1891 - acc: 0.9225
Epoch 97/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1407 - acc: 0.9390
Epoch 98/100 14/14 [==============================] - 0s 3ms/step - loss: 0.1373 - acc: 0.9484
Epoch 99/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1444 - acc: 0.9296
Epoch 100/100 14/14 [==============================] - 0s 2ms/step - loss: 0.1486 - acc: 0.9319
Model: "sequential_2" _________________________________________________________________ Layer
(type) Output Shape Param #
================================================================= dense_5 (Dense)
(None, 20) 620 dense_6 (Dense) (None, 1) 21
================================================================= Total params: 641
(2.50 KB) Trainable params: 641 (2.50 KB) Non-trainable params: 0 (0.00 Byte)
```

____ None 5/5 [==============================] - 0s 3ms/step - loss: 0.2498 - acc: 0.9021 [0.24980774521827698, 0.9020978808403015]

2)



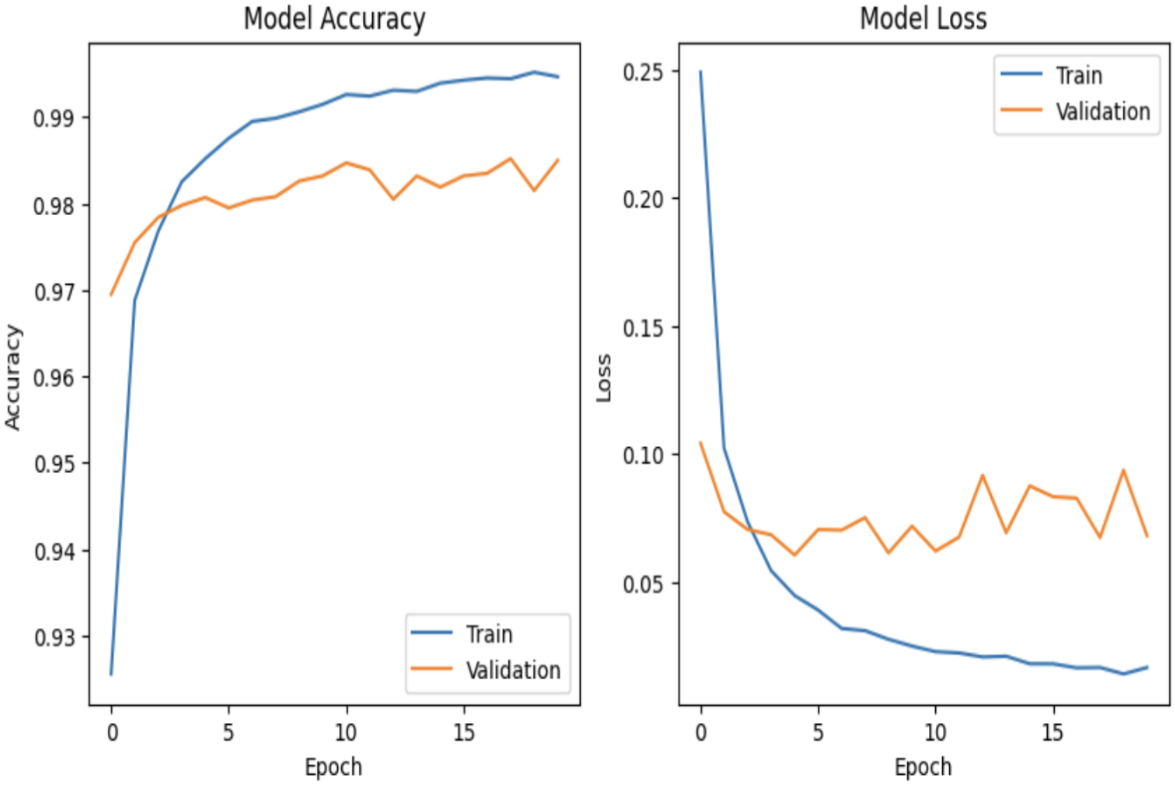
```
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout
import matplotlib.pyplot as plt

# 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'])
```

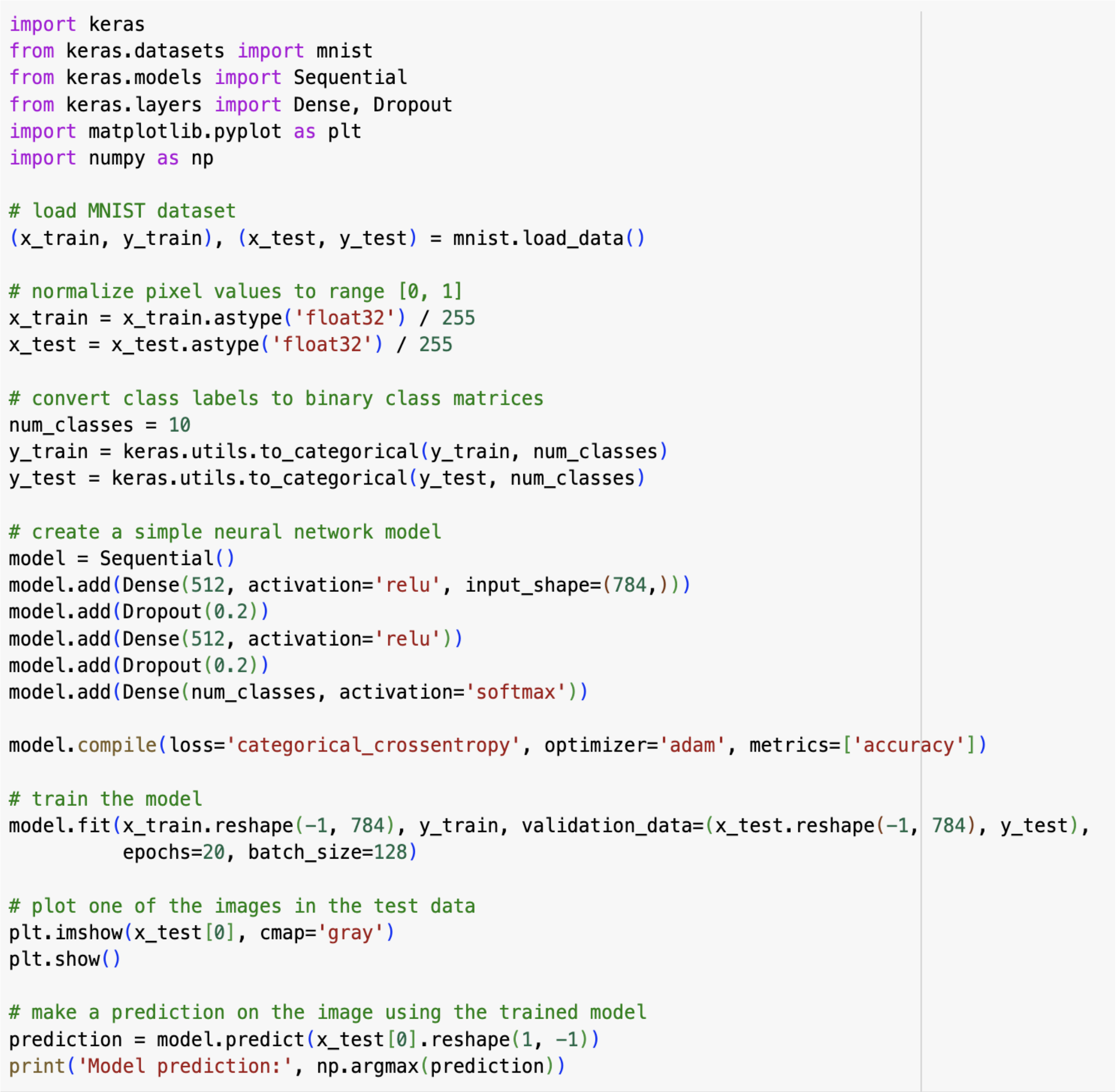


```
# train the model and record the training history
history = model.fit(x_train.reshape(-1, 784), y_train, validation_data=(x_test.reshape(-1, 784), y_test),
                    epochs=20, batch_size=128)

# 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()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz
11490434/11490434 [==============================] - 0s 0us/step
Epoch 1/20
469/469 [==============================] - 10s 21ms/step - loss: 0.2489 - accuracy: 0.9255 -
val_loss: 0.1042 - val_accuracy: 0.9695
Epoch 2/20
469/469 [==============================] - 10s 21ms/step - loss: 0.1023 - accuracy: 0.9688 -
val_loss: 0.0775 - val_accuracy: 0.9755
Epoch 3/20
469/469 [==============================] - 9s 19ms/step - loss: 0.0736 - accuracy: 0.9768 -
val_loss: 0.0706 - val_accuracy: 0.9784
Epoch 4/20
469/469 [==============================] - 14s 31ms/step - loss: 0.0545 - accuracy: 0.9825 -
val_loss: 0.0685 - val_accuracy: 0.9798
Epoch 5/20
469/469 [==============================] - 9s 18ms/step - loss: 0.0447 - accuracy: 0.9852 -
val_loss: 0.0606 - val_accuracy: 0.9807
Epoch 6/20
469/469 [==============================] - 12s 25ms/step - loss: 0.0391 - accuracy: 0.9876 -
val_loss: 0.0706 - val_accuracy: 0.9795
Epoch 7/20
469/469 [==============================] - 9s 20ms/step - loss: 0.0319 - accuracy: 0.9895 -
val_loss: 0.0704 - val_accuracy: 0.9804
Epoch 8/20
469/469 [==============================] - 10s 21ms/step - loss: 0.0310 - accuracy: 0.9899 -
val_loss: 0.0752 - val_accuracy: 0.9808
Epoch 9/20
469/469 [==============================] - 9s 18ms/step - loss: 0.0277 - accuracy: 0.9906 -
val_loss: 0.0614 - val_accuracy: 0.9826
Epoch 10/20
469/469 [==============================] - 10s 20ms/step - loss: 0.0250 - accuracy: 0.9915 -
val_loss: 0.0719 - val_accuracy: 0.9832
Epoch 11/20
469/469 [==============================] - 10s 21ms/step - loss: 0.0228 - accuracy: 0.9926 -
val_loss: 0.0622 - val_accuracy: 0.9847
Epoch 12/20
469/469 [==============================] - 10s 20ms/step - loss: 0.0223 - accuracy: 0.9924 -
val_loss: 0.0676 - val_accuracy: 0.9839
Epoch 13/20
469/469 [==============================] - 9s 19ms/step - loss: 0.0208 - accuracy: 0.9931 -
val_loss: 0.0917 - val_accuracy: 0.9805
Epoch 14/20
469/469 [==============================] - 10s 22ms/step - loss: 0.0211 - accuracy: 0.9930 -
val_loss: 0.0693 - val_accuracy: 0.9832
Epoch 15/20
469/469 [==============================] - 10s 20ms/step - loss: 0.0181 - accuracy: 0.9939 -
val_loss: 0.0876 - val_accuracy: 0.9819
Epoch 16/20
```

```
469/469 [==============================] - 9s 18ms/step - loss: 0.0181 - accuracy: 0.9943 -
val_loss: 0.0833 - val_accuracy: 0.9832
Epoch 17/20
469/469 [==============================] - 10s 20ms/step - loss: 0.0165 - accuracy: 0.9945 -
val_loss: 0.0828 - val_accuracy: 0.9835
Epoch 18/20
469/469 [==============================] - 9s 20ms/step - loss: 0.0166 - accuracy: 0.9944 -
val_loss: 0.0675 - val_accuracy: 0.9852
Epoch 19/20
469/469 [==============================] - 9s 20ms/step - loss: 0.0141 - accuracy: 0.9952 -
val_loss: 0.0937 - val_accuracy: 0.9815
Epoch 20/20
469/469 [==============================] - 9s 18ms/step - loss: 0.0166 - accuracy: 0.9947 -
val_loss: 0.0682 - val_accuracy: 0.9850
```

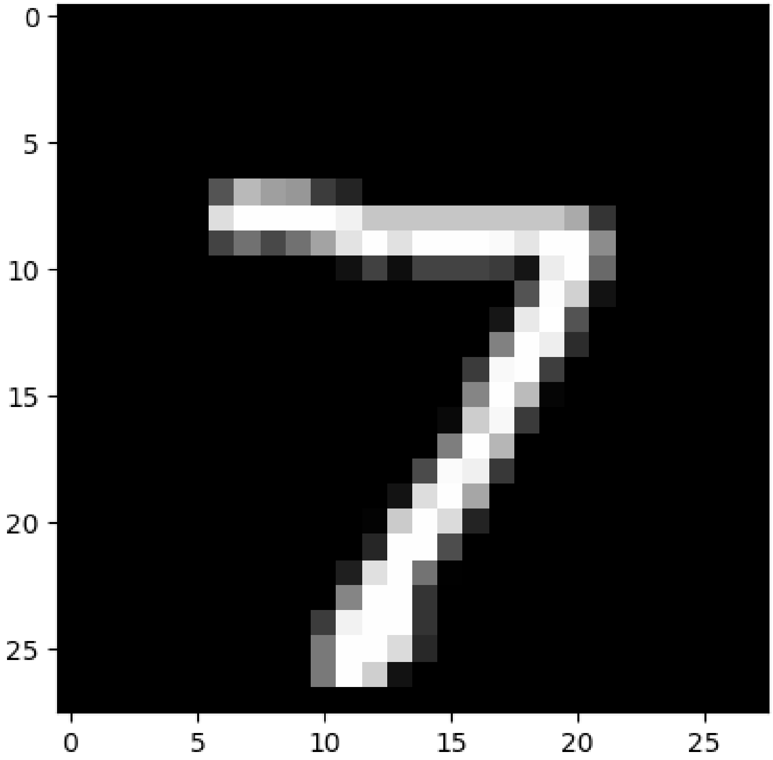




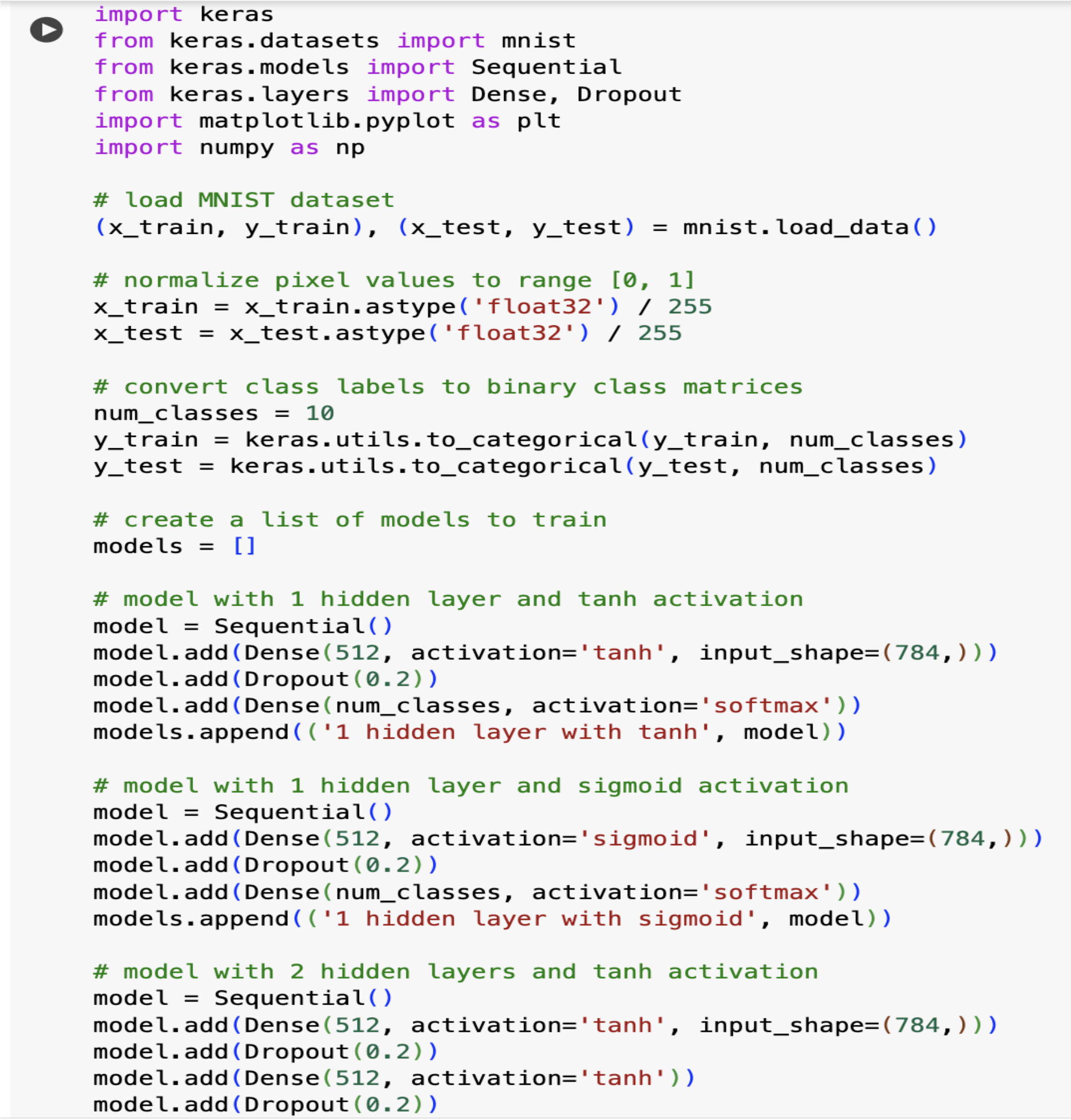
```
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout
import matplotlib.pyplot as plt
import numpy as np

# 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.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))
```

```
Epoch 1/20
469/469 [==============================] - 9s 16ms/step - loss: 0.2501 - accuracy: 0.9247 -
val_loss: 0.1042 - val_accuracy: 0.9654
Epoch 2/20
469/469 [==============================] - 8s 18ms/step - loss: 0.0997 - accuracy: 0.9696 -
val_loss: 0.0816 - val_accuracy: 0.9736
Epoch 3/20
469/469 [==============================] - 8s 18ms/step - loss: 0.0711 - accuracy: 0.9772 -
val_loss: 0.0737 - val_accuracy: 0.9756
Epoch 4/20
469/469 [==============================] - 8s 17ms/step - loss: 0.0563 - accuracy: 0.9815 -
val_loss: 0.0778 - val_accuracy: 0.9771
Epoch 5/20
```

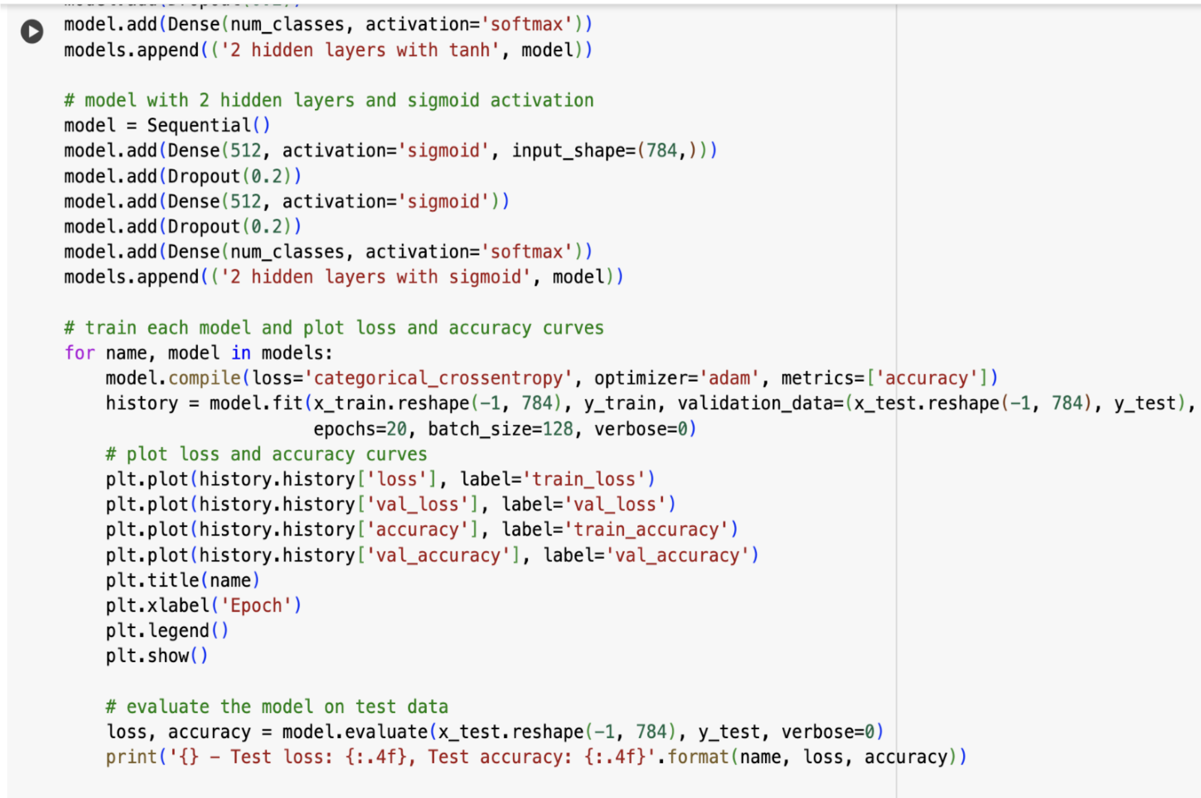
```
469/469 [==============================] - 9s 20ms/step - loss: 0.0464 - accuracy: 0.9847 -
val_loss: 0.0615 - val_accuracy: 0.9813
Epoch 6/20
469/469 [==============================] - 9s 19ms/step - loss: 0.0411 - accuracy: 0.9866 -
val_loss: 0.0619 - val_accuracy: 0.9806
Epoch 7/20
469/469 [==============================] - 8s 16ms/step - loss: 0.0331 - accuracy: 0.9888 -
val_loss: 0.0559 - val_accuracy: 0.9832
Epoch 8/20
469/469 [==============================] - 9s 18ms/step - loss: 0.0292 - accuracy: 0.9907 -
val_loss: 0.0716 - val_accuracy: 0.9795
Epoch 9/20
469/469 [==============================] - 9s 20ms/step - loss: 0.0282 - accuracy: 0.9903 -
val_loss: 0.0788 - val_accuracy: 0.9808
Epoch 10/20
469/469 [==============================] - 8s 17ms/step - loss: 0.0295 - accuracy: 0.9903 -
val_loss: 0.0609 - val_accuracy: 0.9832
Epoch 11/20
469/469 [==============================] - 8s 18ms/step - loss: 0.0231 - accuracy: 0.9919 -
val_loss: 0.0766 - val_accuracy: 0.9810
Epoch 12/20
469/469 [==============================] - 8s 18ms/step - loss: 0.0220 - accuracy: 0.9924 -
val_loss: 0.0692 - val_accuracy: 0.9827
Epoch 13/20
469/469 [==============================] - 8s 16ms/step - loss: 0.0205 - accuracy: 0.9926 -
val_loss: 0.0689 - val_accuracy: 0.9832
Epoch 14/20
469/469 [==============================] - 8s 18ms/step - loss: 0.0198 - accuracy: 0.9932 -
val_loss: 0.0755 - val_accuracy: 0.9825
Epoch 15/20
469/469 [==============================] - 9s 19ms/step - loss: 0.0185 - accuracy: 0.9939 -
val_loss: 0.0668 - val_accuracy: 0.9826
Epoch 16/20
469/469 [==============================] - 8s 16ms/step - loss: 0.0183 - accuracy: 0.9937 -
val_loss: 0.0804 - val_accuracy: 0.9837
Epoch 17/20
469/469 [==============================] - 9s 19ms/step - loss: 0.0173 - accuracy: 0.9941 -
val_loss: 0.0707 - val_accuracy: 0.9848
Epoch 18/20
469/469 [==============================] - 9s 19ms/step - loss: 0.0156 - accuracy: 0.9947 -
val_loss: 0.0799 - val_accuracy: 0.9847
Epoch 19/20
469/469 [==============================] - 8s 17ms/step - loss: 0.0169 - accuracy: 0.9941 -
val_loss: 0.0822 - val_accuracy: 0.9821
Epoch 20/20
469/469 [==============================] - 8s 18ms/step - loss: 0.0142 - accuracy: 0.9956 -
val_loss: 0.0731 - val_accuracy: 0.9848
```



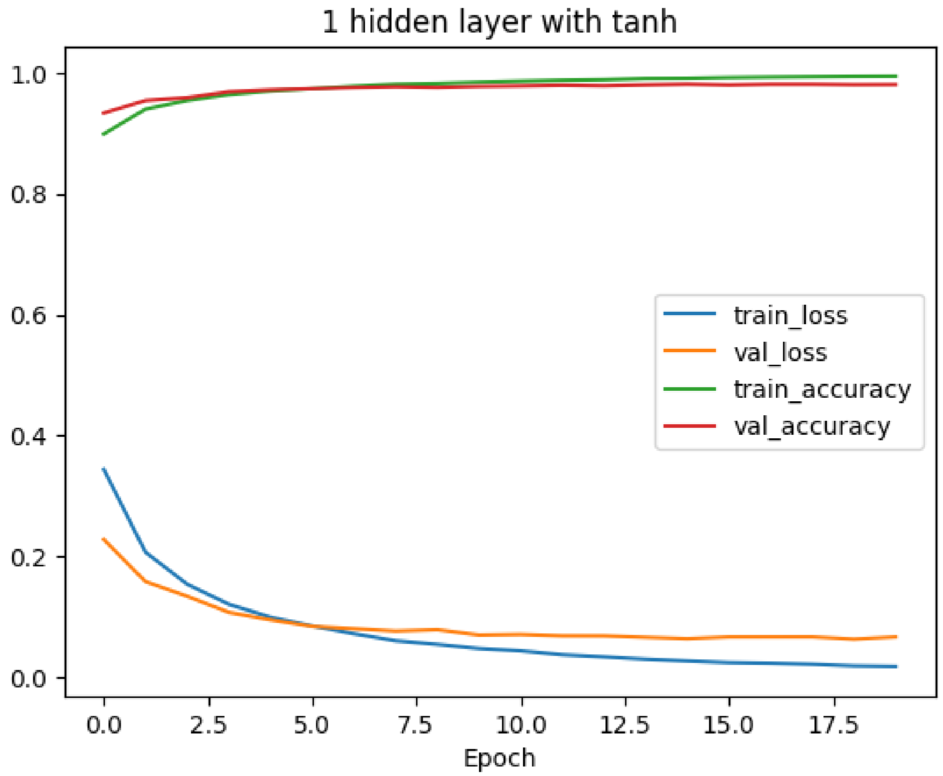
```
1/1 [==============================] - 0s 90ms/step
Model prediction: 7
```



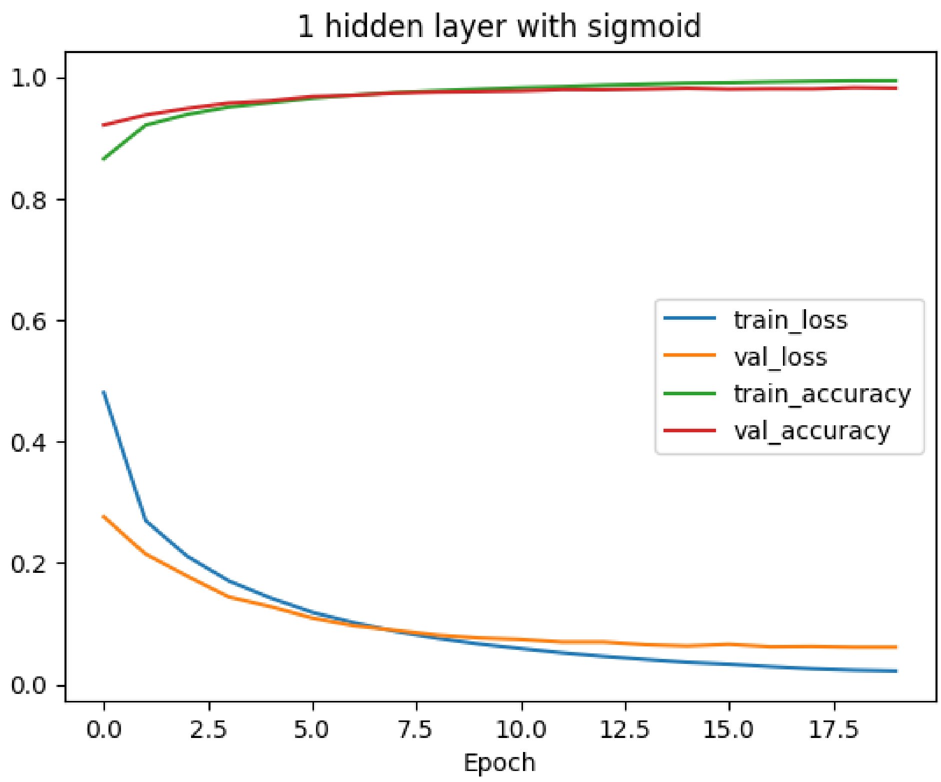
```python
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout
import matplotlib.pyplot as plt
import numpy as np

# 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 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))
```



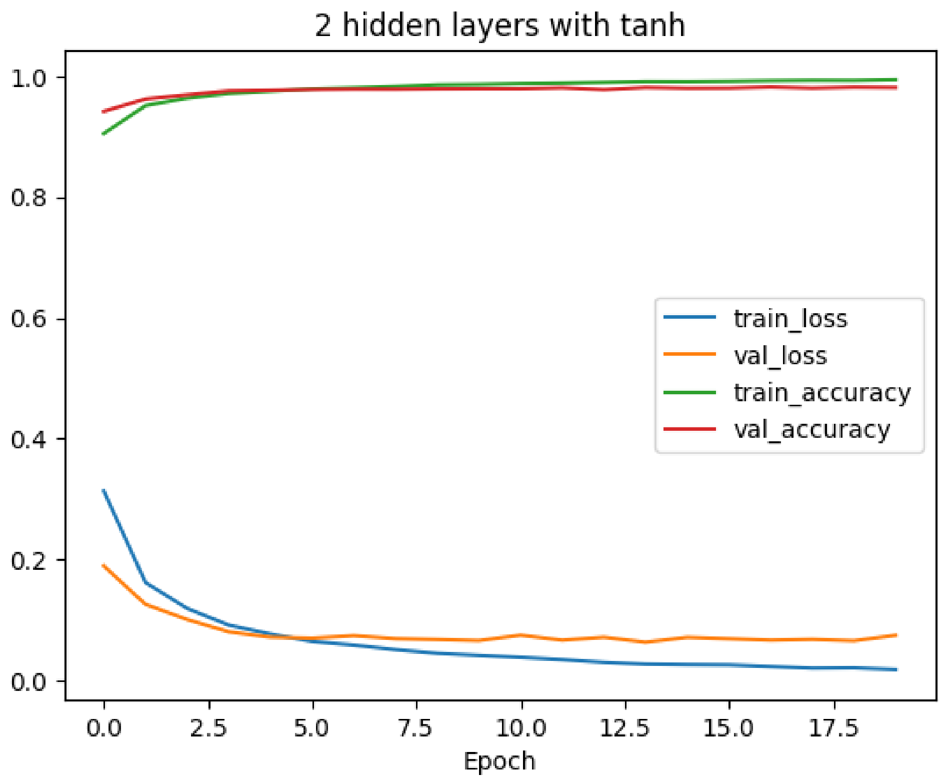
```
model.add(Dense(num_classes, activation='softmax'))
models.append(('2 hidden layers with tanh', model))

# 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))
```



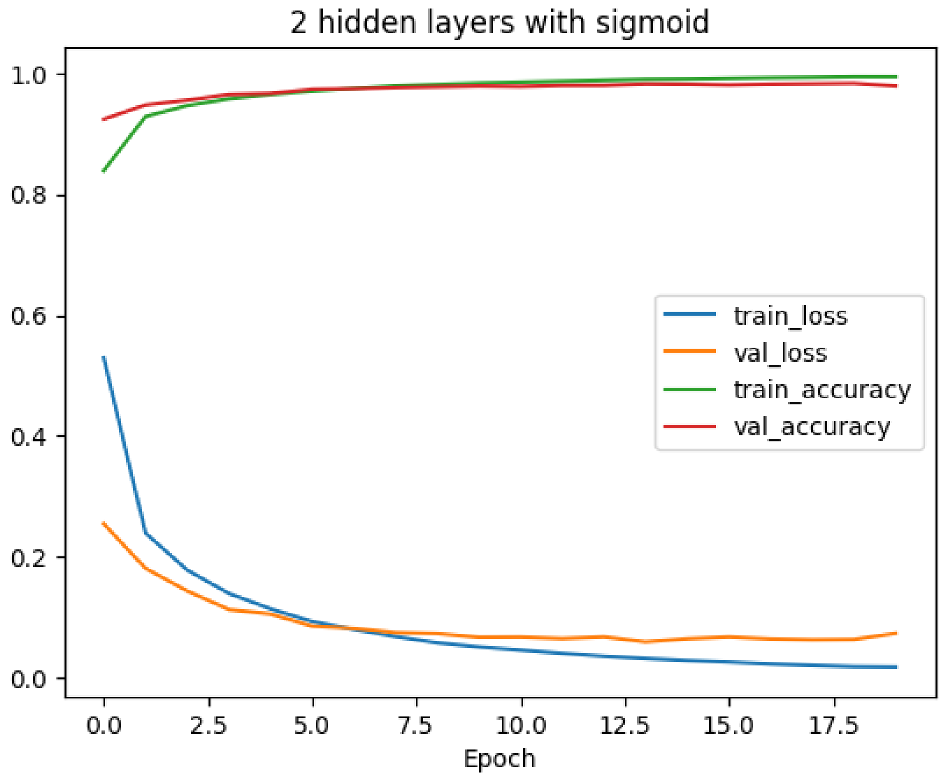
1 hidden layer with tanh - Test loss: 0.0664, Test accuracy: 0.9807



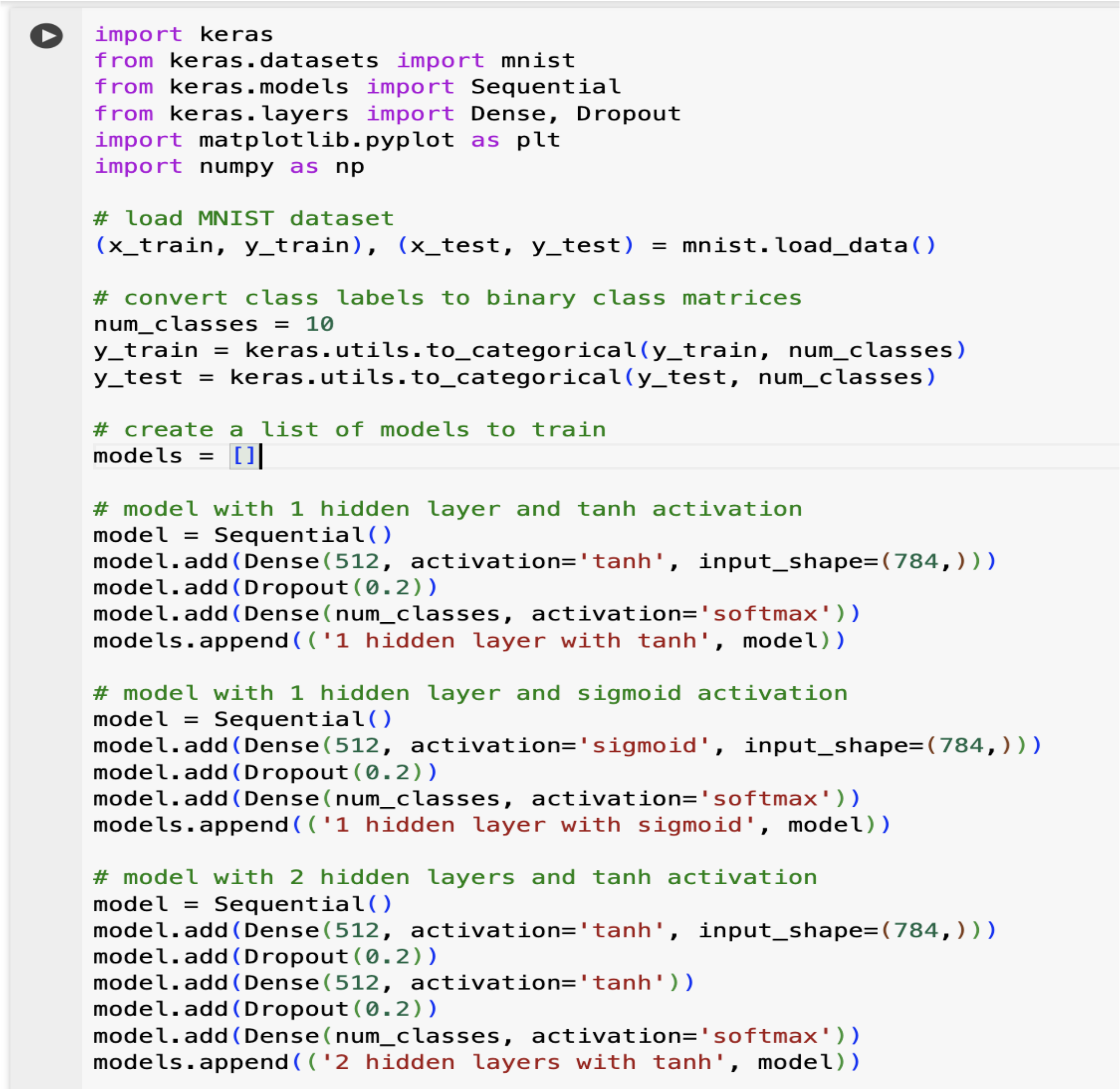
1 hidden layer with sigmoid - Test loss: 0.0616, Test accuracy: 0.9820



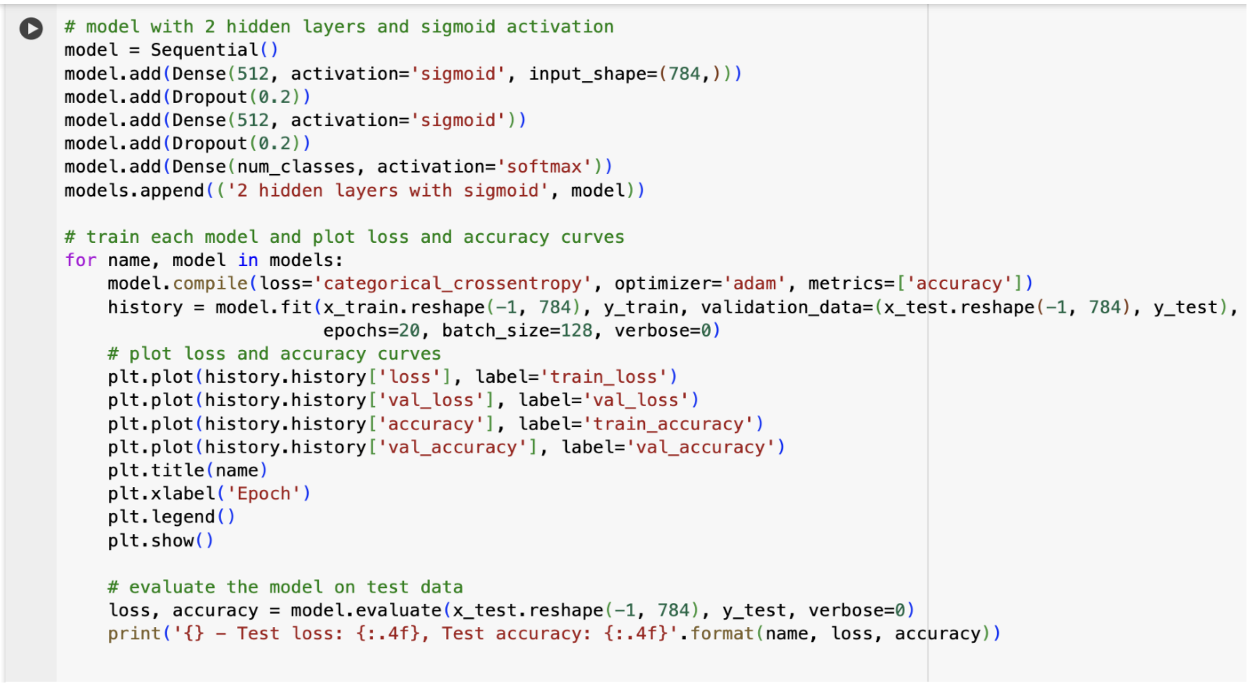
2 hidden layers with tanh - Test loss: 0.0744, Test accuracy: 0.9812



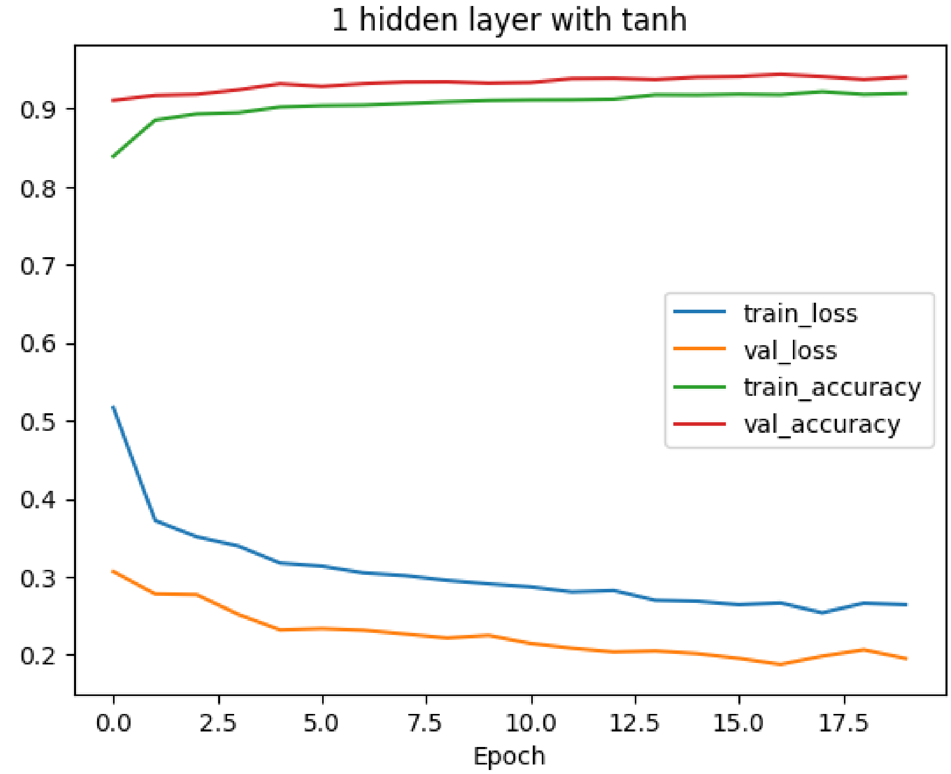
2 hidden layers with sigmoid - Test loss: 0.0733, Test accuracy: 0.9792



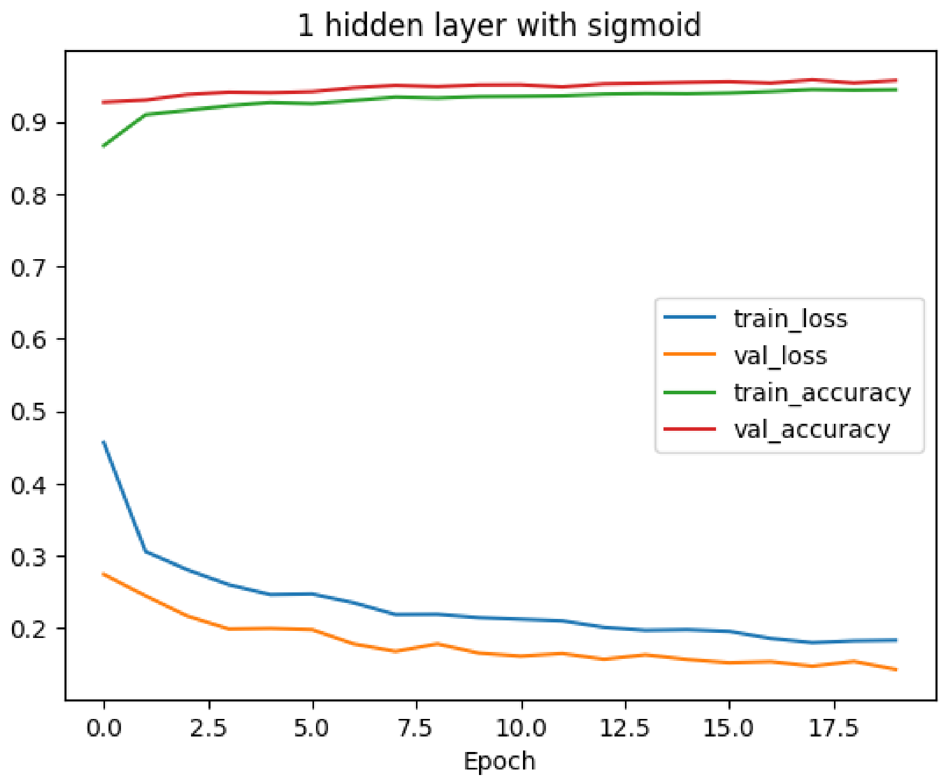
```
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout
import matplotlib.pyplot as plt
import numpy as np

# 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.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))
```



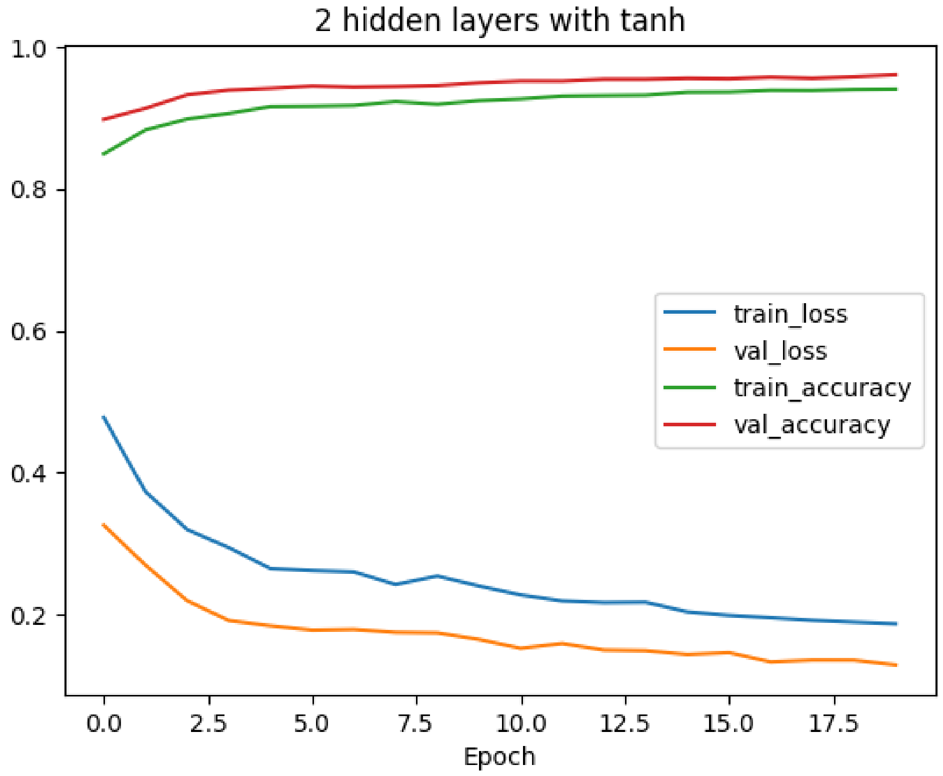
```
# model with 2 hidden layers and sigmoid activation
model = Sequential()
model.add(Dense(512, activation='sigmoid', input_shape=(784,)))
model.add(Dropout(0.2))
model.add(Dense(512, activation='sigmoid'))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
models.append(('2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



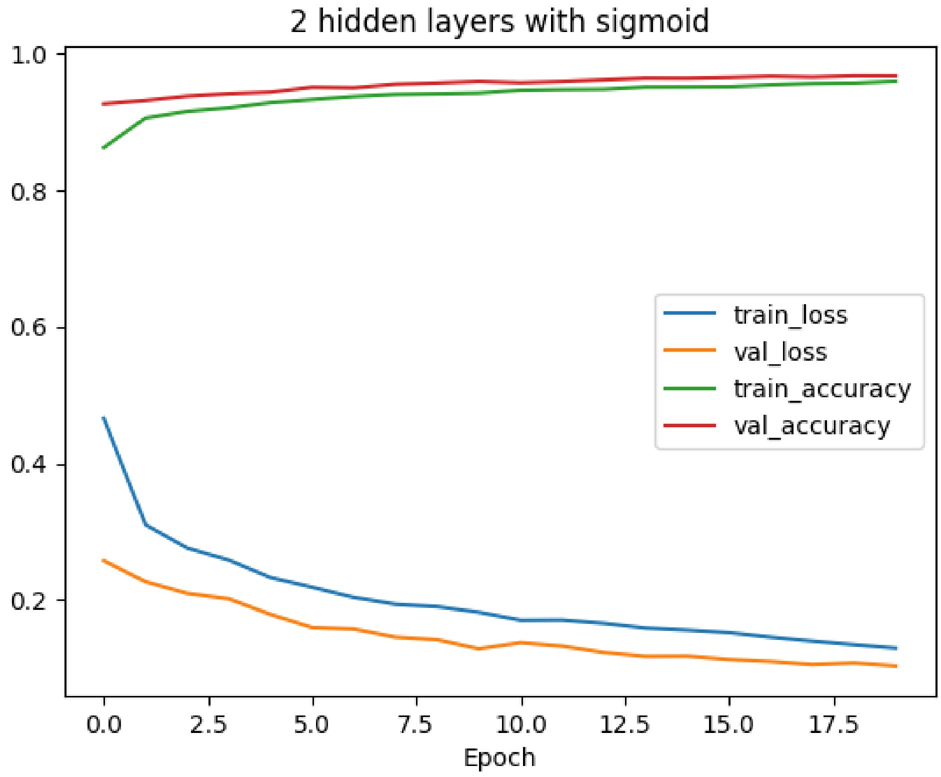
1 hidden layer with tanh - Test loss: 0.1951, Test accuracy: 0.9407



1 hidden layer with sigmoid - Test loss: 0.1426, Test accuracy: 0.9568



2 hidden layers with tanh - Test loss: 0.1289, Test accuracy: 0.9602



2 hidden layers with sigmoid - Test loss: 0.1037, Test accuracy: 0.9665