Lab Assignment No. 13

Code:

```
import tensorflow as tf
from tensorflow import keras
from keras import Sequential
from keras.layers import Dense, Dropout, Flatten
import numpy as np
import pandas as pd
```

```
(x_train, y_train), (x_test, y_test) = keras.datasets.mnist.load_data()
```

```
x_test.shape
```

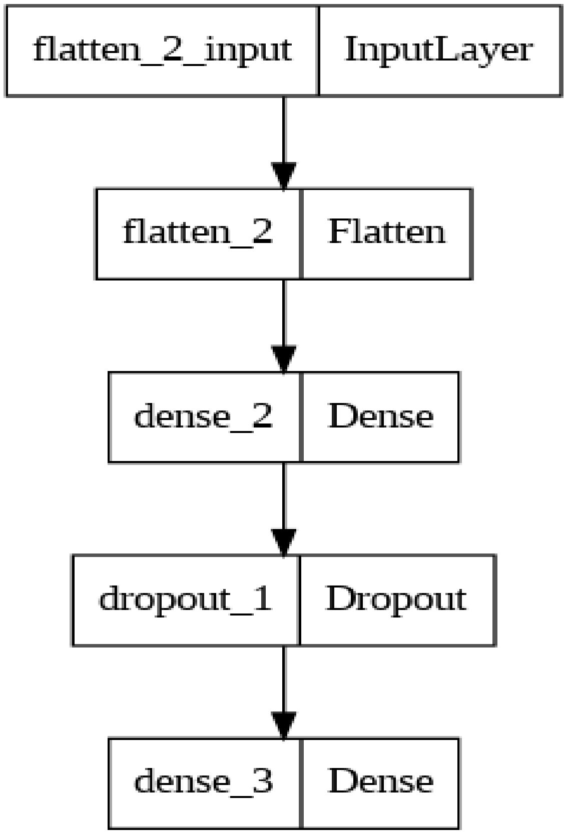
```
(10000, 28, 28)
```

```
x_test[0][0].shape
```

```
(28,)
```

```
model = Sequential()
model.add(Flatten(input_shape=(28,28)))
model.add(Dense(128, activation='relu'))
model.add(Dropout(0.2))
model.add(Dense(10, activation='softmax'))
```

```
from keras.utils import plot_model
plot_model(model)
```



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

```
model.fit(x_train, y_train, epochs=20)
```

```
Epoch 1/20
1875/1875 [==============================] - 10s 5ms/step - loss: 2.4438 -
accuracy: 0.7533
Epoch 2/20
1875/1875 [==============================] - 9s 5ms/step - loss: 0.5959 -
accuracy: 0.8427
Epoch 3/20
1875/1875 [==============================] - 8s 4ms/step - loss: 0.4775 -
accuracy: 0.8741
Epoch 4/20
1875/1875 [==============================] - 9s 5ms/step - loss: 0.4282 -
accuracy: 0.8868
Epoch 5/20
1875/1875 [==============================] - 9s 5ms/step - loss: 0.3929 -
accuracy: 0.8992
Epoch 6/20
1875/1875 [==============================] - 7s 4ms/step - loss: 0.3806 -
accuracy: 0.9053
Epoch 7/20
```

```
1875/1875 [==============================] - 9s 5ms/step - loss: 0.3620 -
accuracy: 0.9105
Epoch 8/20
1875/1875 [==============================] - 8s 4ms/step - loss: 0.3399 -
accuracy: 0.9143
Epoch 9/20
1875/1875 [==============================] - 8s 4ms/step - loss: 0.3321 -
accuracy: 0.9180
Epoch 10/20
1875/1875 [==============================] - 9s 5ms/step - loss: 0.3288 -
accuracy: 0.9205
Epoch 11/20
1875/1875 [==============================] - 7s 4ms/step - loss: 0.3168 -
accuracy: 0.9228
Epoch 12/20
1875/1875 [==============================] - 8s 4ms/step - loss: 0.3086 -
accuracy: 0.9234
Epoch 13/20
1875/1875 [==============================] - 9s 5ms/step - loss: 0.3144 -
accuracy: 0.9246
Epoch 14/20
1875/1875 [==============================] - 15s 8ms/step - loss: 0.2978 -
accuracy: 0.9266
Epoch 15/20
1875/1875 [==============================] - 10s 5ms/step - loss: 0.3015 -
accuracy: 0.9278
Epoch 16/20
1875/1875 [==============================] - 11s 6ms/step - loss: 0.2903 -
accuracy: 0.9278
Epoch 17/20
1875/1875 [==============================] - 13s 7ms/step - loss: 0.2832 -
accuracy: 0.9319
Epoch 18/20
1875/1875 [==============================] - 13s 7ms/step - loss: 0.2923 -
accuracy: 0.9307
Epoch 19/20
1875/1875 [==============================] - 9s 5ms/step - loss: 0.2869 -
accuracy: 0.9321
Epoch 20/20
1875/1875 [==============================] - 9s 5ms/step - loss: 0.2834 -
accuracy: 0.9320
```

```
<keras.callbacks.History at 0x7f2103559030>
```

```
prediction = model.predict(x_test)
```

```
313/313 [==============================] - 1s 2ms/step
```

```
prediction[3].shape
```

```
(10,)
```

```
x_test[0][0]
```

```
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0], dtype=uint8)
```

```
prediction[0]
```

```
array([0.0000000e+00, 1.3933523e-19, 2.9269228e-15, 7.6539842e-12,
       7.4557314e-31, 4.5651832e-31, 0.0000000e+00, 9.9999994e-01,
       0.0000000e+00, 5.6528885e-29], dtype=float32)
```

```
prediction[0][7]
```

```
0.99999994
```

```
prediction[1][1]
```

```
9.435168e-11
```

```
pd.Series(prediction[2]).idxmax()
```

```
1
```

Output:

```
for i in range(10):
  print(f"Prediction of {prediction[i]} is ",
pd.Series(prediction[i]).idxmax())
```

```
Prediction of [0.0000000e+00 1.3933523e-19 2.9269228e-15 7.6539842e-12
7.4557314e-31
 4.5651832e-31 0.0000000e+00 9.9999994e-01 0.0000000e+00 5.6528885e-29] is  7
Prediction of [0.0000000e+00 9.4351679e-11 9.9999994e-01 1.3839746e-21
0.0000000e+00
 0.0000000e+00 0.0000000e+00 2.9035965e-19 2.7713451e-30 0.0000000e+00] is  2
Prediction of [0.0000000e+00 9.9999994e-01 0.0000000e+00 0.0000000e+00
9.8192167e-27
 8.6102357e-27 1.3392039e-24 6.7198263e-25 3.7141534e-19 0.0000000e+00] is  1
Prediction of [9.99999940e-01 0.00000000e+00 3.97543002e-18 2.87898494e-15
 4.17670492e-24 2.52059403e-17 4.16241627e-19 4.58924653e-15
 8.97595410e-23 1.08165845e-29] is  0
Prediction of [2.8448460e-23 1.3613716e-11 1.5544450e-14 2.5488617e-13
9.9999994e-01
 2.5542689e-13 2.4306238e-10 1.3248903e-12 3.4214355e-23 2.7959052e-08] is  4
Prediction of [0.0000000e+00 9.9999994e-01 0.0000000e+00 0.0000000e+00
2.3557797e-24
 5.3822781e-25 7.0089274e-24 7.2132002e-25 1.9120865e-19 0.0000000e+00] is  1
Prediction of [4.9079178e-32 3.3550220e-12 1.7724985e-10 8.9461727e-17
9.9999994e-01
 6.9597727e-16 2.2915382e-23 1.8836836e-13 1.2865342e-32 6.4851630e-10] is  4
Prediction of [6.5651999e-14 1.0212370e-12 4.1792095e-08 2.0033461e-03
2.7078322e-05
 9.8896944e-06 2.2923856e-31 2.4588793e-04 1.6237841e-13 9.9771374e-01] is  9
Prediction of [1.9678354e-04 2.5814313e-06 6.8850612e-05 5.4609153e-04
1.9435544e-09
 5.3101850e-01 4.3385461e-01 9.2009661e-10 2.9303946e-02 5.0086309e-03] is  5
Prediction of [8.8292691e-37 9.5649813e-14 4.9173587e-15 2.1960420e-09
8.8311272e-06
 3.7559491e-12 2.3588077e-30 1.2012749e-05 1.6326638e-16 9.9997908e-01] is  9
```

```
loss, accuracy = model.evaluate(x_test, y_test)
```

```
313/313 [==============================] - 1s 3ms/step - loss: 0.3086 -
accuracy: 0.9480
```

```
print(f"Loss of model is {loss} and accuracy of model is {accuracy}")
```

```
Loss of model is 0.3086441457271576 and accuracy of model is
0.9480000138282776
```