Lab Assignment No. 12

Code:

```
import tensorflow as tf
from tensorflow import keras
from keras import Sequential
from keras.layers import Conv2D, Dense, MaxPooling2D, Flatten, Dropout, Input
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from keras.utils import plot_model
from keras.datasets import mnist
```

```
num_classes = 10
input_shape = (28, 28, 1)
(x_train, y_train), (x_test, y_test)= mnist.load_data()
x_train = x_train.astype("float32") / 255
x_test = x_test.astype("float32") / 255
x_train = np.expand_dims(x_train, -1)
x_test = np.expand_dims(x_test, -1)
print("x_train shape:", x_train.shape)
print(x_train.shape[0], "train samples")
print(x_test.shape[0], "test samples")
# convert class vectors to binary class matrices
y_train = keras.utils.to_categorical(y_train, num_classes)
y_test = keras.utils.to_categorical(y_test, num_classes)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-
datasets/mnist.npz
11490434/11490434 [==============================] - 1s 0us/step
x_train shape: (60000, 28, 28, 1)
60000 train samples
10000 test samples
```

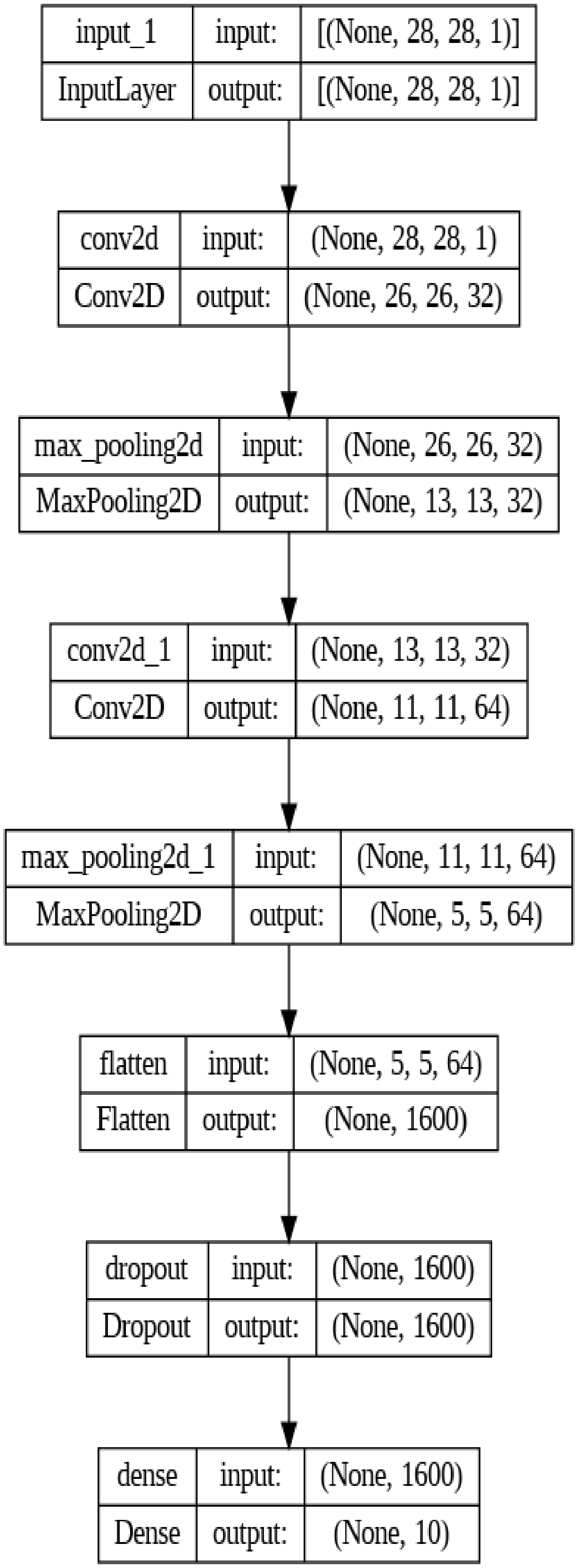
```
print("len of x_train: ", len(x_train), "Len of y_train: ", len(y_train), "
len of x_test: ", len(x_test), " len y_test: ", len(y_test))
```

```
len of x_train:  60000 Len of y_train:  60000  len of x_test:  10000  len
y_test:  10000
```

```
model = keras.Sequential(
    [
        keras.Input(shape=input_shape),
        Conv2D(32, kernel_size=(3, 3), activation="relu"),
        MaxPooling2D(pool_size=(2, 2)),
        Conv2D(64, kernel_size=(3, 3), activation="relu"),
        MaxPooling2D(pool_size=(2, 2)),
        Flatten(),
        Dropout(0.5),
        Dense(num_classes, activation="softmax"),
    ]
)

model.summary()

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

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 26, 26, 32)        320

 max_pooling2d (MaxPooling2D  (None, 13, 13, 32)       0
 )

 conv2d_1 (Conv2D)           (None, 11, 11, 64)        18496

 max_pooling2d_1 (MaxPooling  (None, 5, 5, 64)         0
 2D)

 flatten (Flatten)           (None, 1600)              0

 dropout (Dropout)           (None, 1600)              0

 dense (Dense)               (None, 10)                16010

=================================================================
Total params: 34,826
Trainable params: 34,826
Non-trainable params: 0
_________________________________________________________________
```

```
plot_model(model, show_shapes=True)
```



input_1	input:	[(None, 28, 28, 1)]
InputLayer	output:	[(None, 28, 28, 1)]

conv2d	input:	(None, 28, 28, 1)
Conv2D	output:	(None, 26, 26, 32)

max_pooling2d	input:	(None, 26, 26, 32)
MaxPooling2D	output:	(None, 13, 13, 32)

conv2d_1	input:	(None, 13, 13, 32)
Conv2D	output:	(None, 11, 11, 64)

max_pooling2d_1	input:	(None, 11, 11, 64)
MaxPooling2D	output:	(None, 5, 5, 64)

flatten	input:	(None, 5, 5, 64)
Flatten	output:	(None, 1600)

dropout	input:	(None, 1600)
Dropout	output:	(None, 1600)

dense	input:	(None, 1600)
Dense	output:	(None, 10)

```
x_train.shape
```

```
(60000, 28, 28, 1)
```

```
y_train.shape
```

```
(60000, 10)
```

```
epochs=10
batch_size = 128
history = model.fit(x_train, y_train, batch_size=batch_size, epochs=epochs,
validation_split=0.1)
```

Output:

```
Epoch 1/10
422/422 [==============================] - 57s 133ms/step - loss: 0.3786 -
accuracy: 0.8882 - val_loss: 0.0825 - val_accuracy: 0.9783
Epoch 2/10
422/422 [==============================] - 49s 117ms/step - loss: 0.1133 -
accuracy: 0.9661 - val_loss: 0.0569 - val_accuracy: 0.9850
Epoch 3/10
422/422 [==============================] - 50s 117ms/step - loss: 0.0847 -
accuracy: 0.9744 - val_loss: 0.0498 - val_accuracy: 0.9865
Epoch 4/10
422/422 [==============================] - 48s 114ms/step - loss: 0.0713 -
accuracy: 0.9777 - val_loss: 0.0415 - val_accuracy: 0.9890
Epoch 5/10
422/422 [==============================] - 47s 111ms/step - loss: 0.0638 -
accuracy: 0.9797 - val_loss: 0.0436 - val_accuracy: 0.9885
Epoch 6/10
422/422 [==============================] - 48s 114ms/step - loss: 0.0574 -
accuracy: 0.9824 - val_loss: 0.0360 - val_accuracy: 0.9910
Epoch 7/10
422/422 [==============================] - 51s 120ms/step - loss: 0.0512 -
accuracy: 0.9841 - val_loss: 0.0384 - val_accuracy: 0.9883
Epoch 8/10
422/422 [==============================] - 48s 114ms/step - loss: 0.0476 -
accuracy: 0.9846 - val_loss: 0.0321 - val_accuracy: 0.9905
Epoch 9/10
422/422 [==============================] - 53s 125ms/step - loss: 0.0439 -
accuracy: 0.9861 - val_loss: 0.0302 - val_accuracy: 0.9918
Epoch 10/10
422/422 [==============================] - 50s 117ms/step - loss: 0.0434 -
accuracy: 0.9862 - val_loss: 0.0315 - val_accuracy: 0.9908
```

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

```
313/313 [==============================] - 3s 9ms/step
```

```
prediction.shape
```

```
(10000, 10)
```

```
y_test.shape
```

```
(10000, 10)
```

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

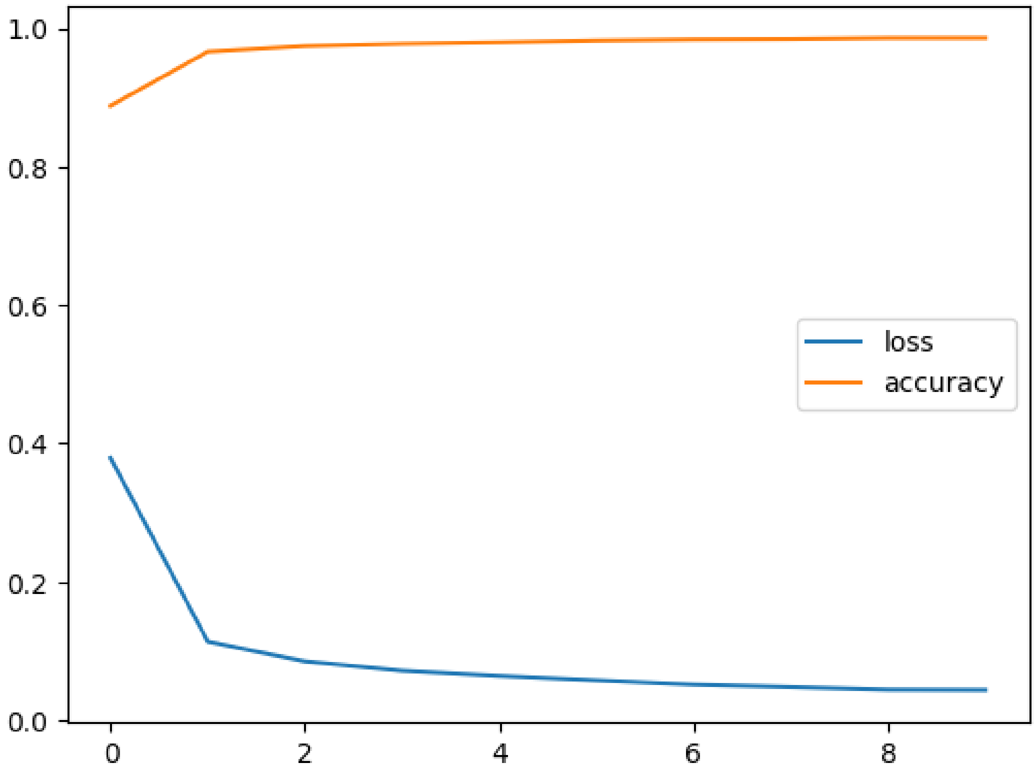
```
313/313 [==============================] - 3s 9ms/step - loss: 0.0276 -
accuracy: 0.9908
```

```
print(f"Loss of model is on testing data: {loss} and accuracy of model is on
testing data: {accuracy}")
```

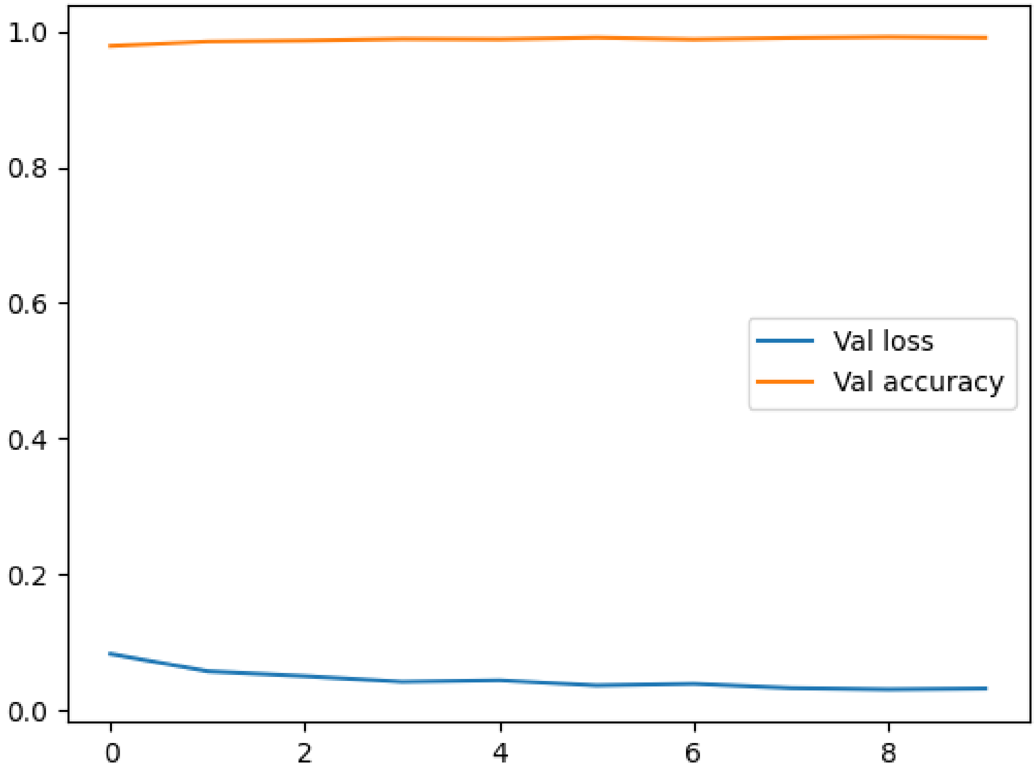
```
Loss of model is on testing data: 0.027647219598293304 and accuracy of model
is on testing data: 0.9908000230789185
```

```
import matplotlib.pyplot as plt
```

```
plt.plot(history.history['loss'], label='loss')
plt.plot(history.history['accuracy'], label='accuracy')
plt.legend()
plt.show()
```



```
plt.plot(history.history['val_loss'], label='Val loss')
plt.plot(history.history['val_accuracy'], label='Val accuracy')
plt.legend()
plt.show()
```


Val loss
Val accuracy