Computer Vision Assignment 4

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[6]:
```
!pip install numpy==1.24.4
```

```
Defaulting to user installation because normal site-packages is not
writeable
Requirement already satisfied: numpy==1.24.4 in
c:\users\admin\appdata\roaming\python\python39\site-packages (1.24.4)
```

[25]:
```
import matplotlib.pyplot as plt
import numpy as np

import tensorflow as tf
# from tensorflow.keras.datassets import mnist
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout
from tensorflow.keras.optimizers import SGD,Adam,Nadam,AdamW
from tensorflow import keras
from tensorflow.keras import layers
from keras_tuner import RandomSearch, GridSearch, BayesianOptimization
```

[2]:
```
print(np.__version__)
```

```
1.24.4
```

[3]:
```
from tensorflow.keras.datasets import mnist
```

[4]:
```
(train_images, train_labels), (test_images, test_labels) =
mnist.load_data()
```

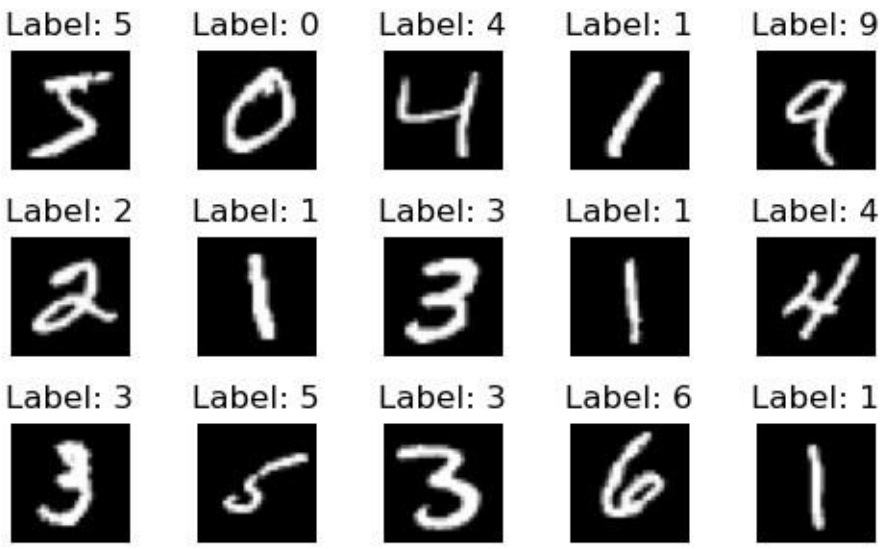
[5]:
```
train_images.shape, train_labels.shape, test_images.shape,
test_labels.shape
```

[5]: ((60000, 28, 28), (60000,), (10000, 28, 28), (10000,))

[6]:
```
plt.figure(figsize=(5,5))
for i in range(15):
    plt.subplot(5, 5,  +1)
    plt.imshow(train_images[i], cmap='gray')
    plt.title(f"Label: {train_labels[i]}")
```

```
    plt.axis('off')

plt.tight_layout()
plt.show()
```



[7]:
```
X_trn = train_images[:1000]
y_trn = train_labels[:1000]
X_tst = test_images[:500]
y_tst = test_labels[:500]
```

[8]:
```
X_trn.shape,y_trn.shape
```

[8]:
```
((1000, 28, 28), (1000,))
```

[9]:
```
X_trn = X_trn.reshape((X_trn.shape[0], 28 * 28)).astype('float32') / 255
X_tst = X_tst.reshape((X_tst.shape[0], 28 * 28)).astype('float32') / 255
```

[54]:
```
# Number of times to call the model
num_calls = 1
# List to store test accuracies
test_accuracies = []
for i in range(num_calls):
 print("step: ",i+1)
 # Define, compile, and train the model

 model = keras.Sequential()
 model.add(Dense(128, activation='sigmoid',input_shape=(784,)))
 model.add(Dropout(0.5))
```

```
 model.add(Dense(64, activation='tanh'))
 model.add(Dropout(0.5))
 model.add(Dense(32, activation='tanh'))
 model.add(Dropout(0.5))
 model.add(Dense(16, activation='tanh'))
 model.add(Dropout(0.5))
 model.add(Dense(10, activation='softmax'))


 sgd = SGD(learning_rate=0.01)
 model.compile(optimizer=sgd, loss='sparse_categorical_crossentropy',␣
 ↪metrics=['accuracy'])
 model.fit(X_trn, y_trn, epochs=5, batch_size=32)

 # Evaluate the model on test data
 _, test_accuracy = model.evaluate(X_tst, y_tst,verbose=0)

 # Append test accuracy to the list
 test_accuracies.append(test_accuracy)
# Compute the mean of test accuracies
mean_test_accuracy = np.mean(test_accuracies)
print("Mean Test Accuracy:", mean_test_accuracy)
```

```
step:  1
Epoch 1/5
32/32 [==============================] - 1s 3ms/step - loss: 2.6412 -
accuracy:
0.1000
Epoch 2/5
32/32 [==============================] - 0s 2ms/step - loss: 2.6385 -
accuracy:
0.0980
Epoch 3/5
32/32 [==============================] - 0s 2ms/step - loss: 2.5544 -
accuracy:
0.1180
Epoch 4/5
32/32 [==============================] - 0s 3ms/step - loss: 2.5167 -
accuracy:
0.1100
Epoch 5/5
32/32 [==============================] - 0s 3ms/step - loss: 2.5503 -
accuracy:
0.1080
Mean Test Accuracy: 0.20999999344348907
```

Mean Accuracy for Sigmoid and Tanh Layers : 0.20999

[11]:
```
def build_model(hp):

 hp_neurons = hp.Int('neurons', min_value=32, max_value=512, step=32)

 model = keras.Sequential()
 model.add(Dense(units=hp_neurons, activation='sigmoid',input_shape=(784,)))
 model.add(Dropout(0.5))
 model.add(Dense(64, activation='tanh'))
 model.add(Dropout(0.5))
 model.add(Dense(32, activation='tanh'))
 model.add(Dropout(0.5))
 model.add(Dense(16, activation='tanh'))
 model.add(Dropout(0.5))
 model.add(Dense(10, activation='softmax'))

 # Tune learning rate and batch size
 hp_learning_rate = hp.Choice('learning_rate', values=[0.1, 0.01, 0.15])
 hp_batch_size = hp.Choice('batch_size', values=[4, 8, 16])
 # Compile the model
 model.compile(optimizer=keras.optimizers.SGD(learning_rate=hp_learning_rate),
 loss='sparse_categorical_crossentropy',
 metrics=['accuracy'])

 return model
```

[12]:
```
# Configure the tuner
tuner = RandomSearch(
 build_model,
 objective='val_accuracy',
 max_trials=10,
 executions_per_trial=1,
 directory='keras_tuner_mnists',
 project_name='mnist_hyperparameters'
)
```

[13]:
```
hp_batch_size = tuner.oracle.get_space()['batch_size']
tuner.search(X_trn, y_trn, epochs=15, validation_data=(X_tst, y_tst),␣
 ↪batch_size=hp_batch_size)
```

```
Trial 10 Complete [00h 00m 11s]
val_accuracy: 0.12200000137090683

Best val_accuracy So Far:
0.6019999980926514 Total elapsed time: 00h
02m 06s
```

Best accuracy with hyperparameter tuning: 0.601999

[17]:
```
# Get the best hyperparameters best_hps =
tuner.get_best_hyperparameters(num_trials=20)[0]
best_neurons = best_hps.get('neurons')
best_learning_rate = best_hps.get('learning_rate')
best_batch_size = best_hps.get('batch_size')
print(f"Best number of neurons: {best_neurons}")
print(f"Best learning rate: {best_learning_rate}")
print(f"Best batch size: {best_batch_size}")
# Get the best model
best_model = tuner.get_best_models(num_models=1)[0]
# Evaluate the best model loss, accuracy =
best_model.evaluate(X_tst, y_tst)
print(f"Test accuracy of the best model:
{accuracy}")
```

```
Best number of neurons: 64
Best learning rate: 0.1
Best batch size: 30
WARNING:tensorflow:Detecting that an object or model or
tf.train.Checkpoint is being deleted with unrestored values. See the
following logs for the specific values in question. To silence these
warnings, use `status.expect_partial()`. See
https://www.tensorflow.org/api_docs/python/tf/train/Checkpoint#restor
efor details about the status object returned by the restore
function. WARNING:tensorflow:Value in checkpoint could not be found
in the restored object: (root).optimizer._variables.1
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.2
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.3
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.4
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.5
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.6
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.7
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.8
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.9
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.10
16/16 [==============================] - 0s 2ms/step - loss: 1.0868 -
accuracy:
```

```
0.6020
Test accuracy of the best model: 0.6019999980926514
```

[18]:
```
best_model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
 ===== dense (Dense)    (None, 64) 50240
 dropout (Dropout)           (None, 64)                0

 dense_1 (Dense)             (None, 64)                4160

 dropout_1 (Dropout)         (None, 64)                0

 dense_2 (Dense)             (None, 32)                2080

 dropout_2 (Dropout)         (None, 32)                0

 dense_3 (Dense)             (None, 16)                528

 dropout_3 (Dropout)         (None, 16)                0

 dense_4 (Dense)             (None, 10)                170
=================================================================
Total params: 57178 (223.35 KB)
Trainable params: 57178 (223.35 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

Model-1: 4 hidden layers having 128, 64, 32, 16 number of neurons respectively with activation function sigmoid, tanh, relu and selu respectively and dropout rate set to 0.5, 0.4, 0.3, 0.1 respectively.
Use optimizer as SGD with batch size set to 32.

[57]:
```
# Number of times to call the model
num_calls = 10
# List to store test accuracies
test_accuracies = []
for i in range(num_calls):
 print("step: ",i+1)
 # Define, compile, and train the model

 model = keras.Sequential()
 model.add(Dense(128, activation='sigmoid',input_shape=(784,)))
 model.add(Dropout(0.5))
 model.add(Dense(64, activation='tanh'))
 model.add(Dropout(0.4))
 model.add(Dense(32, activation='relu'))
 model.add(Dropout(0.3))
 model.add(Dense(16, activation='selu'))
 model.add(Dropout(0.1))

 sgd = SGD(learning_rate=0.01)
 model.compile(optimizer=sgd, loss='sparse_categorical_crossentropy',␣
 ↪metrics=['accuracy'])
 model.fit(X_trn, y_trn, epochs=30, batch_size=32)
```

```
 # Evaluate the model on test data
 _, test_accuracy = model.evaluate(X_tst, y_tst,verbose=0)

 # Append test accuracy to the list
 test_accuracies.append(test_accuracy)
# Compute the mean of test accuracies
mean_test_accuracy = np.mean(test_accuracies)
print("Mean Test Accuracy:", mean_test_accuracy)
```

```
step:  1
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 8.8968 -
accuracy:
0.0950
Epoch 2/30
32/32 [==============================] - 0s 2ms/step - loss: 5.7539 -
accuracy:
0.0850
Epoch 3/30
32/32 [==============================] - 0s 2ms/step - loss: 5.2613 -
accuracy:
0.1120
Epoch 4/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 4.3296 -
accuracy:
0.1000
Epoch 5/30
32/32 [==============================] - 0s 2ms/step - loss: 4.4769 -
accuracy:
0.0920
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0468 -
accuracy:
0.1080
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0153 -
accuracy:
0.1150
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8591 -
accuracy:
0.1170
Epoch 9/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7724 -
accuracy:
0.1130
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8521 -
accuracy:
0.1160
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 3.4960 -
accuracy:
0.1210
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8512 -
accuracy: 0.1180
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8903 -
accuracy:
0.1170
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8507 -
accuracy:
0.1090
Epoch 15/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7711 -
accuracy:
0.1230
```

```
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 3.6288 -
accuracy:
0.1240
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9010 -
accuracy:
0.1180
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7627 -
accuracy:
0.1120
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8129 -
accuracy:
0.1120
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9494 -
accuracy:
0.1150
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7434 -
accuracy:
0.1110
Epoch 22/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8706 -
accuracy:
0.1040
Epoch 23/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7990 -
accuracy:
0.1250
Epoch 24/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8381 -
accuracy:
0.1090
Epoch 25/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8426 -
accuracy:
0.1100
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 3.6591 -
accuracy:
0.1150
Epoch 27/30
```

```
32/32 [==============================] - 0s 2ms/step - loss: 4.0002 -
accuracy:
0.1070
Epoch 28/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7271 -
accuracy: 0.1210
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7803 -
accuracy:
0.1200
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0789 -
accuracy:
0.1170
step: 2
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 7.2365 -
accuracy:
0.0790
Epoch 2/30
32/32 [==============================] - 0s 2ms/step - loss: 5.7287 -
accuracy:
0.0940
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2878 -
accuracy:
0.0950
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 4.5613 -
accuracy:
0.0980
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0115 -
accuracy:
0.0890
Epoch 6/30
32/32 [==============================] - 0s 2ms/step - loss: 4.0935 -
accuracy:
0.0940
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9034 -
accuracy:
0.1000
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9694 -
accuracy:
```

```
0.1000
Epoch 9/30
32/32 [==============================] - 0s 2ms/step - loss: 4.0049 -
accuracy:
0.1190
Epoch 10/30
32/32 [==============================] - 0s 2ms/step - loss: 4.1064 -
accuracy:
0.0880
Epoch 11/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7794 -
accuracy:
0.0920
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9974 -
accuracy:
0.0870
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7051 -
accuracy:
0.1030
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9474 -
accuracy:
0.1070
Epoch 15/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6413 -
accuracy:
0.1050
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9565 -
accuracy:
0.0850
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9605 -
accuracy:
0.1100
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9512 -
accuracy:
0.1010
Epoch 19/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7930 -
accuracy:
0.1020
Epoch 20/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 3.9318 -
accuracy:
0.0950
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9989 -
accuracy:
0.1060
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8975 -
accuracy:
0.1090
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0500 -
accuracy:
0.0800
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8442 -
accuracy:
0.1050
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8207 -
accuracy:
0.1030
Epoch 26/30
32/32 [==============================] - 0s 2ms/step - loss: 3.5623 -
accuracy:
0.0980
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 3.4852 -
accuracy:
0.1010
Epoch 28/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8591 -
accuracy:
0.0970
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0978 -
accuracy:
0.0950
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 3.6719 -
accuracy:
0.0930
step: 3
Epoch 1/30
```

```
32/32 [==============================] - 1s 3ms/step - loss: 8.8892 -
accuracy:
0.0690
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 7.5728 -
accuracy:
0.0920
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 7.9465 -
accuracy:
0.0900
Epoch 4/30
32/32 [==============================] - 0s 2ms/step - loss: 8.4055 -
accuracy:
0.0890
Epoch 5/30
32/32 [==============================] - 0s 2ms/step - loss: 8.2199 -
accuracy:
0.0920
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 8.4596 -
accuracy:
0.0930
Epoch 7/30
32/32 [==============================] - 0s 2ms/step - loss: 8.5009 -
accuracy:
0.0870
Epoch 8/30
32/32 [==============================] - 0s 2ms/step - loss: 7.8603 -
accuracy:
0.0870
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 7.8960 -
accuracy:
0.0910
Epoch 10/30
32/32 [==============================] - 0s 2ms/step - loss: 7.4374 -
accuracy:
0.0970
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 7.4263 -
accuracy:
0.0790
Epoch 12/30
32/32 [==============================] - 0s 2ms/step - loss: 7.2470 -
accuracy:
```

```
0.0930
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 7.4196 -
accuracy:
0.0920
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 7.2063 -
accuracy:
0.0940
Epoch 15/30
32/32 [==============================] - 0s 2ms/step - loss: 7.5489 -
accuracy:
0.0940
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 7.4387 -
accuracy:
0.0850
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 7.2829 -
accuracy:
0.0880
Epoch 18/30
32/32 [==============================] - 0s 2ms/step - loss: 7.1908 -
accuracy:
0.0910
Epoch 19/30
32/32 [==============================] - 0s 2ms/step - loss: 6.9363 -
accuracy:
0.0930
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 7.3902 -
accuracy:
0.0890
Epoch 21/30
32/32 [==============================] - 0s 2ms/step - loss: 7.1242 -
accuracy:
0.0950
Epoch 22/30
32/32 [==============================] - 0s 2ms/step - loss: 7.3762 -
accuracy:
0.0870
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 7.3366 -
accuracy:
0.0890
Epoch 24/30
```

```
32/32 [==============================] - 0s 2ms/step - loss: 6.9698 -
accuracy:
0.0900
Epoch 25/30
32/32 [==============================] - 0s 2ms/step - loss: 7.2476 -
accuracy:
0.0920
Epoch 26/30
32/32 [==============================] - 0s 2ms/step - loss: 6.9810 -
accuracy:
0.0900
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 7.2216 -
accuracy:
0.0820
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 7.0462 -
accuracy:
0.0980
Epoch 29/30
32/32 [==============================] - 0s 2ms/step - loss: 7.0645 -
accuracy:
0.0950
Epoch 30/30
32/32 [==============================] - 0s 2ms/step - loss: 6.8850 -
accuracy:
0.0950
step: 4
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 7.6876 -
accuracy: 0.0820
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 6.4640 -
accuracy:
0.1090
Epoch 3/30
32/32 [==============================] - 0s 2ms/step - loss: 5.9970 -
accuracy:
0.1040
Epoch 4/30
32/32 [==============================] - 0s 2ms/step - loss: 5.3146 -
accuracy:
0.0950
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 4.3365 -
accuracy:
```

```
0.1000
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 4.2539 -
accuracy:
0.0960
Epoch 7/30
32/32 [==============================] - 0s 2ms/step - loss: 4.2709 -
accuracy:
0.1020
Epoch 8/30
32/32 [==============================] - 0s 2ms/step - loss: 4.0493 -
accuracy:
0.0910
Epoch 9/30
32/32 [==============================] - 0s 2ms/step - loss: 3.9577 -
accuracy:
0.1030
Epoch 10/30
32/32 [==============================] - 0s 2ms/step - loss: 3.5907 -
accuracy:
0.0950
Epoch 11/30
32/32 [==============================] - 0s 2ms/step - loss: 3.9507 -
accuracy:
0.1020
Epoch 12/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8869 -
accuracy:
0.0940
Epoch 13/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8451 -
accuracy:
0.1000
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 3.6058 -
accuracy:
0.1020
Epoch 15/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8476 -
accuracy:
0.0980
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 3.5551 -
accuracy:
0.1140
Epoch 17/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 4.1627 -
accuracy: 0.1030
Epoch 18/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8283 -
accuracy:
0.1080
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8577 -
accuracy:
0.0990
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0199 -
accuracy:
0.1110
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7560 -
accuracy:
0.0990
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8723 -
accuracy:
0.1060
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7246 -
accuracy:
0.1030
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8200 -
accuracy:
0.1000
Epoch 25/30
32/32 [==============================] - 0s 2ms/step - loss: 4.1709 -
accuracy:
0.0890
Epoch 26/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7724 -
accuracy:
0.1030
Epoch 27/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6898 -
accuracy:
0.1000
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8929 -
accuracy:
0.1020
```

```
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7424 -
accuracy:
0.0990
Epoch 30/30
32/32 [==============================] - 0s 2ms/step - loss: 3.5955 -
accuracy:
0.1250
step: 5
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 8.5114 -
accuracy:
0.0950
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 5.8459 -
accuracy:
0.1010
Epoch 3/30
32/32 [==============================] - 0s 2ms/step - loss: 4.7901 -
accuracy:
0.1050
Epoch 4/30
32/32 [==============================] - 0s 2ms/step - loss: 4.3093 -
accuracy:
0.0910
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 4.3129 -
accuracy:
0.1010
Epoch 6/30
32/32 [==============================] - 0s 2ms/step - loss: 4.2044 -
accuracy:
0.1000
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 4.7598 -
accuracy:
0.0970
Epoch 8/30
32/32 [==============================] - 0s 2ms/step - loss: 4.3697 -
accuracy:
0.0970
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 4.1322 -
accuracy:
0.1060
Epoch 10/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 4.1465 -
accuracy:
0.0930
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 4.1966 -
accuracy:
0.1000
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0217 -
accuracy:
0.1020
Epoch 13/30
32/32 [==============================] - 0s 2ms/step - loss: 4.0025 -
accuracy:
0.0850
Epoch 14/30
32/32 [==============================] - 0s 2ms/step - loss: 4.0321 -
accuracy:
0.1000
Epoch 15/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8766 -
accuracy:
0.1010
Epoch 16/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8932 -
accuracy:
0.1090
Epoch 17/30
32/32 [==============================] - 0s 2ms/step - loss: 3.9953 -
accuracy:
0.0930
Epoch 18/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7282 -
accuracy:
0.1050
Epoch 19/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6192 -
accuracy:
0.0940
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0197 -
accuracy:
0.1020
Epoch 21/30
32/32 [==============================] - 0s 2ms/step - loss: 3.9268 -
accuracy:
```

```
0.0980
Epoch 22/30
32/32 [==============================] - 0s 2ms/step - loss: 3.9823 -
accuracy:
0.1040
Epoch 23/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8039 -
accuracy:
0.1020
Epoch 24/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7250 -
accuracy:
0.1050
Epoch 25/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6475 -
accuracy:
0.0980
Epoch 26/30
32/32 [==============================] - 0s 2ms/step - loss: 3.9269 -
accuracy:
0.1000
Epoch 27/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6477 -
accuracy:
0.0920
Epoch 28/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7707 -
accuracy:
0.1020
Epoch 29/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8435 -
accuracy:
0.1060
Epoch 30/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6786 -
accuracy:
0.1090
step: 6
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 8.1684 -
accuracy:
0.1030
Epoch 2/30
32/32 [==============================] - 0s 2ms/step - loss: 6.6882 -
accuracy:
0.1130
```

```
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 5.9532 -
accuracy:
0.1160
Epoch 4/30
32/32 [==============================] - 0s 2ms/step - loss: 5.9847 -
accuracy:
0.1130
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 5.9122 -
accuracy:
0.1210
Epoch 6/30
32/32 [==============================] - 0s 2ms/step - loss: 5.8584 -
accuracy:
0.1130
Epoch 7/30
32/32 [==============================] - 0s 2ms/step - loss: 5.9107 -
accuracy:
0.1090
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 5.8011 -
accuracy:
0.1160
Epoch 9/30
32/32 [==============================] - 0s 2ms/step - loss: 5.2969 -
accuracy:
0.1130
Epoch 10/30
32/32 [==============================] - 0s 2ms/step - loss: 5.7898 -
accuracy:
0.1040
Epoch 11/30
32/32 [==============================] - 0s 2ms/step - loss: 5.2364 -
accuracy:
0.1010
Epoch 12/30
32/32 [==============================] - 0s 2ms/step - loss: 5.7227 -
accuracy:
0.1110
Epoch 13/30
32/32 [==============================] - 0s 2ms/step - loss: 5.4862 -
accuracy:
0.0970
Epoch 14/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 5.3790 -
accuracy:
0.1150
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 5.3908 -
accuracy:
0.0940
Epoch 16/30
32/32 [==============================] - 0s 2ms/step - loss: 5.3461 -
accuracy:
0.0960
Epoch 17/30
32/32 [==============================] - 0s 2ms/step - loss: 5.7255 -
accuracy:
0.1040
Epoch 18/30
32/32 [==============================] - 0s 2ms/step - loss: 5.2424 -
accuracy:
0.1010
Epoch 19/30
32/32 [==============================] - 0s 2ms/step - loss: 5.4474 -
accuracy:
0.1180
Epoch 20/30
32/32 [==============================] - 0s 2ms/step - loss: 5.4342 -
accuracy:
0.1080
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 5.4578 -
accuracy:
0.1010
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 5.3021 -
accuracy:
0.1080
Epoch 23/30
32/32 [==============================] - 0s 2ms/step - loss: 5.6463 -
accuracy:
0.1000
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 5.6475 -
accuracy:
0.1020
Epoch 25/30
32/32 [==============================] - 0s 2ms/step - loss: 5.4846 -
accuracy:
```

```
0.0930
Epoch 26/30
32/32 [==============================] - 0s 2ms/step - loss: 4.7024 -
accuracy:
0.1040
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 4.5024 -
accuracy:
0.0870
Epoch 28/30
32/32 [==============================] - 0s 2ms/step - loss: 4.8026 -
accuracy:
0.1060
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 4.4659 -
accuracy:
0.0900
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 4.5021 -
accuracy:
0.0880
step: 7
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 9.1159 -
accuracy:
0.0840
Epoch 2/30
32/32 [==============================] - 0s 2ms/step - loss: 5.4539 -
accuracy:
0.1110
Epoch 3/30
32/32 [==============================] - 0s 2ms/step - loss: 4.5679 -
accuracy:
0.1080
Epoch 4/30
32/32 [==============================] - 0s 2ms/step - loss: 4.3012 -
accuracy:
0.0890
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8050 -
accuracy:
0.1160
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0067 -
accuracy: 0.1010
Epoch 7/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 3.7337 -
accuracy:
0.1100
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7774 -
accuracy:
0.1070
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7327 -
accuracy:
0.1140
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9775 -
accuracy:
0.0900
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9183 -
accuracy:
0.1010
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0879 -
accuracy:
0.0930
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8639 -
accuracy:
0.0920
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8178 -
accuracy:
0.0940
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9328 -
accuracy:
0.1100
Epoch 16/30
32/32 [==============================] - 0s 2ms/step - loss: 3.9871 -
accuracy:
0.0870
Epoch 17/30
32/32 [==============================] - 0s 2ms/step - loss: 3.4787 -
accuracy:
0.0990
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 4.1198 -
accuracy:
```

```
0.0950
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0003 -
accuracy:
0.1100
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0158 -
accuracy:
0.0990
Epoch 21/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7408 -
accuracy:
0.1120
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8206 -
accuracy: 0.1110
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7117 -
accuracy:
0.1060
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9814 -
accuracy:
0.0950
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8529 -
accuracy:
0.1060
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7290 -
accuracy:
0.0870
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7339 -
accuracy:
0.1050
Epoch 28/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8266 -
accuracy:
0.1020
Epoch 29/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8435 -
accuracy:
0.1060
Epoch 30/30
```

```
32/32 [==============================] - 0s 2ms/step - loss: 3.6435 -
accuracy:
0.1120
step: 8
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 9.3408 -
accuracy:
0.0910
Epoch 2/30
32/32 [==============================] - 0s 2ms/step - loss: 5.2753 -
accuracy:
0.0960
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 4.5269 -
accuracy:
0.0910
Epoch 4/30
32/32 [==============================] - 0s 2ms/step - loss: 4.0623 -
accuracy:
0.0910
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9598 -
accuracy:
0.1000
Epoch 6/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6560 -
accuracy:
0.0840
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8120 -
accuracy:
0.0940
Epoch 8/30
32/32 [==============================] - 0s 2ms/step - loss: 4.0576 -
accuracy:
0.0840
Epoch 9/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8488 -
accuracy:
0.1080
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9287 -
accuracy:
0.0950
Epoch 11/30
```

```
32/32 [==============================] - 0s 2ms/step - loss: 3.6209 -
accuracy:
0.1070
Epoch 12/30
32/32 [==============================] - 0s 2ms/step - loss: 3.9160 -
accuracy:
0.1040
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9586 -
accuracy:
0.0790
Epoch 14/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6747 -
accuracy:
0.1080
Epoch 15/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6685 -
accuracy:
0.0950
Epoch 16/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7086 -
accuracy:
0.0980
Epoch 17/30
32/32 [==============================] - 0s 2ms/step - loss: 3.9968 -
accuracy:
0.0830
Epoch 18/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7338 -
accuracy:
0.1030
Epoch 19/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6780 -
accuracy:
0.1100
Epoch 20/30
32/32 [==============================] - 0s 2ms/step - loss: 3.9558 -
accuracy:
0.0970
Epoch 21/30
32/32 [==============================] - 0s 2ms/step - loss: 3.9410 -
accuracy:
0.0950
Epoch 22/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6218 -
accuracy:
```

```
0.1100
Epoch 23/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7730 -
accuracy:
0.0980
Epoch 24/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8189 -
accuracy:
0.0920
Epoch 25/30
32/32 [==============================] - 0s 2ms/step - loss: 3.9988 -
accuracy:
0.1060
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9195 -
accuracy:
0.0920
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 3.5598 -
accuracy:
0.1030
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9011 -
accuracy:
0.0960
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7089 -
accuracy:
0.1010
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7128 -
accuracy:
0.0950
step: 9
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 10.9229
- accuracy:
0.0720
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 7.5878 -
accuracy:
0.0920
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 6.7013 -
accuracy:
0.0870
```

```
Epoch 4/30
32/32 [==============================] - 0s 2ms/step - loss: 5.9512 -
accuracy:
0.1010
Epoch 5/30
32/32 [==============================] - 0s 2ms/step - loss: 5.0212 -
accuracy:
0.1020
Epoch 6/30
32/32 [==============================] - 0s 2ms/step - loss: 5.4067 -
accuracy:
0.0990
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2125 -
accuracy:
0.0950
Epoch 8/30
32/32 [==============================] - 0s 2ms/step - loss: 5.1616 -
accuracy:
0.0900
Epoch 9/30
32/32 [==============================] - 0s 2ms/step - loss: 5.3814 -
accuracy:
0.0990
Epoch 10/30
32/32 [==============================] - 0s 2ms/step - loss: 5.0249 -
accuracy:
0.0940
Epoch 11/30
32/32 [==============================] - 0s 2ms/step - loss: 4.8618 -
accuracy:
0.0970
Epoch 12/30
32/32 [==============================] - 0s 2ms/step - loss: 4.9678 -
accuracy:
0.0870
Epoch 13/30
32/32 [==============================] - 0s 2ms/step - loss: 4.6609 -
accuracy:
0.0900
Epoch 14/30
32/32 [==============================] - 0s 2ms/step - loss: 4.0372 -
accuracy:
0.1040
Epoch 15/30
```

```
32/32 [==============================] - 0s 2ms/step - loss: 3.7921 -
accuracy:
0.0940
Epoch 16/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6026 -
accuracy:
0.1010
Epoch 17/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8789 -
accuracy:
0.1010
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0215 -
accuracy:
0.0930
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8029 -
accuracy:
0.1030
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0765 -
accuracy:
0.1000
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8257 -
accuracy:
0.1050
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8055 -
accuracy:
0.0980
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 3.5974 -
accuracy:
0.1090
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0504 -
accuracy:
0.0910
Epoch 25/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7930 -
accuracy:
0.1040
Epoch 26/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8031 -
accuracy:
```

```
0.0940
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 3.6734 -
accuracy:
0.1020
Epoch 28/30
32/32 [==============================] - 0s 2ms/step - loss: 3.9362 -
accuracy:
0.0990
Epoch 29/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6878 -
accuracy:
0.0990
Epoch 30/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8504 -
accuracy:
0.0960
step: 10
Epoch 1/30
32/32 [==============================] - 1s 2ms/step - loss: 8.6985 -
accuracy:
0.0970
Epoch 2/30
32/32 [==============================] - 0s 2ms/step - loss: 6.0801 -
accuracy:
0.1020
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 5.0769 -
accuracy:
0.0990
Epoch 4/30
32/32 [==============================] - 0s 2ms/step - loss: 4.6068 -
accuracy:
0.0980
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 4.2507 -
accuracy:
0.0910
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 4.1993 -
accuracy:
0.0950
Epoch 7/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7343 -
accuracy:
0.0940
```

```
Epoch 8/30
32/32 [==============================] - 0s 2ms/step - loss: 4.0370 -
accuracy:
0.0940
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7472 -
accuracy:
0.0950
Epoch 10/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8105 -
accuracy:
0.0900
Epoch 11/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8857 -
accuracy: 0.0840
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 3.7085 -
accuracy:
0.0960
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8217 -
accuracy:
0.0920
Epoch 14/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7721 -
accuracy:
0.0890
Epoch 15/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6817 -
accuracy:
0.0940
Epoch 16/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6141 -
accuracy:
0.0910
Epoch 17/30
32/32 [==============================] - 0s 2ms/step - loss: 3.4421 -
accuracy:
0.1000
Epoch 18/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8829 -
accuracy:
0.0940
Epoch 19/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6836 -
accuracy:
```

```
0.1020
Epoch 20/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7945 -
accuracy:
0.0920
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0304 -
accuracy:
0.0980
Epoch 22/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7551 -
accuracy:
0.0960
Epoch 23/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6763 -
accuracy:
0.0950
Epoch 24/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8150 -
accuracy:
0.0910
Epoch 25/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8379 -
accuracy:
0.0960
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8485 -
accuracy:
0.0910
Epoch 27/30
32/32 [==============================] - 0s 2ms/step - loss: 3.6758 -
accuracy: 0.0950
Epoch 28/30
32/32 [==============================] - 0s 2ms/step - loss: 3.8072 -
accuracy:
0.1000
Epoch 29/30
32/32 [==============================] - 0s 2ms/step - loss: 3.5511 -
accuracy:
0.0950
Epoch 30/30
32/32 [==============================] - 0s 2ms/step - loss: 3.7707 -
accuracy:
0.0970
Mean Test Accuracy: 0.10180000215768814
```

Mean test Accuracy for Model 1 is 0.1018

Model-2: 4 hidden layers having 128, 64, 32, 16 number of neurons respectively with activation function sigmoid, tanh, relu and selu respectively and dropout rate set to 0.5, 0.4, 0.3, 0.1 respectively.
Use optimizer as Adam with batch size set to 32

[21]:
```
# Number of times to call the model
num_calls = 10
# List to store test accuracies
test_accuracies = []
for i in range(num_calls):
 print("step: ",i+1)
 # Define, compile, and train the model

 model = keras.Sequential()
 model.add(Dense(128, activation='sigmoid',input_shape=(784,)))
 model.add(Dropout(0.5))
 model.add(Dense(64, activation='tanh'))
 model.add(Dropout(0.4))
 model.add(Dense(32, activation='relu'))
 model.add(Dropout(0.3))
 model.add(Dense(16, activation='selu'))
 model.add(Dropout(0.1))
 model.add(Dense(10, activation='softmax'))


 sgd = Adam(learning_rate=0.01)
 model.compile(optimizer=sgd, loss='sparse_categorical_crossentropy',␣
 ↪metrics=['accuracy'])
 model.fit(X_trn, y_trn, epochs=30, batch_size=32)

 # Evaluate the model on test data
 _, test_accuracy = model.evaluate(X_tst, y_tst,verbose=0)

 # Append test accuracy to the list
 test_accuracies.append(test_accuracy)
# Compute the mean of test accuracies
mean_test_accuracy = np.mean(test_accuracies)
print("Mean Test Accuracy:", mean_test_accuracy)
```

```
step: 1
Epoch 1/30
32/32 [==============================] - 1s 4ms/step - loss: 9.7610 -
accuracy:
0.0850
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.9387 -
accuracy:
0.0710
Epoch 3/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.8079 -
accuracy:
0.0900
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8139 -
accuracy:
0.0790
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7910 -
accuracy:
0.0720
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8261 -
accuracy:
0.0900
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8608 -
accuracy:
0.0990
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8220 -
accuracy:
0.0890
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7833 -
accuracy:
0.0880
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7804 -
accuracy:
0.0790
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7976 -
accuracy:
0.0770
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0730
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7857 -
accuracy:
0.0760
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7843 -
accuracy:
```

```
0.0870
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8093 -
accuracy:
0.0670
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7858 -
accuracy:
0.0940
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0820
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0830
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0900
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8073 -
accuracy:
0.0860
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7820 -
accuracy:
0.0770
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7994 -
accuracy:
0.0910
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7838 -
accuracy:
0.1060
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0790
Epoch 26/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7853 -
accuracy:
0.0950
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7973 -
accuracy:
0.0680
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7982 -
accuracy:
0.0820
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7986 -
accuracy:
0.0810
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0780
step: 2
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 11.9340
- accuracy:
0.1040
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 6.3402 -
accuracy:
0.0930
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.9042 -
accuracy:
0.0800
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8296 -
accuracy:
0.0790
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8075 -
accuracy:
0.0750
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8091 -
accuracy:
0.0760
Epoch 7/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7942 -
accuracy:
0.0770
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8229 -
accuracy:
0.0680
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7850 -
accuracy:
0.0710
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0720
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0770
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0690
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0890
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0650
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7849 -
accuracy:
0.0690
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy: 0.0610
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0680
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0680
```

```
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0590
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0700
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0520
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7846 -
accuracy:
0.0590
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0670
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0740
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0730
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7847 -
accuracy:
0.0730
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0620
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0640
Epoch 30/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
step: 3
WARNING:tensorflow:Detecting that an object or model or
tf.train.Checkpoint is being deleted with unrestored values. See the
following logs for the specific values in question. To silence these
warnings, use `status.expect_partial()`. See
https://www.tensorflow.org/api_docs/python/tf/train/Checkpoint#restor
efor details about the status object returned by the restore
function.
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.1
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.2
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.3
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.4
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.5
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.6
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.7
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.8
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.9
WARNING:tensorflow:Value in checkpoint could not be found in the
restored object: (root).optimizer._variables.10
Epoch 1/30
32/32 [==============================] - 1s 4ms/step - loss: 8.3738 -
accuracy:
0.1070
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 6.2217 -
accuracy:
0.1180
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 5.9759 -
accuracy:
0.1060
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 5.1895 -
accuracy:
```

```
0.1040
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2459 -
accuracy:
0.0970
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2974 -
accuracy:
0.0920
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2565 -
accuracy:
0.1090
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 5.0065 -
accuracy:
0.0950
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 4.9668 -
accuracy:
0.0980
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 5.0173 -
accuracy:
0.1190
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 4.8733 -
accuracy:
0.0890
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 4.8485 -
accuracy:
0.1000
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 4.8802 -
accuracy:
0.1020
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2037 -
accuracy:
0.0900
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9229 -
accuracy:
0.1030
Epoch 16/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 4.0611 -
accuracy:
0.0850
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9256 -
accuracy:
0.1000
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0056 -
accuracy:
0.1070
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8168 -
accuracy:
0.0880
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 3.6094 -
accuracy:
0.0860
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 4.1496 -
accuracy:
0.0850
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 4.1684 -
accuracy:
0.0980
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8015 -
accuracy:
0.0910
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8372 -
accuracy:
0.1140
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 3.6773 -
accuracy:
0.1010
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 3.6914 -
accuracy:
0.1110
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 4.3715 -
accuracy:
```

```
0.0940
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 5.3252 -
accuracy:
0.0910
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 3.4825 -
accuracy:
0.1180
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 3.8837 -
accuracy:
0.1070
step: 4
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 6.7944 -
accuracy:
0.0990
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.9119 -
accuracy:
0.0770
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8430 -
accuracy:
0.0850
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8172 -
accuracy:
0.0540
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7857 -
accuracy:
0.0900
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7983 -
accuracy:
0.0750
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7944 -
accuracy:
0.0850
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7955 -
accuracy:
0.0840
```

```
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7845 -
accuracy:
0.0810
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7836 -
accuracy:
0.0810
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8113 -
accuracy: 0.0760
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7962 -
accuracy:
0.0880
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7839 -
accuracy:
0.0830
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0790
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0690
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0790
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0830
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
```

```
0.0810
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0650
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0700
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0720
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0900
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0730
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0680
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy: 0.0890
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0750
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0730
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0850
step: 5
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 8.5176 -
accuracy:
0.1080
Epoch 2/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 6.9244 -
accuracy:
0.1280
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 6.3654 -
accuracy:
0.1150
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 6.5476 -
accuracy:
0.1210
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 6.3351 -
accuracy:
0.1360
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 5.3059 -
accuracy:
0.1270
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 4.7844 -
accuracy:
0.1630
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 4.5133 -
accuracy:
0.1660
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 4.4208 -
accuracy:
0.1590
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 4.3442 -
accuracy:
0.1540
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 4.6461 -
accuracy:
0.1800
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 5.9347 -
accuracy:
0.1270
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 5.0892 -
accuracy:
```

```
0.1370
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 5.0278 -
accuracy:
0.1300
Epoch 15/30
32/32 [==============================] - 0s 4ms/step - loss: 4.9893 -
accuracy:
0.1240
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 4.2070 -
accuracy:
0.1880
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 5.3246 -
accuracy:
0.1650
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 4.7483 -
accuracy:
0.1590
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 4.2987 -
accuracy:
0.1750
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 5.0651 -
accuracy:
0.2190
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 4.3508 -
accuracy:
0.1590
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 4.2337 -
accuracy:
0.2050
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 3.9967 -
accuracy:
0.2230
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 4.1860 -
accuracy:
0.2090
Epoch 25/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 4.2607 -
accuracy:
0.2000
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 4.5046 -
accuracy:
0.2080
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 4.4013 -
accuracy:
0.1950
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 4.2091 -
accuracy:
0.1650
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 4.3418 -
accuracy:
0.2100
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 4.0212 -
accuracy:
0.2260
step: 6
Epoch 1/30
32/32 [==============================] - 1s 4ms/step - loss: 10.8569
- accuracy:
0.1000
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 10.6001
- accuracy:
0.1350
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 6.0986 -
accuracy:
0.1360
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8458 -
accuracy:
0.0670
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7926 -
accuracy:
0.0710
Epoch 6/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0630
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7833 -
accuracy:
0.0740
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7966 -
accuracy:
0.0830
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7820 -
accuracy:
0.0850
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7853 -
accuracy:
0.0810
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7825 -
accuracy:
0.0730
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7973 -
accuracy:
0.0580
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0640
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0740
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7831 -
accuracy:
0.0570
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7982 -
accuracy:
0.0780
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7698 -
accuracy:
```

```
0.0640
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0620
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7836 -
accuracy:
0.0860
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7839 -
accuracy:
0.0630
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8066 -
accuracy:
0.0710
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7846 -
accuracy:
0.0680
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0770
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7853 -
accuracy:
0.0770
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7854 -
accuracy:
0.0590
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0730
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7846 -
accuracy:
0.0770
Epoch 29/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0660
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0710
step: 7
Epoch 1/30
32/32 [==============================] - 1s 4ms/step - loss: 8.5806 -
accuracy:
0.1090
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 7.9505 -
accuracy:
0.1030
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 7.0934 -
accuracy:
0.1010
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 6.4518 -
accuracy:
0.0980
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 6.4069 -
accuracy:
0.1020
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 6.5988 -
accuracy:
0.1050
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 6.3163 -
accuracy:
0.1160
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 6.2175 -
accuracy:
0.1190
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 6.3932 -
accuracy:
0.0970
Epoch 10/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 6.4612 -
accuracy:
0.1020
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 6.3349 -
accuracy:
0.1040
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 6.4125 -
accuracy:
0.1110
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 6.4424 -
accuracy:
0.1070
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 6.3465 -
accuracy:
0.1280
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 6.4611 -
accuracy:
0.0870
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 6.6365 -
accuracy: 0.1220
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 6.3266 -
accuracy:
0.1120
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 6.3411 -
accuracy:
0.1120
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 6.3667 -
accuracy:
0.1110
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 6.3346 -
accuracy:
0.1040
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 6.1179 -
accuracy:
0.1150
```

```
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 6.3507 -
accuracy:
0.1080
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 6.2880 -
accuracy:
0.1170
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 6.2236 -
accuracy:
0.1210
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 6.3460 -
accuracy:
0.1190
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 6.5229 -
accuracy:
0.1040
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 6.4462 -
accuracy:
0.1150
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 6.4589 -
accuracy:
0.1090
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 6.6017 -
accuracy:
0.1150
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 6.4107 -
accuracy:
0.1100
step: 8
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 7.0204 -
accuracy:
0.0770
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.9665 -
accuracy:
0.0910
Epoch 3/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.9214 -
accuracy:
0.0790
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8466 -
accuracy:
0.0800
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7985 -
accuracy:
0.0910
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7953 -
accuracy:
0.0750
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7828 -
accuracy:
0.0850
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8047 -
accuracy:
0.0790
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7698 -
accuracy:
0.0740
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7855 -
accuracy:
0.0710
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0710
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0690
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7839 -
accuracy:
```

```
0.0680
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7839 -
accuracy:
0.0750
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0640
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0690
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7827 -
accuracy:
0.0730
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0770
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0470
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7848 -
accuracy:
0.0690
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0760
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7833 -
accuracy:
0.0760
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7847 -
accuracy:
0.0700
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0820
Epoch 26/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0850
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0550
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0900
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0820
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0830
step: 9
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 9.6151 -
accuracy:
0.0980
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 7.7990 -
accuracy:
0.1150
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 6.7918 -
accuracy:
0.1280
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 5.7507 -
accuracy:
0.1000
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 5.6139 -
accuracy:
0.1190
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 5.4337 -
accuracy:
0.1140
Epoch 7/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 5.1809 -
accuracy:
0.1190
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 5.3246 -
accuracy:
0.1080
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 5.3960 -
accuracy:
0.1230
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 5.0333 -
accuracy:
0.1160
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 5.1897 -
accuracy:
0.1070
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 5.3886 -
accuracy:
0.1150
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2562 -
accuracy:
0.0950
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 5.8005 -
accuracy:
0.1020
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 5.5480 -
accuracy:
0.1110
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 5.3519 -
accuracy:
0.1040
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2544 -
accuracy:
0.0990
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 4.9664 -
accuracy:
```

```
0.1110
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2366 -
accuracy:
0.1120
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2259 -
accuracy:
0.1170
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2003 -
accuracy:
0.1030
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2124 -
accuracy:
0.1030
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2082 -
accuracy:
0.1310
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 5.4288 -
accuracy:
0.1010
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2150 -
accuracy:
0.1090
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 5.0911 -
accuracy:
0.1190
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 5.2553 -
accuracy:
0.1120
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 5.4463 -
accuracy:
0.0890
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 5.3046 -
accuracy:
0.1040
Epoch 30/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 5.3073 -
accuracy:
0.1110
step: 10
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 7.6246 -
accuracy:
0.1050
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8664 -
accuracy:
0.0670
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7966 -
accuracy:
0.0780
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7821 -
accuracy:
0.0720
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8318 -
accuracy: 0.0740
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7975 -
accuracy:
0.0750
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7935 -
accuracy:
0.0800
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7966 -
accuracy:
0.0910
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7847 -
accuracy:
0.0850
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7847 -
accuracy:
0.0820
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8036 -
accuracy:
```

```
0.0540
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7850 -
accuracy:
0.0650
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7967 -
accuracy:
0.0720
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7841 -
accuracy:
0.0730
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7839 -
accuracy:
0.0800
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7836 -
accuracy:
0.0800
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0660
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0710
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0750
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0660
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy: 0.0590
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0540
Epoch 23/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0860
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0680
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0690
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0750
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0680
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7841 -
accuracy:
0.0580
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0590
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0640
Mean Test Accuracy: 0.07300000041723251
```

Mean Test Accurcy for Model 2: 0.073

Model-3: 4 hidden layers having 128, 64, 32, 16 number of neurons respectively with activation function sigmoid, tanh, relu and selu respectively and dropout rate set to 0.5, 0.4, 0.3, 0.1 respectively

[26]:
```
# Number of times to call the model
num_calls = 10
# List to store test accuracies
test_accuracies = []
for i in range(num_calls):
 print("step: ",i+1)
 # Define, compile, and train the model

 model = keras.Sequential()
 model.add(Dense(128, activation='sigmoid',input_shape=(784,)))
 model.add(Dropout(0.5))
 model.add(Dense(64, activation='tanh'))
 model.add(Dropout(0.4))
 model.add(Dense(32,
 activation='relu'))
 model.add(Dropout(0.3))
 model.add(Dense(16,
 activation='selu'))
 model.add(Dropout(0.1))
 model.add(Dense(10, activation='softmax'))

 sgd = AdamW(learning_rate=0.1) model.compile(optimizer=sgd,
 loss='sparse_categorical_crossentropy',␣
 ↪metrics=['accuracy']) model.fit(X_trn,
 y_trn, epochs=30, batch_size=32)

 # Evaluate the model on test data
 _, test_accuracy = model.evaluate(X_tst, y_tst,verbose=0)

 # Append test accuracy to the list
 test_accuracies.append(test_accuracy) #
Compute the mean of test accuracies
mean_test_accuracy =
np.mean(test_accuracies) print("Mean Test
Accuracy:", mean_test_accuracy)
```

```
step: 1
Epoch 1/30
32/32 [==============================] - 1s 4ms/step - loss: 3.6568 -
accuracy:
0.0890
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8488 -
accuracy:
0.0920
Epoch 3/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.8872 -
accuracy:
0.1020
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8605 -
accuracy:
0.0850
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8100 -
accuracy:
0.0740
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0840
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0850
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7866 -
accuracy:
0.0980
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0930
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8133 -
accuracy:
0.0880
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0800
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0820
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0740
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
```

```
0.0870
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0910
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0880
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0810
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8404 -
accuracy:
0.0880
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7865 -
accuracy:
0.0800
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0890
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0930
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0850
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7870 -
accuracy:
0.0760
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0700
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0860
Epoch 26/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7840 -
accuracy:
0.0900
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0830
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0880
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0840
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0790
step: 2
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 3.5923 -
accuracy:
0.0860
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
0.1080
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0800
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0770
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 7/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0850
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7937 -
accuracy:
0.0900
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7991 -
accuracy:
0.0710
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7857 -
accuracy:
0.0830
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8204 -
accuracy:
0.0830
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7978 -
accuracy:
0.0720
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8116 -
accuracy:
0.0740
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0930
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8113 -
accuracy:
0.0840
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0850
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
0.0820
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8004 -
accuracy:
```

```
0.0890
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7974 -
accuracy:
0.0860
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0920
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0910
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0900
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0960
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0770
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0680
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0830
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0810
Epoch 30/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
step: 3
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 4.0463 -
accuracy:
0.0830
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8667 -
accuracy:
0.1020
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0790
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7985 -
accuracy:
0.0820
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0780
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8123 -
accuracy:
0.0840
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0920
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0860
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
0.0880
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0750
Epoch 11/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.1010
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy: 0.0870
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8131 -
accuracy:
0.0920
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7844 -
accuracy:
0.0840
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.1010
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0790
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8543 -
accuracy:
0.0730
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7849 -
accuracy:
0.0900
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8660 -
accuracy:
0.0900
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0940
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0830
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7977 -
accuracy:
0.0780
```

```
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7969 -
accuracy:
0.0960
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0930
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.1090
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0710
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy: 0.0800
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0810
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0840
step: 4
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 4.4460 -
accuracy:
0.0950
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8863 -
accuracy:
0.0760
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8534 -
accuracy:
0.0900
Epoch 4/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.8396 -
accuracy:
0.0800
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0810
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0960
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0810
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0880
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0870
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0730
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0970
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0900
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7823 -
accuracy:
0.0860
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
```

```
0.0880
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7996 -
accuracy:
0.0840
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0820
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0760
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8000 -
accuracy:
0.0820
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0730
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8102 -
accuracy:
0.0680
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0930
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0710
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0770
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0760
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0720
Epoch 27/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0930
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0830
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0810
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0750
step: 5
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 5.6526 -
accuracy:
0.1000
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8117 -
accuracy:
0.0920
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8400 -
accuracy:
0.0780
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
0.0860
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7856 -
accuracy:
0.0850
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0760
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0950
Epoch 8/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7698 -
accuracy:
0.0970
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0880
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0960
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0860
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0870
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0910
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7857 -
accuracy:
0.0870
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0850
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0790
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7698 -
accuracy:
```

```
0.0880
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0760
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0840
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0850
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0630
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0730
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0940
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0980
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0820
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0840
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0850
step: 6
```

```
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 4.0858 -
accuracy: 0.0870
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8393 -
accuracy:
0.0840
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8857 -
accuracy:
0.0820
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8899 -
accuracy:
0.0960
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.9378 -
accuracy:
0.0890
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.9327 -
accuracy:
0.0940
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.9461 -
accuracy:
0.0720
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8613 -
accuracy:
0.0640
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7857 -
accuracy:
0.0920
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0790
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
```

```
0.0840
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0730
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0900
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0760
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0850
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy: 0.0740
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.1160
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0840
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0670
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0840
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0880
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0860
Epoch 24/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0940
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0830
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0880
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0950
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0810
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0860
step: 7
Epoch 1/30
32/32 [==============================] - 1s 4ms/step - loss: 5.5207 -
accuracy:
0.0840
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8540 -
accuracy:
0.0970
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8861 -
accuracy:
0.0860
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8751 -
accuracy:
0.0680
Epoch 5/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.9985 -
accuracy:
0.0840
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8766 -
accuracy:
0.0830
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.9594 -
accuracy:
0.0820
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8660 -
accuracy:
0.0860
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8121 -
accuracy:
0.0810
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8365 -
accuracy:
0.0980
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8099 -
accuracy:
0.0930
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
0.0760
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8232 -
accuracy:
0.1050
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0820
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
0.0830
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
```

```
0.0790
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8393 -
accuracy:
0.0870
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8471 -
accuracy:
0.0870
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8927 -
accuracy:
0.0770
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0850
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8393 -
accuracy:
0.0730
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0740
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8899 -
accuracy:
0.0960
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0830
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8794 -
accuracy:
0.0690
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0900
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8740 -
accuracy:
0.0880
Epoch 28/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0720
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8660 -
accuracy:
0.0740
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0790
step: 8
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 6.4210 -
accuracy:
0.0820
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.9360 -
accuracy:
0.0930
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8541 -
accuracy:
0.0750
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8132 -
accuracy:
0.0640
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8372 -
accuracy:
0.0800
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0820
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0780
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0840
Epoch 9/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0870
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
0.0760
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0800
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.1070
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7852 -
accuracy:
0.0810
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0890
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0850
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0730
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0860
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0770
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
```

```
0.1000
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0720
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0820
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0840
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0700
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0660
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0910
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7842 -
accuracy:
0.0920
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
0.0860
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.9060 -
accuracy:
0.0750
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7991 -
accuracy:
0.0760
step: 9
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 6.1100 -
accuracy:
0.0910
```

```
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8519 -
accuracy:
0.0810
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8613 -
accuracy:
0.0770
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8376 -
accuracy:
0.0840
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8205 -
accuracy:
0.0910
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7851 -
accuracy: 0.0860
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0920
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8096 -
accuracy:
0.0900
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7850 -
accuracy:
0.0880
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0930
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0810
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0890
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
```

```
0.0830
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.1040
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0900
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0890
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0890
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0830
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0920
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0810
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy: 0.0780
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0930
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0760
Epoch 25/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0910
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0750
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7866 -
accuracy:
0.0780
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0770
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0830
step: 10
Epoch 1/30
32/32 [==============================] - 1s 3ms/step - loss: 13.4151
- accuracy:
0.0940
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 13.0052
- accuracy:
0.1040
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 6.3468 -
accuracy:
0.0790
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 3.5137 -
accuracy:
0.0860
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 3.4419 -
accuracy:
0.0910
Epoch 6/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 3.3169 -
accuracy:
0.0900
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8755 -
accuracy:
0.0890
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8232 -
accuracy:
0.0940
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8502 -
accuracy:
0.0800
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0870
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0710
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
0.0830
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7804 -
accuracy:
0.0930
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0750
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
0.0900
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0750
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8522 -
accuracy:
```

```
0.1000
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0890
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0890
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0930
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7971 -
accuracy:
0.0710
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0550
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0780
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0880
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0820
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
0.0940
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0800
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
0.0710
Epoch 29/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
0.0880
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0930
Mean Test Accuracy: 0.08399999886751175
```

Mean Test Accuracy for Model 3: 0.0834

Model-4: 4 hidden layers having 128, 64, 32, 16 number of neurons respectively with activation function sigmoid, tanh, relu and selu respectively and dropout rate set to 0.5, 0.4, 0.3, 0.1 respectively. Use optimizer as Nadam with learning rate 0.1 with batch size set to 32

[27]:
```
# Number of times to call the model
num_calls = 10
# List to store test accuracies
test_accuracies = []
for i in range(num_calls):
 print("step: ",i+1)
 # Define, compile, and train the model

 model = keras.Sequential()
 model.add(Dense(128, activation='sigmoid',input_shape=(784,)))
 model.add(Dropout(0.5))
 model.add(Dense(64, activation='tanh'))
 model.add(Dropout(0.4))
 model.add(Dense(32, activation='relu'))
 model.add(Dropout(0.3))
 model.add(Dense(16, activation='selu'))
 model.add(Dropout(0.1))
 model.add(Dense(10, activation='softmax'))

 sgd = Nadam(learning_rate=0.1)
 model.compile(optimizer=sgd,
 loss='sparse_categorical_crossentropy',␣
 ↪metrics=['accuracy']) model.fit(X_trn,
 y_trn, epochs=30, batch_size=32)

 # Evaluate the model on test data
 _, test_accuracy = model.evaluate(X_tst, y_tst,verbose=0)

 # Append test accuracy to the list
 test_accuracies.append(test_accuracy) #
Compute the mean of test accuracies
mean_test_accuracy =
```

```
np.mean(test_accuracies) print("Mean Test
Accuracy:", mean_test_accuracy)

step: 1
Epoch 1/30
32/32 [==============================] - 2s 4ms/step - loss: 7.8151 -
accuracy:
0.0920
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8784 -
accuracy:
0.0900
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7698 -
accuracy:
0.0660
Epoch 4/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7859 -
accuracy:
0.0860
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0650
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0670
Epoch 7/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7985 -
accuracy:
0.0730
Epoch 8/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7859 -
accuracy:
0.0840
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0890
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 11/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy: 0.0710
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0910
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0840
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0780
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0870
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0740
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7844 -
accuracy:
0.0890
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.1060
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7698 -
accuracy:
0.0870
Epoch 20/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0750
Epoch 21/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7841 -
accuracy:
0.0810
Epoch 22/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0860
```

```
Epoch 23/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0810
Epoch 24/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0860
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy: 0.0900
Epoch 28/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0730
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0730
Epoch 30/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0780
step: 2
Epoch 1/30
32/32 [==============================] - 2s 4ms/step - loss: 4.4173 -
accuracy:
0.0740
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8634 -
accuracy:
0.0840
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7923 -
accuracy:
0.0820
Epoch 4/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0890
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7987 -
accuracy:
0.0850
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0770
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8250 -
accuracy:
0.0690
Epoch 8/30
32/32 [==============================] - 0s 4ms/step - loss: 2.8860 -
accuracy:
0.0710
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8494 -
accuracy:
0.0710
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8380 -
accuracy:
0.0870
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7832 -
accuracy:
0.0730
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8733 -
accuracy:
0.0880
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7972 -
accuracy:
0.0920
Epoch 14/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7842 -
accuracy:
0.0810
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7832 -
accuracy:
```

```
0.0910
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0890
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8100 -
accuracy:
0.1000
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0920
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0790
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0780
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0770
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0880
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7832 -
accuracy:
0.0940
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0630
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0840
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0970
Epoch 27/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0960
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0770
Epoch 29/30
32/32 [==============================] - 0s 4ms/step - loss: 2.8126 -
accuracy:
0.1000
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0850
step: 3
Epoch 1/30
32/32 [==============================] - 2s 3ms/step - loss: 12.8320
- accuracy:
0.1080
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 13.0261
- accuracy:
0.1160
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 12.8454
- accuracy:
0.1170
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 11.2061
- accuracy:
0.1180
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 3.3893 -
accuracy:
0.0990
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 3.0214 -
accuracy:
0.0820
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8660 -
accuracy:
0.0950
Epoch 8/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.9194 -
accuracy:
0.0810
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0900
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8392 -
accuracy:
0.0760
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0770
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8232 -
accuracy:
0.0730
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8232 -
accuracy:
0.0800
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8232 -
accuracy:
0.0830
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8527 -
accuracy:
0.0810
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8632 -
accuracy:
0.0810
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0670
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8259 -
accuracy:
0.0750
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
```

```
0.0770
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0820
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0860
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8126 -
accuracy:
0.0830
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0910
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0740
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7965 -
accuracy:
0.0850
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8124 -
accuracy:
0.0930
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7870 -
accuracy:
0.0820
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0790
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0720
Epoch 30/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7859 -
accuracy:
0.0850
step: 4
```

```
Epoch 1/30
32/32 [==============================] - 2s 3ms/step - loss: 4.7999 -
accuracy:
0.0820
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8088 -
accuracy:
0.0830
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0870
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8389 -
accuracy:
0.0980
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8118 -
accuracy:
0.0840
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0720
Epoch 7/30
32/32 [==============================] - 0s 2ms/step - loss: 2.7859 -
accuracy:
0.0870
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0890
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0820
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0740
Epoch 12/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0760
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0770
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7698 -
accuracy:
0.0860
Epoch 16/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy: 0.0820
Epoch 17/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7993 -
accuracy:
0.0830
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0640
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7866 -
accuracy:
0.0850
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0930
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0860
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0980
```

```
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0760
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0870
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0810
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0830
Epoch 28/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0910
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8511 -
accuracy:
0.0790
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8260 -
accuracy:
0.0820
step: 5
Epoch 1/30
32/32 [==============================] - 2s 3ms/step - loss: 4.7965 -
accuracy:
0.0760
Epoch 2/30
32/32 [==============================] - 0s 4ms/step - loss: 2.9483 -
accuracy:
0.0860
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.9153 -
accuracy:
0.0730
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8885 -
accuracy:
0.0910
Epoch 5/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0950
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8117 -
accuracy:
0.0920
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0810
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0760
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0750
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7832 -
accuracy:
0.0650
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0830
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0990
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8099 -
accuracy:
0.0900
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0810
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0820
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7698 -
accuracy:
```

```
0.0660
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0850
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0940
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0830
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0720
Epoch 21/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0760
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7981 -
accuracy:
0.0790
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7979 -
accuracy:
0.0840
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0920
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0920
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0950
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0740
Epoch 28/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7851 -
accuracy:
0.0910
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8379 -
accuracy:
0.0710
Epoch 30/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7859 -
accuracy:
0.0910
step: 6
Epoch 1/30
32/32 [==============================] - 2s 4ms/step - loss: 12.7914
- accuracy:
0.1060
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 11.0957
- accuracy:
0.0890
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.9229 -
accuracy:
0.1040
Epoch 4/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7859 -
accuracy:
0.0880
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7852 -
accuracy:
0.0780
Epoch 6/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0770
Epoch 7/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0770
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0840
Epoch 9/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7840 -
accuracy:
0.0770
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7698 -
accuracy:
0.0820
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0660
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0870
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7866 -
accuracy:
0.0850
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0910
Epoch 15/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0840
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0960
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0850
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7832 -
accuracy:
0.0680
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0790
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
```

```
0.0910
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0840
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0770
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0860
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0840
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0880
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0790
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0800
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0900
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0690
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7698 -
accuracy:
0.0770
step: 7
Epoch 1/30
32/32 [==============================] - 2s 4ms/step - loss: 4.1644 -
accuracy:
0.0780
```

```
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0690
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0700
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0840
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy: 0.0710
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7847 -
accuracy:
0.0870
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0800
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0910
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0960
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0990
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0980
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7858 -
accuracy:
0.0900
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
```

```
0.0710
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0860
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0650
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0740
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0910
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0900
Epoch 19/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.1040
Epoch 20/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0730
Epoch 21/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy: 0.0810
Epoch 22/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0950
Epoch 23/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0830
Epoch 24/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0880
Epoch 25/30
```

```
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0660
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7698 -
accuracy:
0.0970
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0950
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0940
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0880
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0740
step: 8
Epoch 1/30
32/32 [==============================] - 2s 3ms/step - loss: 5.4925 -
accuracy:
0.0670
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8352 -
accuracy:
0.0840
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7839 -
accuracy:
0.0800
Epoch 4/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0630
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0900
Epoch 6/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7851 -
accuracy:
0.0800
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0710
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7869 -
accuracy:
0.0910
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0830
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0840
Epoch 12/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0840
Epoch 13/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.1000
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0920
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0890
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0860
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
```

```
0.0690
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0860
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0810
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0670
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0860
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0910
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0960
Epoch 24/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0720
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0760
Epoch 27/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 28/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0710
Epoch 29/30
```

```
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0780
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0760
step: 9
Epoch 1/30
32/32 [==============================] - 2s 4ms/step - loss: 4.2436 -
accuracy:
0.0840
Epoch 2/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7859 -
accuracy:
0.0820
Epoch 3/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0820
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.8873 -
accuracy:
0.0830
Epoch 5/30
32/32 [==============================] - 0s 4ms/step - loss: 2.8509 -
accuracy:
0.0800
Epoch 6/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7857 -
accuracy:
0.1000
Epoch 7/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0790
Epoch 8/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0850
Epoch 9/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7859 -
accuracy:
0.0800
Epoch 10/30
```

```
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0930
Epoch 11/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0870
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0760
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0920
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0750
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0810
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0690
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0830
Epoch 18/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0890
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0900
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0700
Epoch 21/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
```

```
0.0650
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0930
Epoch 24/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0900
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0900
Epoch 26/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0800
Epoch 27/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0850
Epoch 28/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0910
Epoch 29/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0810
Epoch 30/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0990
step: 10
Epoch 1/30
32/32 [==============================] - 2s 3ms/step - loss: 6.1498 -
accuracy:
0.0680
Epoch 2/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0840
```

```
Epoch 3/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7866 -
accuracy:
0.0880
Epoch 4/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0720
Epoch 5/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0730
Epoch 6/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0940
Epoch 7/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7863 -
accuracy:
0.0950
Epoch 8/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7978 -
accuracy:
0.0790
Epoch 9/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7979 -
accuracy:
0.1000
Epoch 10/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy: 0.0670
Epoch 11/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0820
Epoch 12/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0890
Epoch 13/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7974 -
accuracy:
0.0770
Epoch 14/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
```

```
0.0690
Epoch 15/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.1070
Epoch 16/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0810
Epoch 17/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0910
Epoch 18/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0790
Epoch 19/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0840
Epoch 20/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0750
Epoch 21/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0830
Epoch 22/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0700
Epoch 23/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7726 -
accuracy:
0.0900
Epoch 24/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7993 -
accuracy:
0.0720
Epoch 25/30
32/32 [==============================] - 0s 3ms/step - loss: 2.7859 -
accuracy:
0.0850
Epoch 26/30
```

```
32/32 [==============================] - 0s 4ms/step - loss: 2.7993 -
accuracy: 0.0700
Epoch 27/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0890
Epoch 28/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7951 -
accuracy:
0.0800
Epoch 29/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0880
Epoch 30/30
32/32 [==============================] - 0s 4ms/step - loss: 2.7726 -
accuracy:
0.0890
Mean Test Accuracy: 0.08399999886751175
```

Mean Test Accuracy for Model 4: 0.0834

2. Tune the hyperparameters using kerastuner to select the best learning rate among the set {0.1, 0.01, 0.15} with batch size varying between {4,8,16} and first hidden layer neurons varying between 250 to 260 with a step value of 2. 2nd, 3rd and 4th hidden layer contains 16, 8, 4 numbers of neurons respectively. The four layers have activation function sigmoid, tanh, relu and selu respectively. Use optimizer as SGD and find the best hyperparameters to predict the MNIST test data

[51]:
```
def build_model(hp):

    hp_neurons = hp.Int('neurons', min_value=250, max_value=260,
    step=2)

    model = keras.Sequential() model.add(Dense(units=hp_neurons,
    activation='sigmoid',input_shape=(784,)))
    model.add(Dropout(0.5)) model.add(Dense(16, activation='tanh'))
    model.add(Dropout(0.5)) model.add(Dense(8, activation='relu'))
    model.add(Dropout(0.5)) model.add(Dense(4, activation='selu'))
    model.add(Dropout(0.5))
    model.add(Dense(10, activation='softmax'))

    # Tune learning rate and batch size
    hp_learning_rate = hp.Choice('learning_rate', values=[0.1, 0.01,
    0.15]) hp_batch_size = hp.Choice('batch_size', values=[4, 8, 16])
    # Compile the model
```

```
    model.compile(optimizer=keras.optimizers.SGD(learning_rate=hp_learn
    ing_rate), loss='sparse_categorical_crossentropy',
    metrics=['accuracy']) return model
```

[52]:
```
# Configure the tuner
tuner = RandomSearch(
 build_model,
 objective='val_accuracy',
 max_trials=10,
 executions_per_trial=4,
 directory='keras_tuner_b',
 project_name='mnist_hyperparameters'
)
```

[53]:
```
hp_batch_size = tuner.oracle.get_space()['batch_size']
tuner.search(X_trn, y_trn, epochs=15, validation_data=(X_tst, y_tst), ␣
 ↪batch_size=hp_batch_size)
```

```
Trial 10 Complete [00h 00m 46s]
val_accuracy: 0.1340000033378601

Best val_accuracy So Far: 0.1340000033378601
Total elapsed time: 00h 07m 42s
```

[55]:
```
 # Get the best hyperparameters best_hps =
tuner.get_best_hyperparameters(num_trials=20)[0]
best_neurons = best_hps.get('neurons')
best_learning_rate = best_hps.get('learning_rate')
best_batch_size = best_hps.get('batch_size')
print(f"Best number of neurons: {best_neurons}")
print(f"Best learning rate: {best_learning_rate}")
print(f"Best batch size: {best_batch_size}")
# Get the best model
best_model = tuner.get_best_models(num_models=1)[0]
# Evaluate the best model loss, accuracy =
best_model.evaluate(X_tst, y_tst)
print(f"Test accuracy of the best model:
 {accuracy}")
```

```
Best number of neurons: 256
Best learning rate: 0.15
Best batch size: 16
16/16 [==============================] - 0s 3ms/step - loss: 2.3004 -
accuracy:
0.1340
Test accuracy of the best model: 0.1340000033378601
```

Best Accuracy with hyperparameter tuning : 0.134

[56]:
```
best_model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 256)               200960

 dropout (Dropout)           (None, 256)               0

 dense_1 (Dense)             (None, 16)                4112

 dropout_1 (Dropout)         (None, 16)                0

 dense_2 (Dense)             (None, 8)                 136

 dropout_2 (Dropout)         (None, 8)                 0

 dense_3 (Dense)             (None, 4)                 36

 dropout_3 (Dropout)         (None, 4)                 0

 dense_4 (Dense)             (None, 10)                50
=================================================================
Total params: 205294 (801.93 KB)
Trainable params: 205294 (801.93 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

Observations:

Mean test Accuracy for Model 1 is 0.1018

Mean Test Accurcy for Model 2: 0.073

Mean Test Accuracy for Model 3: 0.0834

Mean Test Accuracy for Model 4: 0.0834

Best Accuracy with hyperparameter tuning : 0.134

Hence Hyperparameter tuning shows the highest accuracy among all the methods listed above