```
#install·required·libraries
import·pandas·as·pd
import·numpy·as·np
#data·visualization·packages
import·matplotlib.pyplot·as·plt
#keras·packages
import·keras
from·keras.models·import·Sequential
from·keras.layers·import·Convolution2D
from·keras.layers·import·MaxPooling2D
from·keras.layers·import·Flatten
from·keras.layers·import·Dense
from·keras.wrappers.scikit_learn·import·KerasClassifier
from·keras.layers·import·Dropout
#model·evaluation·packages
from·sklearn.metrics·import·f1_score,·roc_auc_score,·log_loss
from·sklearn.model_selection·import·cross_val_score,·cross_validate

import·tensorflow.keras·as·tk


#read·mnist·fashion·dataset
mnist·=·tk.datasets.mnist
(X_train,·y_train),·(X_test,·y_test)·=·mnist.load_data()
print(X_train.shape,·y_train.shape,·X_test.shape,·y_test.shape)

#reshape·data·from·3-D·to·2-D·array
X_train·=·X_train.reshape(60000,·784)
X_test·=·X_test.reshape(10000,·784)
#feature·scaling
from·sklearn.preprocessing·import·MinMaxScaler
minmax·=·MinMaxScaler()
#fit·and·transform·training·dataset
X_train·=·minmax.fit_transform(X_train)
#transform·testing·dataset
X_test·=·minmax.transform(X_test)
print('Number·of·unique·classes:·',·len(np.unique(y_train)))
print('Classes:·',·np.unique(y_train))

fig,·axes·=·plt.subplots(nrows=2,·ncols=5,figsize=(15,5))·····
ax·=·axes.ravel()
for·i·in·range(10):
····ax[i].imshow(X_train[i].reshape(28,28))
····ax[i].title.set_text('Class:·'·+·str(y_train[i]))·····
plt.subplots_adjust(hspace=0.5)·····
plt.show()

#initializing·CNN·model
classifier_e25·=·Sequential()
#add·1st·hidden·layer
classifier_e25.add(Dense(input_dim·=·X_train.shape[1],·units·=·256,·kernel_initializer
#add·output·layer
classifier_e25.add(Dense(units·=·10,·kernel_initializer='uniform',·activation='softmax
#compile·the·neural·network
```

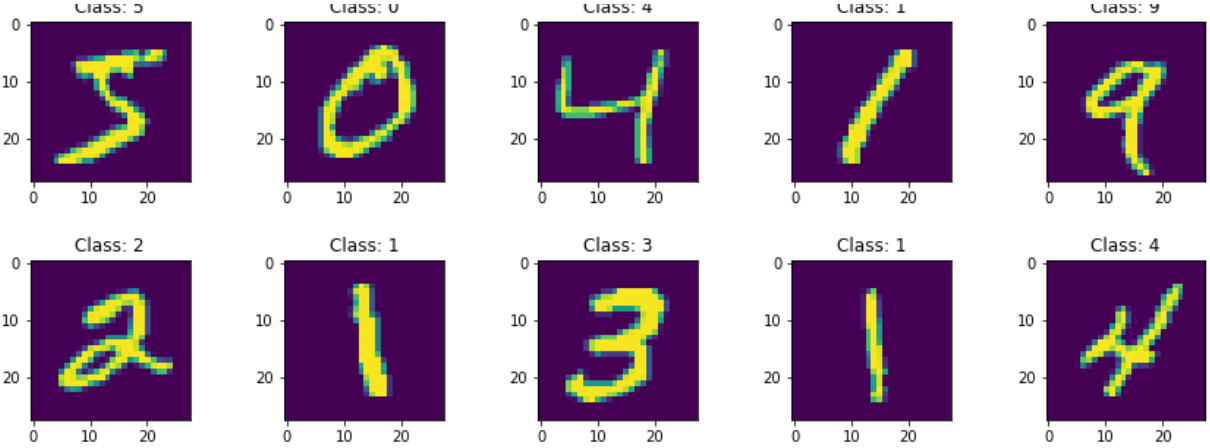
```
#compile the neural network
classifier_e25.compile(optimizer='adam',·loss='sparse_categorical_crossentropy',·metri
#model·summary
classifier_e25.summary()
#fit·training·dataset·into·the·model
classifier_e25_fit·=·classifier_e25.fit(X_train,·y_train,·epochs=25,·verbose=1)

#evaluate·the·model·for·testing·dataset
test_loss_e25·=·classifier_e25.evaluate(X_test,·y_test,·verbose=0)
#calculate·evaluation·parameters
predict_x=classifier_e25.predict(X_test)·
classes_x=np.argmax(predict_x,axis=1)



y_prob·=·classifier_e25.predict(X_test·)

f1_e25·=·f1_score(y_test,classes_x,·average='micro')
roc_e25·=·roc_auc_score(y_test,·y_prob·,·multi_class='ovo')
#create·evaluation·dataframe
stats_e25·=·pd.DataFrame({'Test·accuracy'·:··round(test_loss_e25[1]*100,3),
·····················'F1·score'·····:·round(f1_e25,3),
·····················'ROC·AUC·score'·:·round(roc_e25,3),
·····················'Total·Loss'····:·round(test_loss_e25[0],3)},·index=[0])
#print·evaluation·dataframe
display(stats_e25)
```




```
Model: "sequential_9"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_18 (Dense)            (None, 256)               200960

 dense_19 (Dense)            (None, 10)                2570

=================================================================
Total params: 203,530
Trainable params: 203,530
Non-trainable params: 0
_________________________________________________________________
Epoch 1/25
1875/1875 [==============================] - 6s 3ms/step - loss: 0.2517 - acc
Epoch 2/25
1875/1875 [==============================] - 6s 3ms/step - loss: 0.0981 - acc
Epoch 3/25
1875/1875 [==============================] - 6s 3ms/step - loss: 0.0654 - acc
Epoch 4/25
1875/1875 [==============================] - 6s 3ms/step - loss: 0.0470 - acc
Epoch 5/25
1875/1875 [==============================] - 6s 3ms/step - loss: 0.0348 - acc
Epoch 6/25
1875/1875 [==============================] - 6s 3ms/step - loss: 0.0264 - acc
Epoch 7/25
1875/1875 [==============================] - 6s 3ms/step - loss: 0.0203 - acc
Epoch 8/25
1875/1875 [==============================] - 6s 3ms/step - loss: 0.0162 - acc
Epoch 9/25
1875/1875 [==============================] - 6s 3ms/step - loss: 0.0132 - acc
Epoch 10/25
1875/1875 [==============================] - 6s 3ms/step - loss: 0.0103 - acc
Epoch 11/25
1875/1875 [==============================] - 6s 3ms/step - loss: 0.0105 - acc
Epoch 12/25
1875/1875 [==============================] - 6s 3ms/step - loss: 0.0077 - acc
Epoch 13/25
1875/1875 [==============================] - 6s 3ms/step - loss: 0.0087 - acc
Epoch 14/25
1875/1875 [==============================] - 6s 3ms/step - loss: 0.0072 - acc
Epoch 15/25
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0060 - acc
Epoch 16/25
```