

```
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import tensorflow as tf
import keras
```

```
(X_train, y_train), (X_test, y_test)=tf.keras.datasets.fashion_mnist.load_data()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/train-32768/29515 [=====] - 0s 0us/step
40960/29515 [=====] - 0s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/train-26427392/26421880 [=====] - 0s 0us/step
26435584/26421880 [=====] - 0s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/t10k-16384/5148 [=====]
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/t10k-4423680/4422102 [=====] - 0s 0us/step
4431872/4422102 [=====] - 0s 0us/step
```

```
X_train.shape,y_train.shape, "*****" , X_test.shape,y_test.shape
```

```
((60000, 28, 28), (60000,), '*****', (10000, 28, 28), (10000,))
```

```
X_train[0]
```

```
[229, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
 183, 225, 216, 223, 228, 235, 227, 224, 222, 224, 221, 223, 245,
 173, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
 193, 228, 218, 213, 198, 180, 212, 210, 211, 213, 223, 220, 243,
 202, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 1, 3, 0, 12,
 219, 220, 212, 218, 192, 169, 227, 208, 218, 224, 212, 226, 197,
 209, 52],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 6, 0, 99,
 244, 222, 220, 218, 203, 198, 221, 215, 213, 222, 220, 245, 119,
 167, 56],
[ 0, 0, 0, 0, 0, 0, 0, 0, 4, 0, 0, 55,
 236, 228, 230, 228, 240, 232, 213, 218, 223, 234, 217, 217, 209,
 92, 0],
[ 0, 0, 1, 4, 6, 7, 2, 0, 0, 0, 0, 237,
 226, 217, 223, 222, 219, 222, 221, 216, 223, 229, 215, 218, 255,
 77, 0],
[ 0, 3, 0, 0, 0, 0, 0, 0, 62, 145, 204, 228,
 207, 213, 221, 218, 208, 211, 218, 224, 223, 219, 215, 224, 244,
 159, 0],
[ 0, 0, 0, 18, 44, 82, 107, 189, 228, 220, 222, 217,
 226, 200, 205, 211, 230, 224, 234, 176, 188, 250, 248, 233, 238,
 215, 0],
```

```
y_train[0]
```

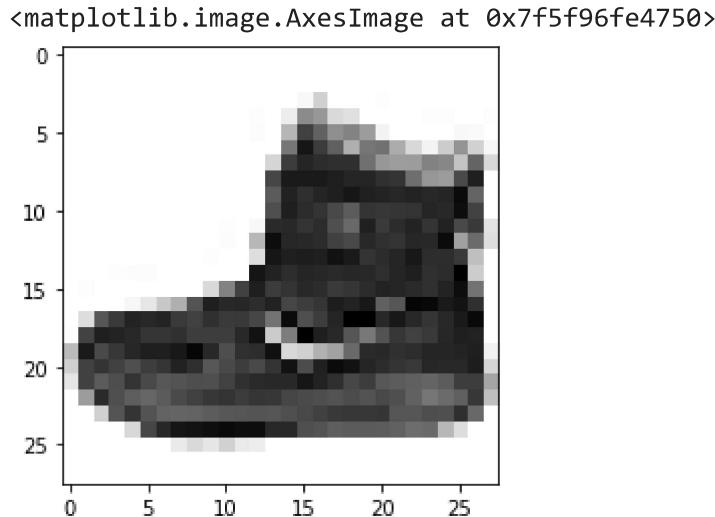
9

```
class_labels = ["T-shirt/top", "Trouser", "Pullover", "Dress", "Coat", "Sandal", "Shirt", "Sneaker"]
```

class_labels

```
[ 'T-shirt/top',
  'Trouser',
  'Pullover',
  'Dress',
  'Coat',
  'Sandal',
  'Shirt',
  'Sneaker',
  'Bag',
  'Ankle boot']
```

```
plt.imshow(X_train[0],cmap='Greys')
```



```
plt.figure(figsize=(16,16))
```

```
j=1
for i in np.random.randint(0,1000,25):
    plt.subplot(5,5,j);j+=1
    plt.imshow(X_train[i],cmap='Greys')
    plt.axis('off')
    plt.title('{} / {}'.format(class_labels[y_train[i]],y_train[i]))
```

↳



X_train.ndim

3

Shirt / 6

Ankle boot / 9

Coat / 4

T-shirt/top / 0

Sneaker / 7

X_train = np.expand_dims(X_train, -1)



X_train.ndim

4

X_test=np.expand_dims(X_test,-1)

X_train = X_train/255

X_test= X_test/255

```
from sklearn.model_selection import train_test_split
X_train,X_Validation,y_train,y_Validation=train_test_split(X_train,y_train,test_size=0.2,rand
```

X_train.shape,X_Validation.shape,y_train.shape,y_Validation.shape

((48000, 28, 28, 1), (12000, 28, 28, 1), (48000,), (12000,))

```
model=keras.models.Sequential([
    keras.layers.Conv2D(filters=32,kernel_size=3,strides=(1,1),padding='same'),
    keras.layers.MaxPooling2D(pool_size=(2,2)),
    keras.layers.Flatten(),
    keras.layers.Dense(units=128,activation='relu'),
    keras.layers.Dense(units=10,activation='softmax')
])
```

```
model.summary()
```

Model: "sequential"

| Layer (type) | Output Shape | Param # |
|------------------------------|--------------------|---------|
| <hr/> | | |
| conv2d (Conv2D) | (None, 26, 26, 32) | 320 |
| max_pooling2d (MaxPooling2D) | (None, 13, 13, 32) | 0 |
| flatten (Flatten) | (None, 5408) | 0 |
| dense (Dense) | (None, 128) | 692352 |
| dense_1 (Dense) | (None, 10) | 1290 |
| <hr/> | | |
| Total params: 693,962 | | |
| Trainable params: 693,962 | | |
| Non-trainable params: 0 | | |

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

```
model.fit(X_train,y_train,epochs=50,batch_size=512,verbose=1,validation_data=(X_Validation,y_
```

```
Epoch 1/50
94/94 [=====] - 26s 262ms/step - loss: 0.6515 - accuracy: 0.
Epoch 2/50
94/94 [=====] - 20s 209ms/step - loss: 0.4059 - accuracy: 0.
Epoch 3/50
94/94 [=====] - 19s 207ms/step - loss: 0.3543 - accuracy: 0.
Epoch 4/50
94/94 [=====] - 19s 204ms/step - loss: 0.3244 - accuracy: 0.
Epoch 5/50
94/94 [=====] - 21s 229ms/step - loss: 0.2980 - accuracy: 0.
Epoch 6/50
94/94 [=====] - 21s 221ms/step - loss: 0.2798 - accuracy: 0.
Epoch 7/50
94/94 [=====] - 20s 209ms/step - loss: 0.2654 - accuracy: 0.
Epoch 8/50
94/94 [=====] - 20s 212ms/step - loss: 0.2540 - accuracy: 0.
```

```
Epoch 9/50
94/94 [=====] - 20s 208ms/step - loss: 0.2391 - accuracy: 0.
Epoch 10/50
94/94 [=====] - 20s 209ms/step - loss: 0.2285 - accuracy: 0.
Epoch 11/50
94/94 [=====] - 20s 211ms/step - loss: 0.2192 - accuracy: 0.
Epoch 12/50
94/94 [=====] - 21s 222ms/step - loss: 0.2113 - accuracy: 0.
Epoch 13/50
94/94 [=====] - 19s 204ms/step - loss: 0.2007 - accuracy: 0.
Epoch 14/50
94/94 [=====] - 20s 209ms/step - loss: 0.1960 - accuracy: 0.
Epoch 15/50
94/94 [=====] - 20s 211ms/step - loss: 0.1856 - accuracy: 0.
Epoch 16/50
94/94 [=====] - 20s 211ms/step - loss: 0.1766 - accuracy: 0.
Epoch 17/50
94/94 [=====] - 20s 208ms/step - loss: 0.1698 - accuracy: 0.
Epoch 18/50
94/94 [=====] - 20s 216ms/step - loss: 0.1629 - accuracy: 0.
Epoch 19/50
94/94 [=====] - 20s 213ms/step - loss: 0.1570 - accuracy: 0.
Epoch 20/50
94/94 [=====] - 20s 211ms/step - loss: 0.1505 - accuracy: 0.
Epoch 21/50
94/94 [=====] - 19s 207ms/step - loss: 0.1441 - accuracy: 0.
Epoch 22/50
94/94 [=====] - 19s 205ms/step - loss: 0.1391 - accuracy: 0.
Epoch 23/50
94/94 [=====] - 19s 204ms/step - loss: 0.1378 - accuracy: 0.
Epoch 24/50
94/94 [=====] - 19s 207ms/step - loss: 0.1287 - accuracy: 0.
Epoch 25/50
94/94 [=====] - 20s 217ms/step - loss: 0.1219 - accuracy: 0.
Epoch 26/50
94/94 [=====] - 19s 201ms/step - loss: 0.1167 - accuracy: 0.
Epoch 27/50
94/94 [=====] - 20s 210ms/step - loss: 0.1096 - accuracy: 0.
Epoch 28/50
94/94 [=====] - 19s 204ms/step - loss: 0.1069 - accuracy: 0.
Epoch 29/50
```

```
y_pred = model.predict(X_test)
y_pred.round(2)
```

```
array([[0. , 0. , 0. , ..., 0. , 0. , 1. ],
       [0. , 0. , 1. , ..., 0. , 0. , 0. ],
       [0. , 1. , 0. , ..., 0. , 0. , 0. ],
       ...,
       [0. , 0. , 0. , ..., 0. , 1. , 0. ],
       [0. , 1. , 0. , ..., 0. , 0. , 0. ],
       [0. , 0. , 0. , ..., 0.02, 0. , 0. ]], dtype=float32)
```

```
y_test
```

```
array([9, 2, 1, ..., 8, 1, 5], dtype=uint8)
```

```
model.evaluate(X_test, y_test)
```

```
313/313 [=====] - 2s 7ms/step - loss: 0.3649 - accuracy: 0.9111  
[0.3649125099182129, 0.91130003528595]
```

```
plt.figure(figsize=(16,16))
```

```
j=1  
for i in np.random.randint(0, 1000, 25):  
    plt.subplot(5,5, j); j+=1  
    plt.imshow(X_test[i].reshape(28,28), cmap = 'Greys')  
    plt.title('Actual = {} / {}\nPredicted = {} / {}'.format(class_labels[y_test[i]], y_test[i]))  
    plt.axis('off')
```

Actual = Ankle boot / 9
Predicted = Ankle boot / 9



Actual = Bag / 8
Predicted = Bag / 8



Actual = Dress / 3

Actual = Trouser / 1
Predicted = Trouser / 1



Actual = Sneaker / 7
Predicted = Ankle boot / 9



Actual = Pullover / 2

Actual = Sandal / 5
Predicted = Sandal / 5

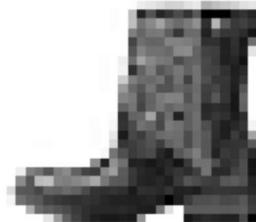


Actual = Coat / 4
Predicted = Coat / 4



Actual = Sandal / 5

Actual = Ankle boot / 9
Predicted = Ankle boot / 9



Actual = T-shirt/top / 0
Predicted = T-shirt/top / 0



Actual = Bag / 8

Acti
Predi

A
Pre

A
A

```
plt.figure(figsize=(16,30))
```

```
j=1
for i in np.random.randint(0, 1000, 60):
    plt.subplot(10,6, j); j+=1
    plt.imshow(X_test[i].reshape(28,28), cmap = 'Greys')
    plt.title('Actual = {} / {} \nPredicted = {} / {}'.format(class_labels[y_test[i]], y_test[i]
    plt.axis('off')
```

Actual = Sneaker / 7 Actual = T-shirt/top / 0 Actual = Ankle boot / 9 Actual = Sandal / 5 Actual = Sneaker / 7 Actual = T-shirt/top / 0
 Predicted = Sneaker / 7 Predicted = T-shirt/top / 0 Predicted = Ankle boot / 9 Predicted = Sandal / 5 Predicted = Sneaker / 7 Predicted = T-shirt/top / 0



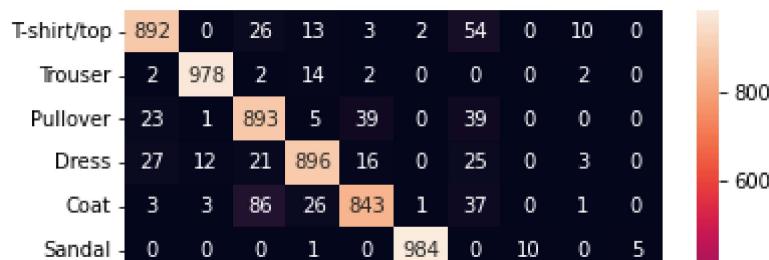
```
from sklearn.metrics import confusion_matrix
plt.figure(figsize=(16,9))
y_pred_labels = [ np.argmax(label) for label in y_pred ]
cm = confusion_matrix(y_test, y_pred_labels)
```

<Figure size 1152x648 with 0 Axes>

```
sns.heatmap(cm, annot=True, fmt='d', xticklabels=class_labels, yticklabels=class_labels)
```

```
from sklearn.metrics import classification_report
cr= classification_report(y_test, y_pred_labels, target_names=class_labels)
print(cr)
```

| | precision | recall | f1-score | support |
|--------------|-----------|--------|----------|---------|
| T-shirt/top | 0.82 | 0.89 | 0.86 | 1000 |
| Trouser | 0.98 | 0.98 | 0.98 | 1000 |
| Pullover | 0.82 | 0.89 | 0.85 | 1000 |
| Dress | 0.92 | 0.90 | 0.91 | 1000 |
| Coat | 0.87 | 0.84 | 0.86 | 1000 |
| Sandal | 0.98 | 0.98 | 0.98 | 1000 |
| Shirt | 0.82 | 0.72 | 0.77 | 1000 |
| Sneaker | 0.97 | 0.97 | 0.97 | 1000 |
| Bag | 0.98 | 0.97 | 0.97 | 1000 |
| Ankle boot | 0.97 | 0.97 | 0.97 | 1000 |
| accuracy | | | 0.91 | 10000 |
| macro avg | 0.91 | 0.91 | 0.91 | 10000 |
| weighted avg | 0.91 | 0.91 | 0.91 | 10000 |



```
model.save('fashion_mnist_cnn_model.h5')
```

```
cnn_model2 = keras.models.Sequential([
    keras.layers.Conv2D(filters=32, kernel_size=3, strides=(1,1), padding='same'),
    keras.layers.MaxPooling2D(pool_size=(2,2)),
    keras.layers.Conv2D(filters=64, kernel_size=3, strides=(2,2), padding='same'),
    keras.layers.MaxPooling2D(pool_size=(2,2)),
    keras.layers.Flatten(),
    keras.layers.Dense(units=128, activation='relu'),
    keras.layers.Dropout(0.25),
    keras.layers.Dense(units=256, activation='relu'),
    keras.layers.Dropout(0.25),
    keras.layers.Dense(units=128, activation='relu'),
    keras.layers.Dense(units=10, activation='softmax')
])
```

```
cnn_model2.compile(optimizer='adam', loss= 'sparse_categorical_crossentropy', metrics=['accuracy'])
```

```
cnn_model2.fit(X_train, y_train, epochs=30, batch_size=512, verbose=1, validation_data=(X_Val,
```

```
Epoch 1/30
94/94 [=====] - 25s 262ms/step - loss: 0.7085 - accuracy: 0.5161
Epoch 2/30
94/94 [=====] - 24s 255ms/step - loss: 0.5161 - accuracy: 0.5161
Epoch 3/30
```

```
94/94 [=====] - 27s 289ms/step - loss: 0.4433 - accuracy: 0.  
Epoch 4/30  
94/94 [=====] - 25s 264ms/step - loss: 0.3926 - accuracy: 0.  
Epoch 5/30  
94/94 [=====] - 25s 261ms/step - loss: 0.3569 - accuracy: 0.  
Epoch 6/30  
94/94 [=====] - 24s 255ms/step - loss: 0.3299 - accuracy: 0.  
Epoch 7/30  
94/94 [=====] - 25s 263ms/step - loss: 0.3161 - accuracy: 0.  
Epoch 8/30  
94/94 [=====] - 26s 272ms/step - loss: 0.2941 - accuracy: 0.  
Epoch 9/30  
94/94 [=====] - 24s 256ms/step - loss: 0.2824 - accuracy: 0.  
Epoch 10/30  
94/94 [=====] - 24s 257ms/step - loss: 0.2707 - accuracy: 0.  
Epoch 11/30  
94/94 [=====] - 24s 254ms/step - loss: 0.2600 - accuracy: 0.  
Epoch 12/30  
94/94 [=====] - 24s 253ms/step - loss: 0.2516 - accuracy: 0.  
Epoch 13/30  
94/94 [=====] - 24s 258ms/step - loss: 0.2415 - accuracy: 0.  
Epoch 14/30  
94/94 [=====] - 25s 266ms/step - loss: 0.2350 - accuracy: 0.  
Epoch 15/30  
94/94 [=====] - 24s 252ms/step - loss: 0.2298 - accuracy: 0.  
Epoch 16/30  
94/94 [=====] - 25s 262ms/step - loss: 0.2204 - accuracy: 0.  
Epoch 17/30  
94/94 [=====] - 24s 256ms/step - loss: 0.2150 - accuracy: 0.  
Epoch 18/30  
94/94 [=====] - 24s 257ms/step - loss: 0.2172 - accuracy: 0.  
Epoch 19/30  
94/94 [=====] - 25s 267ms/step - loss: 0.2056 - accuracy: 0.  
Epoch 20/30  
94/94 [=====] - 24s 251ms/step - loss: 0.1978 - accuracy: 0.  
Epoch 21/30  
94/94 [=====] - 24s 253ms/step - loss: 0.1907 - accuracy: 0.  
Epoch 22/30  
94/94 [=====] - 24s 255ms/step - loss: 0.1874 - accuracy: 0.  
Epoch 23/30  
94/94 [=====] - 24s 251ms/step - loss: 0.1831 - accuracy: 0.  
Epoch 24/30  
94/94 [=====] - 24s 253ms/step - loss: 0.1778 - accuracy: 0.  
Epoch 25/30  
94/94 [=====] - 25s 266ms/step - loss: 0.1705 - accuracy: 0.  
Epoch 26/30  
94/94 [=====] - 24s 258ms/step - loss: 0.1691 - accuracy: 0.  
Epoch 27/30  
94/94 [=====] - 24s 251ms/step - loss: 0.1623 - accuracy: 0.  
Epoch 28/30  
94/94 [=====] - 24s 256ms/step - loss: 0.1583 - accuracy: 0.  
[...]
```

```
cnn_model3 = keras.models.Sequential([  
    keras.layers.Conv2D(filters=64, kernel_size=3, strides=(1,1), padding='same', activation='relu'),  
    keras.layers.MaxPooling2D(pool_size=(2,2)),  
    keras.layers.Conv2D(filters=128, kernel_size=3, strides=(1,1), padding='same', activation='relu'),  
    keras.layers.MaxPooling2D(pool_size=(2,2)),  
    keras.layers.Conv2D(filters=256, kernel_size=3, strides=(1,1), padding='same', activation='relu'),  
    keras.layers.MaxPooling2D(pool_size=(2,2)),  
    keras.layers.Flatten(),  
    keras.layers.Dense(1024, activation='relu'),  
    keras.layers.Dropout(0.5),  
    keras.layers.Dense(512, activation='relu'),  
    keras.layers.Dropout(0.5),  
    keras.layers.Dense(10, activation='softmax')])
```

```
keras.layers.MaxPooling2D(pool_size=(2,2)),  
keras.layers.Conv2D(filters=128, kernel_size=3, strides=(2,2), padding='same'),  
keras.layers.MaxPooling2D(pool_size=(2,2)),  
keras.layers.Conv2D(filters=64, kernel_size=3, strides=(2,2), padding='same'),  
keras.layers.MaxPooling2D(pool_size=(2,2)),  
keras.layers.Flatten(),  
keras.layers.Dense(units=128, activation='relu'),  
keras.layers.Dropout(0.25),  
keras.layers.Dense(units=256, activation='relu'),  
keras.layers.Dropout(0.5),  
keras.layers.Dense(units=256, activation='relu'),  
keras.layers.Dropout(0.25),  
keras.layers.Dense(units=128, activation='relu'),  
keras.layers.Dropout(0.10),  
keras.layers.Dense(units=10, activation='softmax')  
])
```

```
cnn_model3.compile(optimizer='adam', loss= 'sparse_categorical_crossentropy', metrics=['accuracy'])
```

```
cnn_model3.fit(X_train, y_train, epochs=50, batch_size=512, verbose=1, validation_data=(X_Val,
```

```
Epoch 1/50  
94/94 [=====] - 54s 571ms/step - loss: 0.7497 - accuracy: 0.  
Epoch 2/50  
94/94 [=====] - 53s 562ms/step - loss: 0.5473 - accuracy: 0.  
Epoch 3/50  
94/94 [=====] - 51s 543ms/step - loss: 0.4741 - accuracy: 0.  
Epoch 4/50  
94/94 [=====] - 51s 547ms/step - loss: 0.4199 - accuracy: 0.  
Epoch 5/50  
94/94 [=====] - 53s 564ms/step - loss: 0.3702 - accuracy: 0.  
Epoch 6/50  
94/94 [=====] - 51s 542ms/step - loss: 0.3398 - accuracy: 0.  
Epoch 7/50  
94/94 [=====] - 52s 555ms/step - loss: 0.3170 - accuracy: 0.  
Epoch 8/50  
94/94 [=====] - 51s 546ms/step - loss: 0.2920 - accuracy: 0.  
Epoch 9/50  
94/94 [=====] - 52s 554ms/step - loss: 0.2826 - accuracy: 0.  
Epoch 10/50  
94/94 [=====] - 53s 564ms/step - loss: 0.2686 - accuracy: 0.  
Epoch 11/50  
94/94 [=====] - 51s 546ms/step - loss: 0.2608 - accuracy: 0.  
Epoch 12/50  
94/94 [=====] - 53s 565ms/step - loss: 0.2406 - accuracy: 0.  
Epoch 13/50  
94/94 [=====] - 51s 545ms/step - loss: 0.2289 - accuracy: 0.  
Epoch 14/50  
94/94 [=====] - 51s 545ms/step - loss: 0.2156 - accuracy: 0.  
Epoch 15/50  
94/94 [=====] - 53s 560ms/step - loss: 0.2122 - accuracy: 0.  
Epoch 16/50
```

```
94/94 [=====] - 52s 551ms/step - loss: 0.2039 - accuracy: 0.  
Epoch 17/50  
94/94 [=====] - 51s 546ms/step - loss: 0.1947 - accuracy: 0.  
Epoch 18/50  
94/94 [=====] - 52s 554ms/step - loss: 0.1836 - accuracy: 0.  
Epoch 19/50  
94/94 [=====] - 51s 540ms/step - loss: 0.1851 - accuracy: 0.  
Epoch 20/50  
94/94 [=====] - 52s 557ms/step - loss: 0.1694 - accuracy: 0.  
Epoch 21/50  
94/94 [=====] - 52s 550ms/step - loss: 0.1612 - accuracy: 0.  
Epoch 22/50  
94/94 [=====] - 52s 549ms/step - loss: 0.1577 - accuracy: 0.  
Epoch 23/50  
94/94 [=====] - 52s 554ms/step - loss: 0.1537 - accuracy: 0.  
Epoch 24/50  
94/94 [=====] - 51s 538ms/step - loss: 0.1494 - accuracy: 0.  
Epoch 25/50  
94/94 [=====] - 53s 563ms/step - loss: 0.1435 - accuracy: 0.  
Epoch 26/50  
94/94 [=====] - 50s 533ms/step - loss: 0.1349 - accuracy: 0.  
Epoch 27/50  
94/94 [=====] - 51s 542ms/step - loss: 0.1293 - accuracy: 0.  
Epoch 28/50  
94/94 [=====] - 52s 554ms/step - loss: 0.1226 - accuracy: 0.  
Epoch 29/50
```