


```
In [1]: !pip install tensorflow
```

Defaulting to user installation because normal site-packages is not writeable
Requirement already satisfied: tensorflow in c:\users\hp\appdata\roaming\python\python39\site-packages (2.12.0)
Requirement already satisfied: tensorflow-intel==2.12.0 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow) (2.12.0)
Requirement already satisfied: jax>=0.3.15 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (0.4.11)
Requirement already satisfied: wrapt<1.15,>=1.11.0 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.12.0->tensorflow) (1.14.1)
Requirement already satisfied: flatbuffers>=2.0 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (23.5.26)
Requirement already satisfied: absl-py>=1.0.0 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (1.4.0)
Requirement already satisfied: typing-extensions>=3.6.6 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.12.0->tensorflow) (4.3.0)
Requirement already satisfied: keras<2.13,>=2.12.0 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (2.12.0)
Requirement already satisfied: gast<=0.4.0,>=0.2.1 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (0.4.0)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (1.54.2)
Requirement already satisfied: setuptools in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.12.0->tensorflow) (63.4.1)
Requirement already satisfied: h5py>=2.9.0 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.12.0->tensorflow) (3.7.0)
Requirement already satisfied: tensorflow-estimator<2.13,>=2.12.0 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (2.12.0)
Requirement already satisfied: tensorboard<2.13,>=2.12 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (2.12.3)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (0.31.0)
Requirement already satisfied: google-pasta>=0.1.1 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (0.2.0)
Requirement already satisfied: protobuf!=4.21.0,!4.21.1,!4.21.2,!4.21.3,!4.21.4,!4.21.5,<5.0.0dev,>=3.20.3 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (4.23.2)
Requirement already satisfied: numpy<1.24,>=1.22 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (1.23.5)
Requirement already satisfied: packaging in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.12.0->tensorflow) (21.3)
Requirement already satisfied: opt-einsum>=2.3.2 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (3.3.0)
Requirement already satisfied: termcolor>=1.1.0 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (2.3.0)

Requirement already satisfied: six>=1.12.0 in c:\programdata\anaconda3\lib\site-packages (from tensorflow-intel==2.12.0->tensorflow) (1.16.0)

Requirement already satisfied: astunparse>=1.6.0 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (1.6.3)

Requirement already satisfied: libclang>=13.0.0 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorflow-intel==2.12.0->tensorflow) (16.0.0)

Requirement already satisfied: wheel<1.0,>=0.23.0 in c:\programdata\anaconda3\lib\site-packages (from astunparse>=1.6.0->tensorflow-intel==2.12.0->tensorflow) (0.37.1)

Requirement already satisfied: importlib-metadata>=4.6 in c:\programdata\anaconda3\lib\site-packages (from jax>=0.3.15->tensorflow-intel==2.12.0->tensorflow) (4.11.3)

Requirement already satisfied: ml-dtypes>=0.1.0 in c:\users\hp\appdata\roaming\python\python39\site-packages (from jax>=0.3.15->tensorflow-intel==2.12.0->tensorflow) (0.1.0)

Requirement already satisfied: scipy>=1.7 in c:\programdata\anaconda3\lib\site-packages (from jax>=0.3.15->tensorflow-intel==2.12.0->tensorflow) (1.9.1)

Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (0.7.0)

Requirement already satisfied: markdown>=2.6.8 in c:\programdata\anaconda3\lib\site-packages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (3.3.4)

Requirement already satisfied: google-auth<3,>=1.6.3 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (2.19.0)

Requirement already satisfied: google-auth-oauthlib<1.1,>=0.5 in c:\users\hp\appdata\roaming\python\python39\site-packages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (1.0.0)

Requirement already satisfied: requests<3,>=2.21.0 in c:\programdata\anaconda3\lib\site-packages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (2.28.1)

Requirement already satisfied: werkzeug>=1.0.1 in c:\programdata\anaconda3\lib\site-packages (from tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (2.0.3)

Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in c:\programdata\anaconda3\lib\site-packages (from packaging->tensorflow-intel==2.12.0->tensorflow) (3.0.9)

Requirement already satisfied: pyasn1-modules>=0.2.1 in c:\programdata\anaconda3\lib\site-packages (from google-auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (0.2.8)

Requirement already satisfied: urllib3<2.0 in c:\programdata\anaconda3\lib\site-packages (from google-auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (1.26.11)

Requirement already satisfied: cachetools<6.0,>=2.0.0 in c:\users\hp\appdata\roaming\python\python39\site-packages (from google-auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (5.3.1)

Requirement already satisfied: rsa<5,>=3.1.4 in c:\users\hp\appdata\roaming\python\python39\site-packages (from google-auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (4.9)

Requirement already satisfied: requests-oauthlib>=0.7.0 in c:\users\hp\appdata\roaming\python\python39\site-packages (from google-auth-oauthlib<1.1,>=0.5->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (1.3.1)

Requirement already satisfied: zipp>=0.5 in c:\programdata\anaconda3\lib\site-packages (from importlib-metadata>=4.6->jax>=0.3.15->tensorflow-intel==2.12.

```

0->tensorflow) (3.8.0)
Requirement already satisfied: certifi>=2017.4.17 in c:\programdata\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (2022.9.14)
Requirement already satisfied: idna<4,>=2.5 in c:\programdata\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (3.3)
Requirement already satisfied: charset-normalizer<3,>=2 in c:\programdata\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (2.0.4)
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in c:\programdata\anaconda3\lib\site-packages (from pyasn1-modules>=0.2.1->google-auth<3,>=1.6.3->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (0.4.8)
Requirement already satisfied: oauthlib>=3.0.0 in c:\users\hp\appdata\roaming\python\python39\site-packages (from requests-oauthlib>=0.7.0->google-auth-oauthlib<1.1,>=0.5->tensorboard<2.13,>=2.12->tensorflow-intel==2.12.0->tensorflow) (3.2.2)

```

```

In [2]: import tensorflow as tf
import keras
import numpy as np
import matplotlib.pyplot as plt
from keras.datasets import mnist

```

Get the data and pre-process it

```

In [3]: (x_train, y_train), (x_test, y_test) = mnist.load_data()

```

```

In [4]: x_train.shape , y_train.shape , x_test.shape , y_test.shape

```

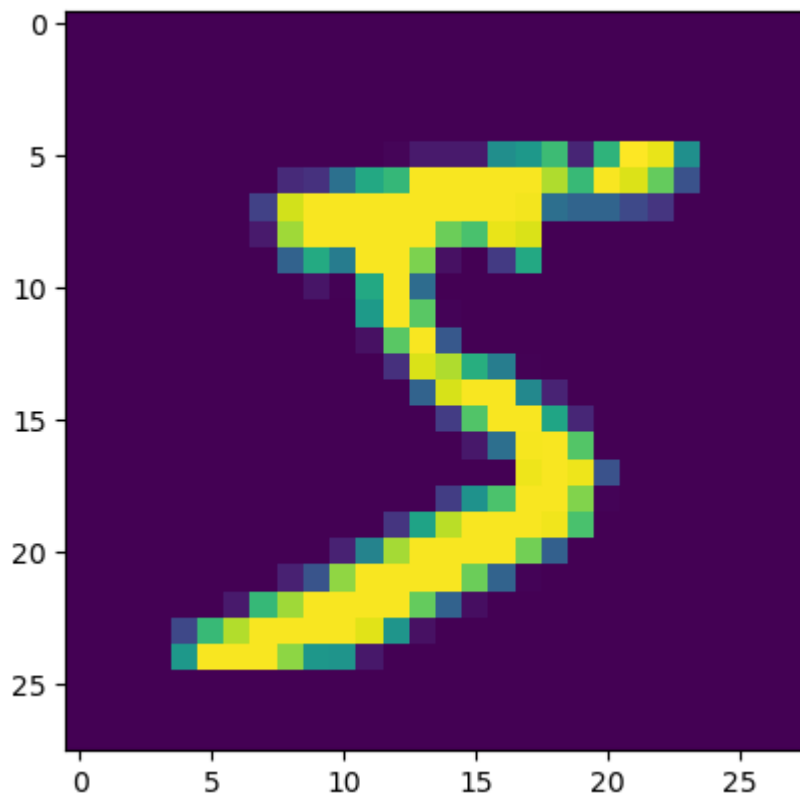
```

Out[4]: ((60000, 28, 28), (60000,), (10000, 28, 28), (10000,))

```

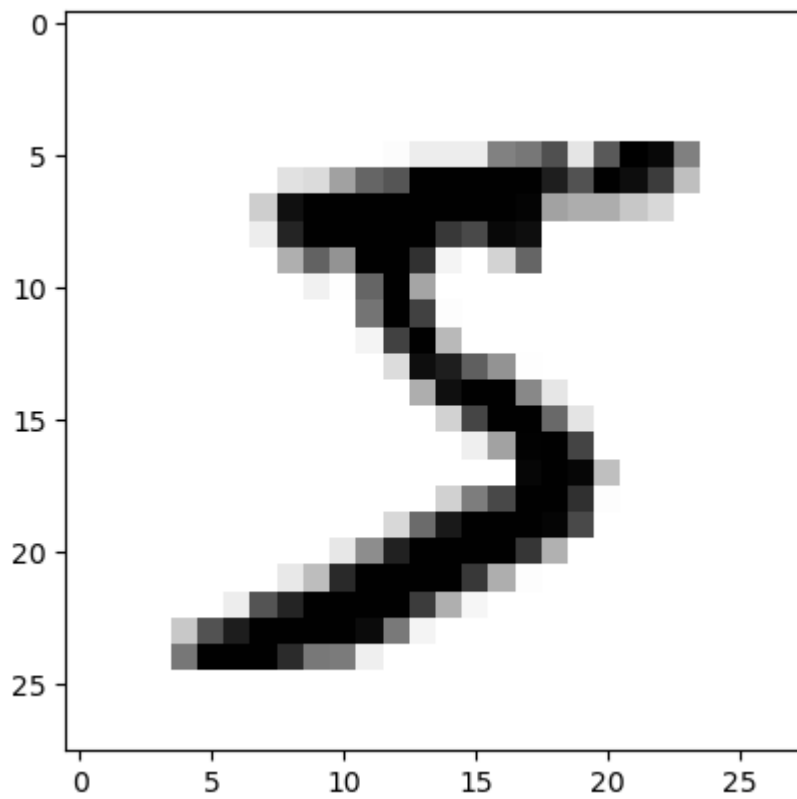
```
In [5]: plt.imshow(x_train[0])
```

```
Out[5]: <matplotlib.image.AxesImage at 0x1a114e66c10>
```



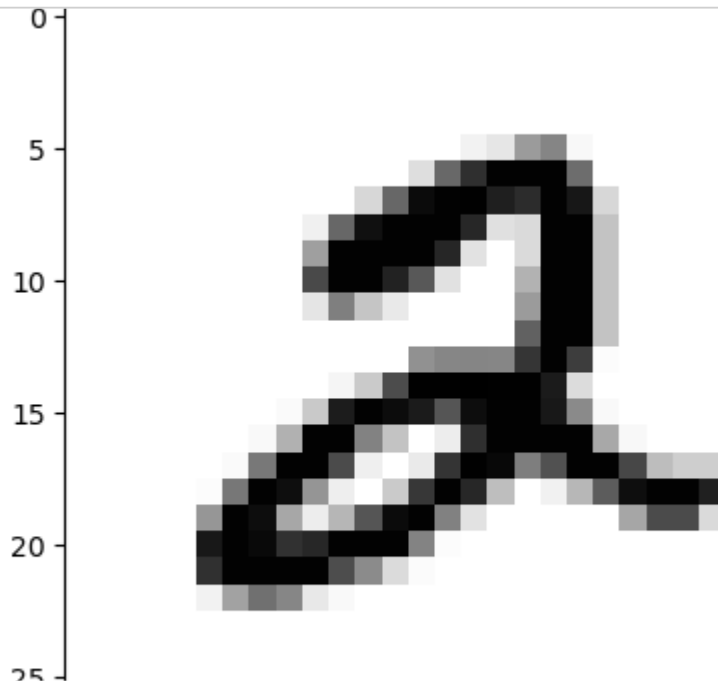
```
In [6]: plt.imshow(x_train[0],cmap='binary')
```

```
Out[6]: <matplotlib.image.AxesImage at 0x1a114eaf310>
```



```
In [7]: def plot_input_img(i):  
    plt.imshow(x_train[i],cmap='binary')  
    plt.title(y_train[i])  
    plt.show()
```

```
In [8]: for i in range(10):  
        plot_input_img(i)
```



Preprocess the images

```
In [9]: # Normalizing the image to [0,1] range  
x_train = x_train.astype(np.float32)/255  
x_test = x_test.astype(np.float32)/255  
## Reshape / expand the dimensions of images to (28,28,1)  
x_train = np.expand_dims(x_train,-1)  
x_test = np.expand_dims(x_test,-1)
```

```
In [10]: x_train.shape
```

```
Out[10]: (60000, 28, 28, 1)
```

```
In [11]: #Convert classes to one hot vectors  
y_train=keras .utils.to_categorical(y_train)  
y_test=keras .utils.to_categorical(y_test)
```

```
In [12]: from keras.models import Sequential  
         from keras.datasets import mnist  
         from keras.layers import Dense,Conv2D,MaxPool2D,Flatten, Dropout
```



```
In [13]: model= Sequential()
model.add(Conv2D(32,(3,3),input_shape=(28,28,1),activation='relu'))
model.add(MaxPool2D((2,2)))
model.add(Conv2D(64,(3,3),activation='relu'))
model.add(MaxPool2D((2,2)))
model.add(Flatten())
model.add(Dropout(0.25))
model.add(Dense(10,activation="softmax"))
```

```
In [14]: model.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Param #
=====		
conv2d (Conv2D)	(None, 26, 26, 32)	320
max_pooling2d (MaxPooling2D)	(None, 13, 13, 32)	0
conv2d_1 (Conv2D)	(None, 11, 11, 64)	18496
max_pooling2d_1 (MaxPooling2D)	(None, 5, 5, 64)	0
flatten (Flatten)	(None, 1600)	0
dropout (Dropout)	(None, 1600)	0
dense (Dense)	(None, 10)	16010
=====		
Total params: 34,826		
Trainable params: 34,826		
Non-trainable params: 0		

```
In [15]: model.compile(optimizer='adam',loss=keras.losses.categorical_crossentropy,metrics=['accuracy'])
```

```
In [16]: ##Callbacks
from keras.callbacks import EarlyStopping,ModelCheckpoint
#Earlystopping
es=EarlyStopping(monitor='val_acc',min_delta=0.01,patience=4,verbose=1)
#Model Check point
mc=ModelCheckpoint("./bestmodel.hs",monitor="val_acc",varbose=1,save_best_only=True)
cb=[es,mc]
```

```
In [*]: his=model.fit(x_train,y_train,epochs=50,validation_split=0.3)
```

Epoch 1/50

1313/1313 [=====] - 36s 26ms/step - loss: 0.1975 - accuracy: 0.9398 - val_loss: 0.0917 - val_accuracy: 0.9727

Epoch 2/50

1313/1313 [=====] - 34s 26ms/step - loss: 0.0634 - accuracy: 0.9802 - val_loss: 0.0651 - val_accuracy: 0.9796

Epoch 3/50

1313/1313 [=====] - 34s 26ms/step - loss: 0.0457 - accuracy: 0.9855 - val_loss: 0.0474 - val_accuracy: 0.9857

Epoch 4/50

1313/1313 [=====] - 34s 26ms/step - loss: 0.0345 - accuracy: 0.9890 - val_loss: 0.0457 - val_accuracy: 0.9863

Epoch 5/50

1313/1313 [=====] - 34s 26ms/step - loss: 0.0270 - accuracy: 0.9920 - val_loss: 0.0470 - val_accuracy: 0.9863

Epoch 6/50

1313/1313 [=====] - 33s 25ms/step - loss: 0.0224 - accuracy: 0.9922 - val_loss: 0.0539 - val_accuracy: 0.9851

Epoch 7/50

1313/1313 [=====] - 38s 29ms/step - loss: 0.0168 - accuracy: 0.9947 - val_loss: 0.0564 - val_accuracy: 0.9849

Epoch 8/50

1227/1313 [=====>..] - ETA: 2s - loss: 0.0144 - accuracy: 0.9948