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

```
Requirement already satisfied: tensorflow in c:\users\tarpi\appdata\local\program
s\python\python312\lib\site-packages (2.18.0)
Requirement already satisfied: tensorflow-intel==2.18.0 in c:\users\tarpi\appdata
\local\programs\python\python312\lib\site-packages (from tensorflow) (2.18.0)
Requirement already satisfied: absl-py>=1.0.0 in c:\users\tarpi\appdata\local\pro
grams\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->tensorfl
ow) (2.1.0)
Requirement already satisfied: astunparse>=1.6.0 in c:\users\tarpi\appdata\local
\programs\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->tens
orflow) (1.6.3)
Requirement already satisfied: flatbuffers>=24.3.25 in c:\users\tarpi\appdata\loc
al\programs\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->te
nsorflow) (24.3.25)
Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in c:\users\ta
rpi\appdata\local\programs\python\python312\lib\site-packages (from tensorflow-in
tel==2.18.0->tensorflow) (0.6.0)
Requirement already satisfied: google-pasta>=0.1.1 in c:\users\tarpi\appdata\loca
l\programs\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->ten
sorflow) (0.2.0)
Requirement already satisfied: libclang>=13.0.0 in c:\users\tarpi\appdata\local\p
rograms\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->tensor
flow) (18.1.1)
Requirement already satisfied: opt-einsum>=2.3.2 in c:\users\tarpi\appdata\local
\programs\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->tens
orflow) (3.4.0)
Requirement already satisfied: packaging in c:\users\tarpi\appdata\local\programs
\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->tensorflow)
(24.1)
Requirement already satisfied: protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.2
1.4,!=4.21.5,<6.0.0dev,>=3.20.3 in c:\users\tarpi\appdata\local\programs\python\p
ython312\lib\site-packages (from tensorflow-intel==2.18.0->tensorflow) (5.27.4)
Requirement already satisfied: requests<3,>=2.21.0 in c:\users\tarpi\appdata\loca
l\programs\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->ten
sorflow) (2.32.3)
Requirement already satisfied: setuptools in c:\users\tarpi\appdata\local\program
s\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->tensorflow)
(70.1.0)
Requirement already satisfied: six>=1.12.0 in c:\users\tarpi\appdata\local\progra
ms\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->tensorflow)
(1.16.0)
Requirement already satisfied: termcolor>=1.1.0 in c:\users\tarpi\appdata\local\p
rograms\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->tensor
flow) (2.5.0)
Requirement already satisfied: typing-extensions>=3.6.6 in c:\users\tarpi\appdata
\local\programs\python\python312\lib\site-packages (from tensorflow-intel==2.18.0
->tensorflow) (4.12.2)
Requirement already satisfied: wrapt>=1.11.0 in c:\users\tarpi\appdata\local\prog
rams\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->tensorflo
w) (1.16.0)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in c:\users\tarpi\appdata\loca
l\programs\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->ten
sorflow) (1.67.1)
Requirement already satisfied: tensorboard<2.19,>=2.18 in c:\users\tarpi\appdata
\local\programs\python\python312\lib\site-packages (from tensorflow-intel==2.18.0
->tensorflow) (2.18.0)
Requirement already satisfied: keras>=3.5.0 in c:\users\tarpi\appdata\local\progr
ams\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->tensorflo
w) (3.6.0)
Requirement already satisfied: numpy<2.1.0,>=1.26.0 in c:\users\tarpi\appdata\loc
al\programs\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->te
```

```
nsorflow) (1.26.4)
Requirement already satisfied: h5py>=3.11.0 in c:\users\tarpi\appdata\local\progr
ams\python\python312\lib\site-packages (from tensorflow-intel==2.18.0->tensorflo
w) (3.12.1)
Requirement already satisfied: ml-dtypes<0.5.0,>=0.4.0 in c:\users\tarpi\appdata
\local\programs\python\python312\lib\site-packages (from tensorflow-intel==2.18.0
->tensorflow) (0.4.1)
Requirement already satisfied: wheel<1.0,>=0.23.0 in c:\users\tarpi\appdata\local
\programs\python\python312\lib\site-packages (from astunparse>=1.6.0->tensorflow-
intel==2.18.0->tensorflow) (0.45.0)
Requirement already satisfied: rich in c:\users\tarpi\appdata\local\programs\pyth
on\python312\lib\site-packages (from keras>=3.5.0->tensorflow-intel==2.18.0->tens
orflow) (13.8.0)
Requirement already satisfied: namex in c:\users\tarpi\appdata\local\programs\pyt
hon\python312\lib\site-packages (from keras>=3.5.0->tensorflow-intel==2.18.0->ten
sorflow) (0.0.8)
Requirement already satisfied: optree in c:\users\tarpi\appdata\local\programs\py
thon\python312\lib\site-packages (from keras>=3.5.0->tensorflow-intel==2.18.0->te
nsorflow) (0.13.1)
Requirement already satisfied: charset-normalizer<4,>=2 in c:\users\tarpi\appdata
\local\programs\python\python312\lib\site-packages (from requests<3,>=2.21.0->ten
sorflow-intel==2.18.0->tensorflow) (3.3.2)
Requirement already satisfied: idna<4,>=2.5 in c:\users\tarpi\appdata\local\progr
ams\python\python312\lib\site-packages (from requests<3,>=2.21.0->tensorflow-inte
l==2.18.0->tensorflow) (3.7)
Requirement already satisfied: urllib3<3,>=1.21.1 in c:\users\tarpi\appdata\local
\programs\python\python312\lib\site-packages (from requests<3,>=2.21.0->tensorflo
w-intel==2.18.0->tensorflow) (2.2.2)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\tarpi\appdata\local
\programs\python\python312\lib\site-packages (from requests<3,>=2.21.0->tensorflo
w-intel==2.18.0->tensorflow) (2024.6.2)
Requirement already satisfied: markdown>=2.6.8 in c:\users\tarpi\appdata\local\pr
ograms\python\python312\lib\site-packages (from tensorboard<2.19,>=2.18->tensorfl
ow-intel==2.18.0->tensorflow) (3.7)
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in c:\users
\tarpi\appdata\local\programs\python\python312\lib\site-packages (from tensorboar
d<2.19,>=2.18->tensorflow-intel==2.18.0->tensorflow) (0.7.2)
Requirement already satisfied: werkzeug>=1.0.1 in c:\users\tarpi\appdata\local\pr
ograms\python\python312\lib\site-packages (from tensorboard<2.19,>=2.18->tensorfl
ow-intel==2.18.0->tensorflow) (3.0.3)
Requirement already satisfied: MarkupSafe>=2.1.1 in c:\users\tarpi\appdata\local
\programs\python\python312\lib\site-packages (from werkzeug>=1.0.1->tensorboard<
2.19,>=2.18->tensorflow-intel==2.18.0->tensorflow) (2.1.5)
Requirement already satisfied: markdown-it-py>=2.2.0 in c:\users\tarpi\appdata\lo
cal\programs\python\python312\lib\site-packages (from rich->keras>=3.5.0->tensorf
low-intel==2.18.0->tensorflow) (3.0.0)
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in c:\users\tarpi\appdata
\local\programs\python\python312\lib\site-packages (from rich->keras>=3.5.0->tens
orflow-intel==2.18.0->tensorflow) (2.18.0)
Requirement already satisfied: mdurl~=0.1 in c:\users\tarpi\appdata\local\program
s\python\python312\lib\site-packages (from markdown-it-py>=2.2.0->rich->keras>=3.
5.0->tensorflow-intel==2.18.0->tensorflow) (0.1.2)
Note: you may need to restart the kernel to use updated packages.
```

In [2]:
```
import tensorflow as tf
```

In [3]:
```
print("TensorFlow version:", tf.__version__)
print("Keras version:", tf.keras.__version__)
```

```
TensorFlow version: 2.18.0
Keras version: 3.6.0
```

In [4]:
```
import pandas as pd

df = pd.read_csv("wine.csv")
print(df.shape)
```

```
(1599, 12)
```

In [5]:
```
df.isnull().sum()
```

Out[5]:
```
fixed acidity           0
volatile acidity        0
citric acid             0
residual sugar          0
chlorides               0
free sulfur dioxide     0
total sulfur dioxide    0
density                 0
pH                      0
sulphates               0
alcohol                 0
quality                 0
dtype: int64
```

In [6]:
```
df.dtypes
```

Out[6]:
```
fixed acidity           float64
volatile acidity        float64
citric acid             float64
residual sugar          float64
chlorides               float64
free sulfur dioxide     float64
total sulfur dioxide    float64
density                 float64
pH                      float64
sulphates               float64
alcohol                 float64
quality                  object
dtype: object
```

In [7]:
```
df
```

Out[7]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulph
0	7.4	0.700	0.00	1.9	0.076	11.0	34.0	0.99780	3.51	
1	7.8	0.880	0.00	2.6	0.098	25.0	67.0	0.99680	3.20	
2	7.8	0.760	0.04	2.3	0.092	15.0	54.0	0.99700	3.26	
3	11.2	0.280	0.56	1.9	0.075	17.0	60.0	0.99800	3.16	
4	7.4	0.700	0.00	1.9	0.076	11.0	34.0	0.99780	3.51	
...	...	...	...	...	...	...	...	...	...	
1594	6.2	0.600	0.08	2.0	0.090	32.0	44.0	0.99490	3.45	
1595	5.9	0.550	0.10	2.2	0.062	39.0	51.0	0.99512	3.52	
1596	6.3	0.510	0.13	2.3	0.076	29.0	40.0	0.99574	3.42	
1597	5.9	0.645	0.12	2.0	0.075	32.0	44.0	0.99547	3.57	
1598	6.0	0.310	0.47	3.6	0.067	18.0	42.0	0.99549	3.39	

1599 rows × 12 columns

In [8]:
```
df['quality'].unique()
```

Out[8]:
```
array(['bad', 'good'], dtype=object)
```

In [9]:
```
from sklearn.preprocessing import LabelEncoder
encoder = LabelEncoder()
df['quality'] = encoder.fit_transform(df['quality'])
```

In [10]:
```
df['quality']
```

Out[10]:
```
0       0
1       0
2       0
3       1
4       0
       ..
1594    0
1595    1
1596    1
1597    0
1598    1
Name: quality, Length: 1599, dtype: int32
```

In [11]:
```
x = df.drop(columns=['quality'])
y = df['quality']
```

In [12]:
```
from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test = train_test_split(x,y,test_size=0.2,random_state=
x_train,x_valid,y_train,y_valid = train_test_split(x_train,y_train,test_size=0.2
print("Training data dimensions:", x_train.shape)
```

```
print("Validation data dimensions:", x_valid.shape)
print("Test data dimensions:", x_test.shape)
```

```
Training data dimensions: (1023, 11)
Validation data dimensions: (256, 11)
Test data dimensions: (320, 11)
```

In [13]:
```
from sklearn.preprocessing import StandardScaler

scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(x_train)
X_val_scaled = scaler.transform(x_valid)
X_test_scaled = scaler.transform(x_test)
```

In [14]:
```
from tensorflow.keras import layers
model = tf.keras.Sequential([
    layers.Dense(64,activation='relu',input_dim = X_train_scaled.shape[1]),
    layers.Dense(32,activation='relu'),
    layers.Dense(1,activation='sigmoid')
])
```

```
c:\Users\tarpi\AppData\Local\Programs\Python\Python312\Lib\site-packages\keras\src\layers\core\dense.py:87: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

In [15]:
```
from tensorflow.keras.callbacks import TensorBoard

# Define the TensorBoard callback
tensorboard_callback = TensorBoard(log_dir='./logs', histogram_freq=1)
```

In [16]:
```
from tensorflow.keras.callbacks import EarlyStopping

# EarlyStopping callback
early_stopping_callback = EarlyStopping(monitor='val_loss', patience=10, restore
```

In [20]:
```
from tensorflow.keras.callbacks import ModelCheckpoint

# Define the ModelCheckpoint callback
checkpoint_callback = ModelCheckpoint(
    filepath='best_model.keras',  # Path to save the model
    monitor='val_loss',       # Metric to monitor
    save_best_only=True       # Save only the best model
)
```

In [21]:
```
model.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Param #
dense (Dense)	(None, 64)	768
dense_1 (Dense)	(None, 32)	2,080
dense_2 (Dense)	(None, 1)	33

Total params: 2,881 (11.25 KB)

Trainable params: 2,881 (11.25 KB)

Non-trainable params: 0 (0.00 B)

In [22]:
```
# Compile the model
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy']
```

In [24]:
```
# Fit the model with the callbacks
history = model.fit(
    X_train_scaled, y_train,
    epochs=100,
    batch_size=32,
    validation_data=(X_val_scaled, y_valid),
    callbacks=[tensorboard_callback, early_stopping_callback, checkpoint_callbac
)
```

```
Epoch 1/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 2s 15ms/step - accuracy: 0.4809 - loss: 0.7008 - val_a
ccuracy: 0.6953 - val_loss: 0.6150
Epoch 2/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step - accuracy: 0.7302 - loss: 0.5709 - val_ac
curacy: 0.7461 - val_loss: 0.5600
Epoch 3/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step - accuracy: 0.7335 - loss: 0.5200 - val_ac
curacy: 0.7539 - val_loss: 0.5454
Epoch 4/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.7463 - loss: 0.5078 - val_ac
curacy: 0.7578 - val_loss: 0.5447
Epoch 5/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.7514 - loss: 0.4989 - val_ac
curacy: 0.7695 - val_loss: 0.5311
Epoch 6/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.7699 - loss: 0.4736 - val_ac
curacy: 0.7812 - val_loss: 0.5334
Epoch 7/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.7771 - loss: 0.4699 - val_ac
curacy: 0.7812 - val_loss: 0.5352
Epoch 8/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.7715 - loss: 0.4680 - val_ac
curacy: 0.7812 - val_loss: 0.5286
Epoch 9/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.7643 - loss: 0.4576 - val_ac
curacy: 0.7852 - val_loss: 0.5276
Epoch 10/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.7722 - loss: 0.4711 - val_ac
curacy: 0.7695 - val_loss: 0.5250
Epoch 11/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.7988 - loss: 0.4464 - val_ac
curacy: 0.7773 - val_loss: 0.5275
Epoch 12/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.7736 - loss: 0.4460 - val_ac
curacy: 0.7734 - val_loss: 0.5337
Epoch 13/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.7636 - loss: 0.4560 - val_ac
curacy: 0.7852 - val_loss: 0.5263
Epoch 14/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.7688 - loss: 0.4621 - val_ac
curacy: 0.7773 - val_loss: 0.5323
Epoch 15/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.7748 - loss: 0.4574 - val_ac
curacy: 0.7852 - val_loss: 0.5360
Epoch 16/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.7745 - loss: 0.4607 - val_ac
curacy: 0.7812 - val_loss: 0.5348
Epoch 17/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.7815 - loss: 0.4503 - val_ac
curacy: 0.7812 - val_loss: 0.5355
Epoch 18/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.7991 - loss: 0.4212 - val_ac
curacy: 0.7617 - val_loss: 0.5419
Epoch 19/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.7970 - loss: 0.4221 - val_ac
curacy: 0.7734 - val_loss: 0.5382
Epoch 20/100
32/32 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.7817 - loss: 0.4460 - val_ac
curacy: 0.7773 - val_loss: 0.5338
```

In [25]:
```
# Get the model's parameters (weights and biases)
model_params = model.get_weights()
print("Model parameters:", model_params)
```

```
Model parameters: [array([[ 0.0455909 , -0.2613523 , -0.16469033,  0.25747868,
0.07900122,
        -0.06818879,  0.25334254, -0.2281851 ,  0.24688764,  0.0513058 ,
        -0.14542711, -0.2516201 , -0.10569511,  0.11557723,  0.14764872,
         0.25776598, -0.2205724 ,  0.01453421, -0.00660318,  0.01370211,
        -0.23418418,  0.07420379,  0.19866684, -0.12607741,  0.22923297,
         0.13318272,  0.02428265, -0.2599732 , -0.07241066,  0.24569498,
        -0.21626179, -0.00526786, -0.22416115,  0.23564528,  0.23958187,
         0.13390344, -0.2900923 ,  0.02762399, -0.15228908,  0.0639738 ,
        -0.26338455,  0.15969877, -0.0019689 ,  0.04468832,  0.13906907,
        -0.09296207,  0.00783422,  0.06917532,  0.24741833,  0.17124291,
        -0.09642583,  0.18243472, -0.04799188,  0.13962114,  0.16478112,
         0.28124812,  0.09541534,  0.23837641,  0.25976458, -0.2404207 ,
        -0.2733864 , -0.02215098, -0.16017658,  0.0454437 ],
       [ 0.23518994, -0.19807972, -0.19742298,  0.1473825 , -0.28987598,
         0.03494297, -0.30227488,  0.21995756, -0.02636124, -0.2091777 ,
        -0.1314193 , -0.00477603,  0.22959419, -0.24651027, -0.08402471,
        -0.15693907, -0.21184498,  0.13562626, -0.02717484, -0.1765222 ,
         0.03761206, -0.24526252,  0.06100202,  0.07107606, -0.02029228,
        -0.12092665, -0.17765005,  0.03960975,  0.11063071,  0.03072313,
        -0.13416001,  0.08002871,  0.18278591,  0.05904222,  0.15822938,
        -0.09497082,  0.22727728, -0.03430969,  0.24095125,  0.15551443,
         0.28045395, -0.21590061,  0.05847417,  0.03241823, -0.03268919,
         0.04110063, -0.08425414, -0.02311478,  0.03627575,  0.09391899,
        -0.31261867, -0.04943141, -0.15953673,  0.19369744,  0.27964765,
         0.13692355,  0.20985058,  0.06552616,  0.216845  ,  0.26728642,
        -0.04874385,  0.23974274,  0.16012041, -0.10406253],
       [-0.02961336,  0.3135237 , -0.09188004,  0.09931439,  0.05896747,
         0.15109672, -0.27076426, -0.04315162,  0.2198645 ,  0.2744653 ,
        -0.27524272,  0.1264555 , -0.2206231 ,  0.07832842, -0.04146848,
         0.19513415,  0.2090387 ,  0.12797   , -0.15076452,  0.20210129,
         0.12388225,  0.32691678,  0.06946606, -0.14664787, -0.21855019,
        -0.25343156, -0.03047119,  0.17845616, -0.06060734,  0.16521166,
         0.20714584,  0.24900936, -0.15801266,  0.08893349, -0.06060553,
        -0.2514172 , -0.13218978,  0.03064767,  0.21185264, -0.04471546,
        -0.11990424, -0.30259433,  0.17385626, -0.00421009,  0.16755438,
        -0.26372305,  0.16496328, -0.04309115, -0.0350754 ,  0.1630242 ,
         0.03794766,  0.08164404, -0.18856043, -0.1885305 , -0.1652108 ,
         0.15343079,  0.27881798,  0.15987046,  0.20784137,  0.1315052 ,
         0.21848011,  0.21582289, -0.13926458,  0.04170069],
       [ 0.28780812, -0.03786569,  0.22184071, -0.15823907, -0.05237747,
        -0.13595495, -0.06607293,  0.13434145, -0.06242744,  0.27073908,
        -0.00976227,  0.27591085,  0.01737395,  0.2774447 ,  0.26057294,
        -0.20918085,  0.00351144, -0.18320444, -0.10728009,  0.06262261,
         0.23192377, -0.07891189, -0.2074818 , -0.06872025,  0.04833085,
        -0.08019623, -0.13837744,  0.01114106,  0.12350097, -0.26478928,
        -0.18940745, -0.1310804 , -0.10146826, -0.18788125,  0.07972601,
         0.18028279, -0.13130172, -0.2747514 , -0.03910989,  0.08604535,
        -0.00633215, -0.03500395,  0.03901118, -0.10194347, -0.01334469,
         0.16240808,  0.10608586,  0.26589596, -0.15581568,  0.14418721,
        -0.27212054,  0.06729291,  0.06880697,  0.07610951,  0.17408612,
         0.05189034,  0.06753704, -0.20082562,  0.1997    ,  0.2553833 ,
         0.05167256, -0.04430104, -0.22230552,  0.10550608],
       [ 0.21124266, -0.23861137,  0.26070327, -0.17393734,  0.0652309 ,
         0.28308517, -0.12787518,  0.02801233, -0.07103281,  0.10006834,
         0.19000477,  0.12306066,  0.01849688,  0.28515097, -0.30153793,
        -0.00176893, -0.1038177 , -0.14467423, -0.21357389,  0.07237007,
         0.16379301, -0.01407706,  0.27273056,  0.08115458, -0.25388598,
        -0.21035482, -0.2058353 , -0.27860537,  0.13649015, -0.13775414,
        -0.04275607,  0.05243411, -0.22690026, -0.21835975, -0.21166775,
```

```
  0.1876934 , -0.06595476,  0.05736166, -0.06457245, -0.18009917,
  0.2499033 ,  0.02656066,  0.1997333 , -0.2582929 , -0.15777291,
  0.27920973,  0.25897175,  0.21465787,  0.14197575, -0.14639853,
 -0.15739946,  0.17179337, -0.15765019,  0.21491244,  0.00489028,
 -0.18973528,  0.13145359, -0.15579039,  0.09843222,  0.20297623,
  0.12387305, -0.04329624,  0.04142902,  0.11131071],
[-0.07016955, -0.1617391 ,  0.00437327,  0.21062131, -0.1940078 ,
  0.21132983,  0.12391274, -0.00944802, -0.0359631 , -0.15417011,
  0.07649442,  0.17897607, -0.06506521,  0.29473144, -0.00106856,
 -0.13725215,  0.19854936,  0.19548428,  0.22843656,  0.19090149,
  0.2658535 , -0.1260797 , -0.02011314,  0.24207447, -0.3131682 ,
  0.13758612, -0.00090067, -0.31941321,  0.09239575,  0.10462625,
 -0.1589565 ,  0.07988171, -0.17167027,  0.20336959, -0.26411083,
  0.0507432 , -0.12891293, -0.05998676, -0.25437647, -0.09937578,
 -0.02718652,  0.10910209,  0.01812348,  0.16823792, -0.1884016 ,
  0.16551436,  0.08526715, -0.11785964, -0.17241064,  0.13003933,
 -0.2755901 ,  0.10823845, -0.08710425, -0.04276298,  0.22288434,
  0.04411649,  0.0016295 ,  0.15145394,  0.17450912,  0.17649552,
  0.2569875 ,  0.04430935, -0.13813575,  0.24239282],
[-0.2941237 ,  0.2785069 ,  0.2064631 ,  0.01572031, -0.17685793,
 -0.05675457, -0.0125469 ,  0.13402477,  0.21580854, -0.09406304,
  0.0370644 ,  0.1877382 ,  0.08174387, -0.14019315, -0.19018306,
  0.2520642 , -0.02101713,  0.07383719, -0.03039247,  0.22901343,
  0.21489196, -0.22682844,  0.01208977, -0.0494329 , -0.17469332,
  0.23909338,  0.0982971 ,  0.08880139, -0.14364308, -0.05970851,
  0.16632396,  0.04078849,  0.17808716, -0.28473693,  0.03621225,
 -0.05111776,  0.17359267,  0.24901211, -0.1580332 ,  0.08927251,
 -0.18053517, -0.33482268, -0.05173531,  0.09185692,  0.2862997 ,
 -0.08732662, -0.10140744, -0.24990278,  0.07662789,  0.24174374,
  0.11304376,  0.16518842, -0.29681703,  0.27353096, -0.28563032,
  0.07382577,  0.07421682,  0.01851081, -0.09457166,  0.25713226,
 -0.11514678, -0.1561355 ,  0.01666341,  0.27870792],
[ 0.06769143,  0.10581334,  0.29176936,  0.07478901, -0.10683031,
 -0.1770085 , -0.12805119,  0.03040375,  0.12994769,  0.22118586,
 -0.2295873 ,  0.19968598, -0.03875319,  0.12692535,  0.08052212,
 -0.06312236, -0.27103812,  0.25885344, -0.23521689,  0.04947055,
 -0.18373147, -0.03396001, -0.08466689, -0.06690974,  0.2693808 ,
  0.07206696, -0.23278926,  0.14620797, -0.11704487, -0.1448335 ,
 -0.27157867,  0.00113586, -0.05639987,  0.04361619, -0.13568108,
  0.03383395,  0.19192018,  0.16136272, -0.00527689, -0.15951262,
  0.02875259,  0.06971148, -0.06515244,  0.27382576, -0.05057034,
 -0.05188619, -0.29284012, -0.07534444,  0.22970659, -0.11354873,
 -0.13251336, -0.05440576, -0.21927622, -0.06864843, -0.04462207,
 -0.22164729,  0.22372386, -0.06378368,  0.01745862, -0.16317725,
 -0.17663147,  0.12637612, -0.13213126,  0.02703644],
[ 0.33385834,  0.06650735,  0.18534262, -0.2840767 ,  0.04836031,
 -0.21510395,  0.17802073, -0.21024083,  0.21371172,  0.23850834,
 -0.12807563,  0.18965675,  0.11005844, -0.07621224,  0.01142492,
  0.16667144, -0.208463  , -0.12248529,  0.01324144, -0.22950278,
  0.14085764, -0.21394467, -0.13982911, -0.2547483 , -0.2857298 ,
  0.2826952 ,  0.01068516,  0.06385898, -0.08132758,  0.2106635 ,
 -0.10038956,  0.18889998, -0.09647033, -0.05346303,  0.04250821,
 -0.23656309,  0.07438383, -0.18428357,  0.25379294, -0.29002485,
  0.19300304,  0.23315272, -0.15244992, -0.23544145, -0.06968082,
 -0.04814653, -0.00551017,  0.2620859 , -0.15433882,  0.02130239,
  0.14891416,  0.06448945, -0.2226119 , -0.09365339,  0.17489855,
 -0.17026748,  0.21641555, -0.17749639, -0.1140952 , -0.05848356,
  0.19308898, -0.18387264, -0.264337  , -0.1891974 ],
[-0.30195683, -0.277343  , -0.11260252, -0.19208014,  0.04632489,
 -0.1628301 ,  0.29258853,  0.01163228, -0.30279496, -0.15919071,
```

```
          0.13099107,  0.21203244, -0.08724998, -0.12790044,  0.13532309,
         -0.28241146,  0.04885739, -0.2206636 , -0.08775835, -0.19118592,
          0.00559055, -0.0043945 , -0.08236115, -0.09240491, -0.26003262,
          0.2598181 , -0.218094  , -0.38423488,  0.23752795, -0.15179875,
          0.3344297 , -0.05974888,  0.15032461, -0.01515011, -0.31608927,
         -0.12655325, -0.32654145,  0.20876428, -0.21772015,  0.09576156,
         -0.2829315 ,  0.1741738 , -0.017183  ,  0.2406275 , -0.16455661,
          0.19313537, -0.01985446,  0.14746688, -0.23914874,  0.19074467,
         -0.0972278 ,  0.01387208, -0.15939887,  0.12790614, -0.22160745,
         -0.15410958,  0.31581527,  0.20004968, -0.14627494, -0.0089634 ,
         -0.08546514,  0.11861269,  0.18839008,  0.23400988],
        [ 0.18058117, -0.16079839,  0.17977636, -0.30878836, -0.19940768,
          0.1584246 , -0.01182572, -0.188043  , -0.16879946,  0.3114908 ,
         -0.1505246 , -0.2075168 , -0.05905503,  0.21571422, -0.27598986,
          0.0748008 , -0.08885375, -0.07797983,  0.26987183, -0.2208808 ,
          0.23273295,  0.31219667, -0.2474494 , -0.14409772,  0.07865633,
         -0.16108236,  0.19566922,  0.12421945,  0.06772655,  0.24633737,
          0.4218604 ,  0.15906653, -0.00682672,  0.28042853, -0.17269795,
          0.10587087,  0.08859328,  0.23865479, -0.18553081,  0.3178732 ,
          0.16684683,  0.3264665 ,  0.02520182,  0.11007605,  0.17677096,
          0.34004104, -0.15373729,  0.1755972 ,  0.10533071,  0.12764388,
         -0.0383264 ,  0.08255145, -0.1258623 , -0.09328399,  0.11378769,
          0.10711434,  0.23410732,  0.23015319,  0.26110893, -0.38358402,
          0.08445591, -0.16845359,  0.07942922, -0.2453724 ]],
       dtype=float32), array([ 0.00448612,  0.0005645 , -0.04497583, -0.004732  ,
0.04228575,
         0.04996926,  0.12358782,  0.03489493,  0.06471246,  0.00515073,
         0.005071  , -0.03485748, -0.00763997,  0.00145413, -0.01888343,
        -0.05073709, -0.03298131, -0.03172688, -0.01388086, -0.01082975,
         0.05719258,  0.07587177,  0.01972931, -0.01000294,  0.05692729,
        -0.03492251,  0.00247024,  0.0289649 ,  0.1178323 ,  0.0030075 ,
         0.08472206, -0.00420412, -0.04284465,  0.05625653,  0.01407852,
        -0.05030031, -0.04114263,  0.0264356 ,  0.02935652,  0.04877984,
        -0.04369634,  0.11943266, -0.00617497,  0.03679795, -0.05770929,
        -0.0188814 , -0.05641283,  0.0437349 , -0.06383646,  0.03064828,
        -0.03589769,  0.04477007,  0.00571063,  0.0149363 ,  0.01980837,
        -0.02832933,  0.03549065,  0.0636043 ,  0.00536977,  0.0517955 ,
        -0.03967901, -0.01007346,  0.0304575 , -0.04045224], dtype=float32), array
([[-0.13314342, -0.01590801,  0.00712414, ...,  0.18306638,
         -0.04147108, -0.0298831 ],
        [-0.19104902, -0.17384806, -0.06815369, ..., -0.11783163,
          0.08022851,  0.23316698],
        [ 0.27403688,  0.21777435, -0.2208577 , ..., -0.10673349,
          0.02738874,  0.1957516 ],
        ...,
        [-0.20135875,  0.11001708, -0.24004559, ...,  0.21789236,
          0.04300056, -0.15642363],
        [ 0.14941229,  0.03473527, -0.22741638, ..., -0.02700841,
         -0.17975922, -0.04451101],
        [-0.18464461, -0.12875047,  0.10288469, ..., -0.22377732,
          0.08517078,  0.01629572]], dtype=float32), array([ 0.09123158,  0.001432
06,  0.0307738 ,  0.0678304 ,  0.0703734 ,
         0.01364454,  0.05360002,  0.00296734, -0.00654276,  0.0212737 ,
         0.01071163, -0.03197084,  0.02728394,  0.01711101,  0.07160128,
         0.00061575,  0.04699316, -0.03374936,  0.09602843, -0.05210454,
         0.05694572,  0.00161194, -0.00453596, -0.01758465,  0.0463166 ,
         0.08353598,  0.00321005,  0.06553409, -0.01865472,  0.04960533,
         0.0275596 , -0.02044683], dtype=float32), array([[ 0.11388243],
        [ 0.2374851 ],
        [-0.20863886],
```

```
       [ 0.15251306],
       [ 0.21842872],
       [-0.4808954 ],
       [ 0.3657866 ],
       [-0.07629909],
       [ 0.08272406],
       [ 0.46717754],
       [ 0.33272073],
       [-0.09698314],
       [-0.22368625],
       [ 0.38138372],
       [ 0.2842798 ],
       [-0.41498855],
       [ 0.03466677],
       [-0.35882175],
       [ 0.37588826],
       [-0.35584483],
       [ 0.46586576],
       [-0.4097346 ],
       [-0.4349258 ],
       [-0.20229822],
       [ 0.4151654 ],
       [ 0.21910124],
       [-0.24373327],
       [ 0.26411948],
       [-0.36202368],
       [ 0.29284132],
       [-0.49576575],
       [-0.14093001]], dtype=float32), array([0.02808232], dtype=float32)]
```

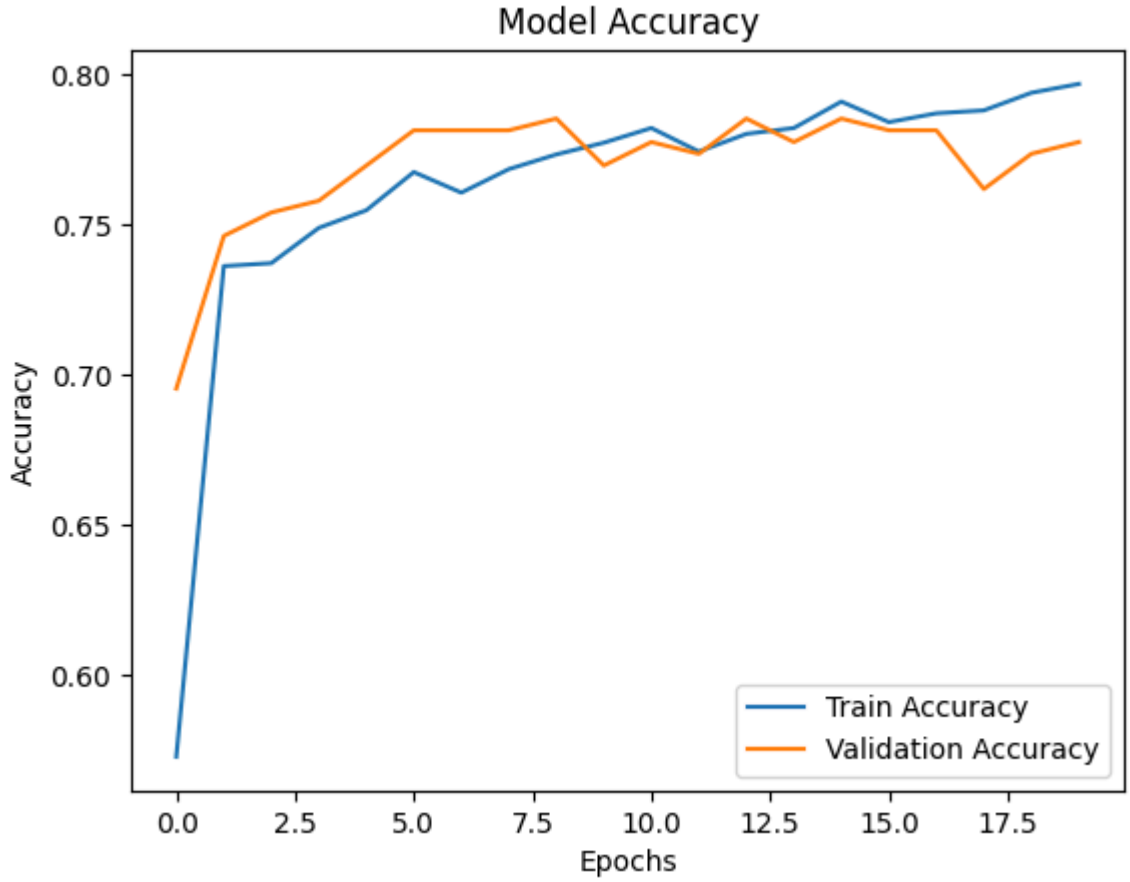
In [26]:
```python
# Convert training history to a DataFrame
history_df = pd.DataFrame(history.history)
print(history_df.head())
```

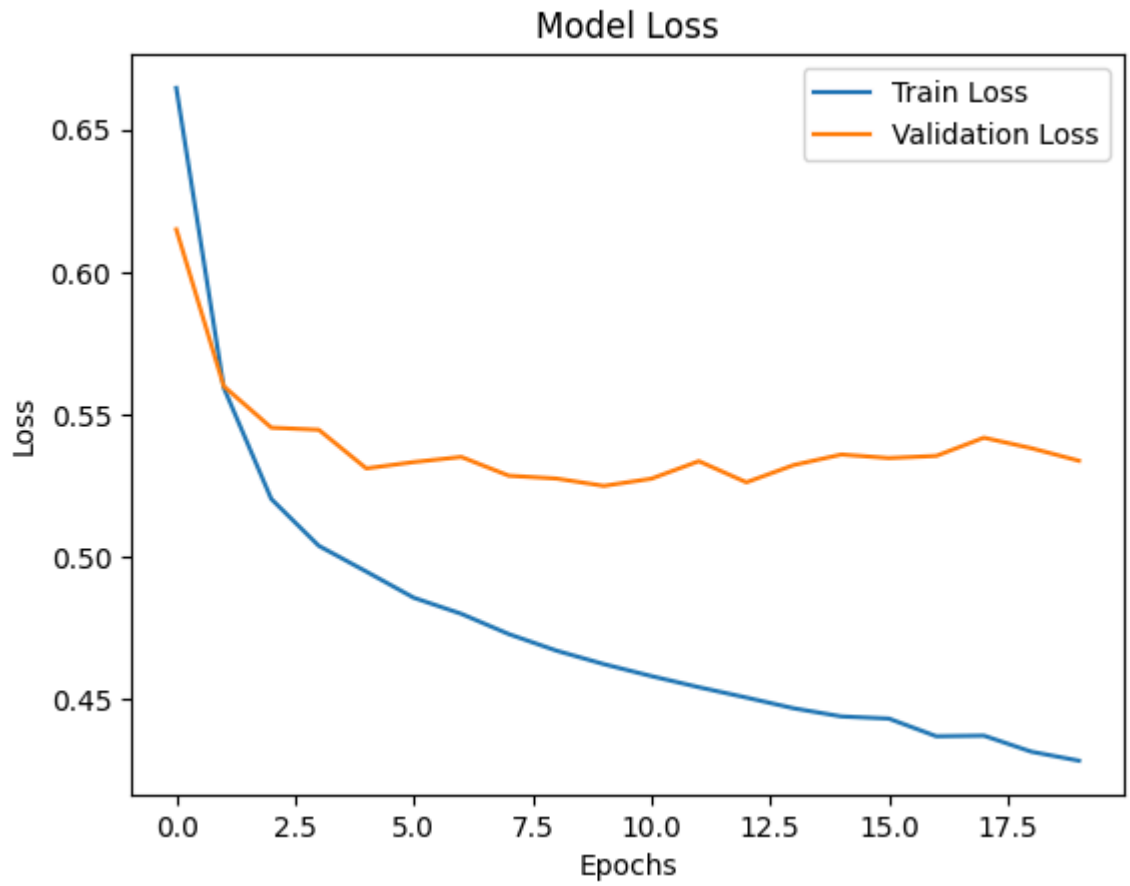
```
   accuracy      loss  val_accuracy  val_loss
0  0.572825  0.664629      0.695312  0.615001
1  0.736070  0.559410      0.746094  0.559952
2  0.737048  0.520419      0.753906  0.545445
3  0.748778  0.503992      0.757812  0.544699
4  0.754643  0.494959      0.769531  0.531149
```

In [27]:
```python
import matplotlib.pyplot as plt

# Plot training & validation accuracy values
plt.plot(history_df['accuracy'], label='Train Accuracy')
plt.plot(history_df['val_accuracy'], label='Validation Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.title('Model Accuracy')
plt.legend(loc='best')
plt.show()

# Plot training & validation loss values
plt.plot(history_df['loss'], label='Train Loss')
plt.plot(history_df['val_loss'], label='Validation Loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.title('Model Loss')
plt.legend(loc='best')
plt.show()
```





In [28]:
```
# Evaluate the model on the test data
test_loss, test_accuracy = model.evaluate(X_test_scaled, y_test)
print("Test Loss:", test_loss)
print("Test Accuracy:", test_accuracy)
```

```
10/10 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.7429 - loss: 0.4909
Test Loss: 0.4965953230857849
Test Accuracy: 0.746874988079071
```

In [ ]: