lab-3 Binary Classification of Heart Disease of Patients using Deep Neural Network

NAME: Annapoornima S

225229101

Load Data

In [1]:
```
import pandas as pd
```

In [2]:
```
df = pd.read_csv("heart_data.csv")
```

In [3]:
```
df
```

Out[3]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	ta
0	63	1	3	145	233	1	0	150	0	2.3	0	0	1	
1	37	1	2	130	250	0	1	187	0	3.5	0	0	2	
2	41	0	1	130	204	0	0	172	0	1.4	2	0	2	
3	56	1	1	120	236	0	1	178	0	0.8	2	0	2	
4	57	0	0	120	354	0	1	163	1	0.6	2	0	2	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
298	57	0	0	140	241	0	1	123	1	0.2	1	0	3	
299	45	1	3	110	264	0	1	132	0	1.2	1	0	3	
300	68	1	0	144	193	1	1	141	0	3.4	1	2	3	
301	57	1	0	130	131	0	1	115	1	1.2	1	1	3	
302	57	0	1	130	236	0	0	174	0	0.0	1	1	2	

303 rows × 14 columns

In [5]:
```
df.describe()
```

Out[5]:

	age	sex	cp	trestbps	chol	fbs	restecg
count	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000
mean	54.366337	0.683168	0.966997	131.623762	246.264026	0.148515	0.528053
std	9.082101	0.466011	1.032052	17.538143	51.830751	0.356198	0.525860
min	29.000000	0.000000	0.000000	94.000000	126.000000	0.000000	0.000000
25%	47.500000	0.000000	0.000000	120.000000	211.000000	0.000000	0.000000
50%	55.000000	1.000000	1.000000	130.000000	240.000000	0.000000	1.000000
75%	61.000000	1.000000	2.000000	140.000000	274.500000	0.000000	1.000000
max	77.000000	1.000000	3.000000	200.000000	564.000000	1.000000	2.000000

In [10]:
```
df.value_counts()
```

Out[10]:
```
age  sex  cp  trestbps  chol  fbs  restecg  thalach  exang  oldpeak  slope
ca  thal  target
38   1    2   138       175   0    1        173      0      0.0      2
4   2     1         2
59   1    0   110       239   0    0        142      1      1.2      1
1   3     0         1
                2   126       218   1    1        134      0      2.2      1
1   1     0         1
                1   140       221   0    1        164      1      0.0      2
0   2     1         1
                0   170       326   0    0        140      1      3.4      0
0   3     0         1

..
51   1    2   94        227   0    1        154      1      0.0      2
1   3     1         1
                0   140       299   0    1        173      1      1.6      2
0   3     0         1
                                298   0    1        122      1      4.2      1
3   3     0         1
                                261   0    0        186      1      0.0      2
0   2     1         1
77   1    0   125       304   0    0        162      1      0.0      2
3   2     0         1
Name: count, Length: 302, dtype: int64
```

Split Dataset

In [14]:
```
X = df.drop(['target'],axis=1)
```

In [20]:
```
X.sample(5)
```

Out[20]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal
249	69	1	2	140	254	0	0	146	0	2.0	1	3	3
155	58	0	0	130	197	0	1	131	0	0.6	1	0	2
147	60	0	3	150	240	0	1	171	0	0.9	2	0	2
113	43	1	0	110	211	0	1	161	0	0.0	2	0	3
108	50	0	1	120	244	0	1	162	0	1.1	2	0	2

In [22]:
```
y = df['target']
```

In [23]:
```
y
```

Out[23]:
```
0      1
1      1
2      1
3      1
4      1
      ..
298    0
299    0
300    0
301    0
302    0
Name: target, Length: 303, dtype: int64
```

In [24]:
```
y.value_counts()
```

Out[24]:
```
target
1    165
0    138
Name: count, dtype: int64
```

In [25]:
```
from sklearn.model_selection import train_test_split
```

In [26]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, ra
```

In [27]:
```
X_train.shape
```

Out[27]:
```
(242, 13)
```

Create neural network

In [28]:
```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
```

In [31]:
```
def create_neural_network(neurons_dense):
    model = Sequential()
    model.add(Dense(neurons_dense, input_dim=13, activation='relu'))
    model.add(Dense(1, activation='sigmoid'))
    return model
```

Summary

In [32]:
```
neurons_dense = 8
model = create_neural_network(neurons_dense)
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 8)                 112

 dense_1 (Dense)             (None, 1)                 9

=================================================================
Total params: 121
Trainable params: 121
Non-trainable params: 0
_________________________________________________________________
```

Compile model

In [33]:
```
from tensorflow import keras
```

In [34]:
```
optimizer = keras.optimizers.RMSprop(learning_rate=0.001)
```

In [35]:
```
def train_neural_network(model, X_train, y_train, epochs, batch_size):
    model.compile(loss='mse', optimizer='adam', metrics=['accuracy'])
    model.fit(X_train, y_train, epochs=epochs, batch_size=batch_size, verbo
    return model
```

In [36]:
```
epochs = 200
batch_size = 10
```

In [37]:
```
trained_model = train_neural_network(model, X_train, y_train, epochs, batch
```

```
Epoch 1/200
25/25 [==============================] - 3s 3ms/step - loss: 0.5496 - ac
curacy: 0.4504
Epoch 2/200
25/25 [==============================] - 0s 1ms/step - loss: 0.5475 - ac
curacy: 0.4504
Epoch 3/200
25/25 [==============================] - 0s 1ms/step - loss: 0.5466 - ac
curacy: 0.4545
Epoch 4/200
25/25 [==============================] - 0s 1ms/step - loss: 0.5491 - ac
curacy: 0.4504
Epoch 5/200
25/25 [==============================] - 0s 1ms/step - loss: 0.5460 - ac
curacy: 0.4545
Epoch 6/200
25/25 [==============================] - 0s 1ms/step - loss: 0.5469 - ac
curacy: 0.4545
Epoch 7/200
```

Save the trained model

In [38]:
```
history = model.fit(X_train, y_train, validation_split=0.2, epochs=100, bat
```

```
Epoch 1/100
20/20 [==============================] - 0s 15ms/step - loss: 0.5440 - a
ccuracy: 0.4560 - val_loss: 0.5714 - val_accuracy: 0.4286
Epoch 2/100
20/20 [==============================] - 0s 3ms/step - loss: 0.5440 - ac
curacy: 0.4560 - val_loss: 0.5714 - val_accuracy: 0.4286
Epoch 3/100
20/20 [==============================] - 0s 3ms/step - loss: 0.5508 - ac
curacy: 0.4404 - val_loss: 0.5714 - val_accuracy: 0.4286
Epoch 4/100
20/20 [==============================] - 0s 3ms/step - loss: 0.5440 - ac
curacy: 0.4560 - val_loss: 0.5714 - val_accuracy: 0.4286
Epoch 5/100
20/20 [==============================] - 0s 3ms/step - loss: 0.5440 - ac
curacy: 0.4560 - val_loss: 0.5714 - val_accuracy: 0.4286
Epoch 6/100
20/20 [==============================] - 0s 3ms/step - loss: 0.5440 - ac
curacy: 0.4560 - val_loss: 0.5714 - val_accuracy: 0.4286
Epoch 7/100
```

Evaluate

In [39]:
```
model.evaluate(X_test, y_test)
```

```
2/2 [==============================] - 0s 3ms/step - loss: 0.5246 - accura
cy: 0.4754
```

Out[39]:
```
[0.5245901346206665, 0.4754098355770111]
```

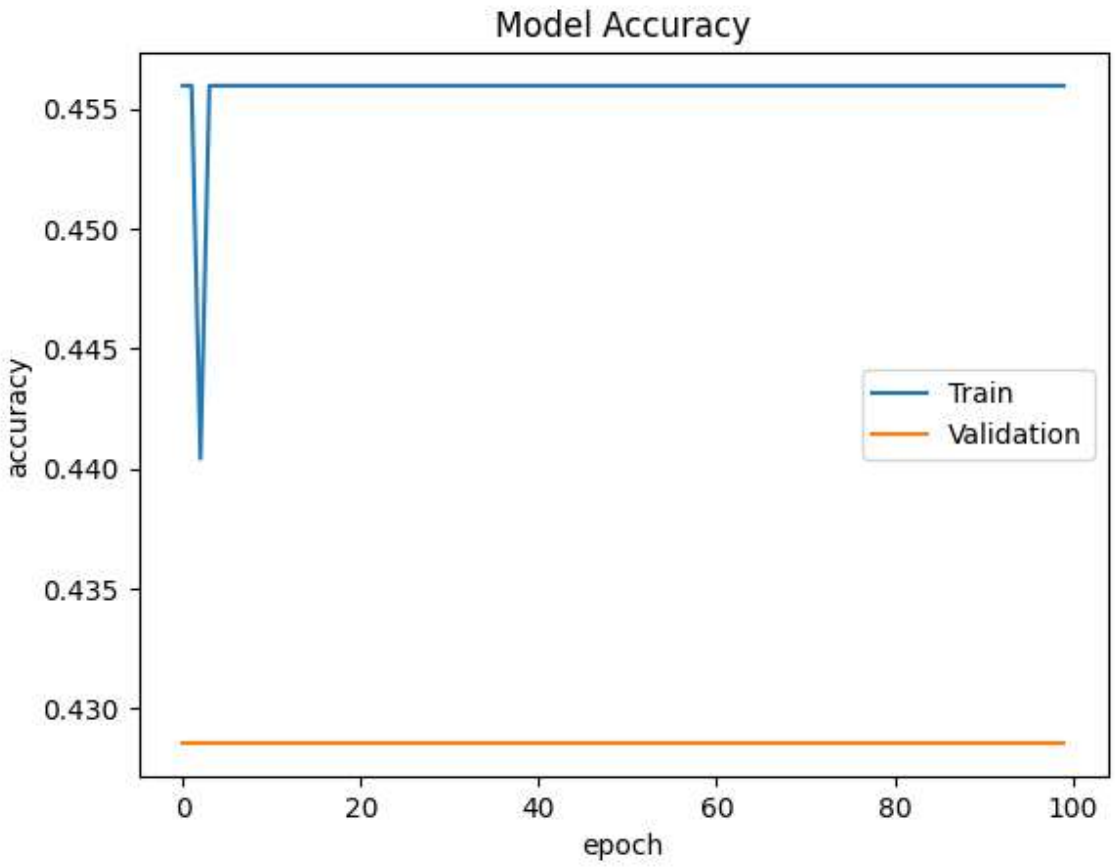
Print the model accuracy

In [40]:
```
history.history.keys()
```

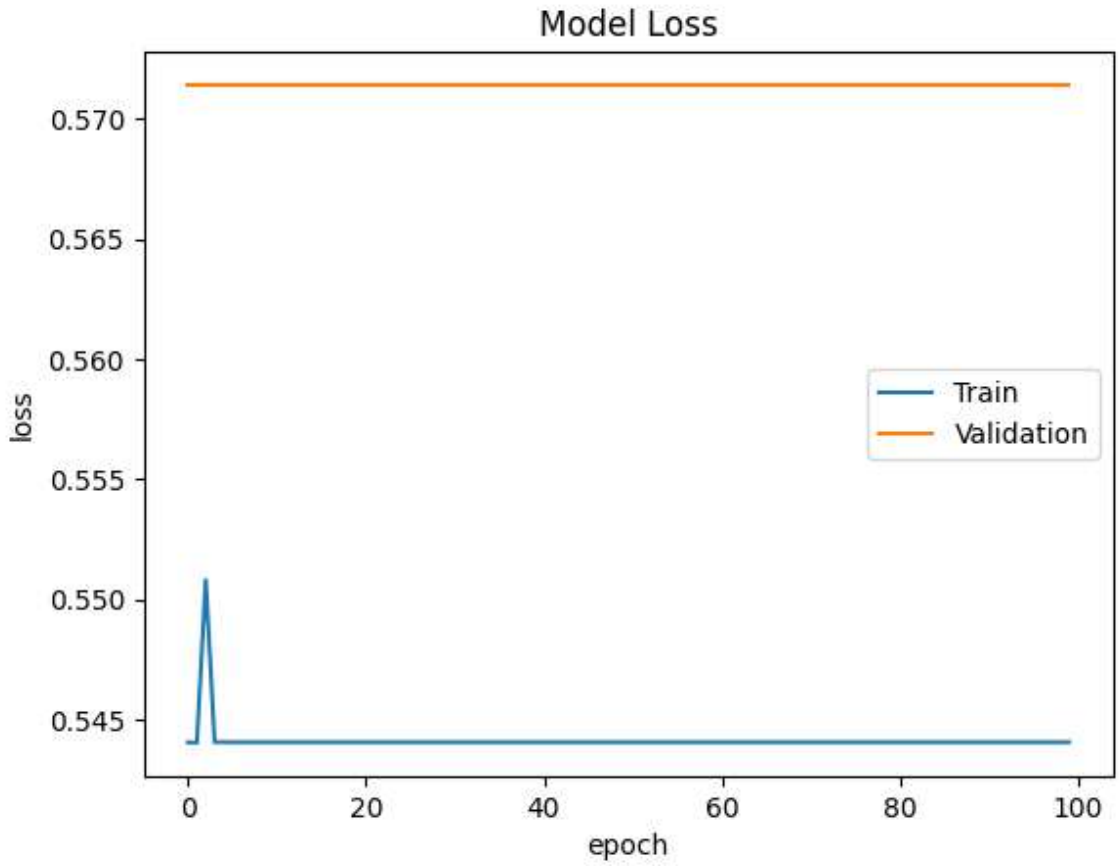
Out[40]:
```
dict_keys(['loss', 'accuracy', 'val_loss', 'val_accuracy'])
```

In [42]:
```
import matplotlib.pyplot as plt
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['Train', 'Validation'])
plt.show()
```

```
Matplotlib is building the font cache; this may take a moment.
```



In [43]:
```
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model Loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['Train', 'Validation'])
plt.show()
```



Change

Dense = 16

In [44]:
```
model1 = Sequential()
model1.add(Dense(16, input_dim=13, activation='relu'))
model1.add(Dense(8, activation='relu'))
model1.add(Dense(1, activation='sigmoid'))
```

In [45]:
```
model1.compile(loss='mse', optimizer=optimizer, metrics=['accuracy'])
model1.fit(X_train, y_train, epochs=10, batch_size=30, verbose=1)
```

```
Epoch 1/10
9/9 [==============================] - 1s 1ms/step - loss: 0.5496 - accura
cy: 0.4504
Epoch 2/10
9/9 [==============================] - 0s 1ms/step - loss: 0.5496 - accura
cy: 0.4504
Epoch 3/10
9/9 [==============================] - 0s 1ms/step - loss: 0.5492 - accura
cy: 0.4504
Epoch 4/10
9/9 [==============================] - 0s 1ms/step - loss: 0.5424 - accura
cy: 0.4545
Epoch 5/10
9/9 [==============================] - 0s 1ms/step - loss: 0.4296 - accura
cy: 0.5496
Epoch 6/10
9/9 [==============================] - 0s 1ms/step - loss: 0.3933 - accura
cy: 0.5620
Epoch 7/10
9/9 [==============================] - 0s 2ms/step - loss: 0.3865 - accura
cy: 0.5826
Epoch 8/10
9/9 [==============================] - 0s 1ms/step - loss: 0.4014 - accura
cy: 0.5372
Epoch 9/10
9/9 [==============================] - 0s 2ms/step - loss: 0.3759 - accura
cy: 0.5868
Epoch 10/10
9/9 [==============================] - 0s 2ms/step - loss: 0.3816 - accura
cy: 0.5785
```

Out[45]:
```
<keras.callbacks.History at 0x1f951b3ce50>
```

In [46]:
```
model1.evaluate(X_test, y_test)
```

```
2/2 [==============================] - 0s 4ms/step - loss: 0.3022 - accura
cy: 0.6393
```

Out[46]:
```
[0.3022478520870209, 0.6393442749977112]
```

In [47]:
```
history1 = model.fit(X_train, y_train, validation_split=0.2, epochs=100, ba
```

```
Epoch 1/100
20/20 [==============================] - 0s 5ms/step - loss: 0.5440 - ac
curacy: 0.4560 - val_loss: 0.5714 - val_accuracy: 0.4286
Epoch 2/100
20/20 [==============================] - 0s 3ms/step - loss: 0.5440 - ac
curacy: 0.4560 - val_loss: 0.5714 - val_accuracy: 0.4286
Epoch 3/100
20/20 [==============================] - 0s 3ms/step - loss: 0.5440 - ac
curacy: 0.4560 - val_loss: 0.5714 - val_accuracy: 0.4286
Epoch 4/100
20/20 [==============================] - 0s 3ms/step - loss: 0.5440 - ac
curacy: 0.4560 - val_loss: 0.5714 - val_accuracy: 0.4286
Epoch 5/100
20/20 [==============================] - 0s 3ms/step - loss: 0.5440 - ac
curacy: 0.4560 - val_loss: 0.5714 - val_accuracy: 0.4286
Epoch 6/100
20/20 [==============================] - 0s 3ms/step - loss: 0.5440 - ac
curacy: 0.4560 - val_loss: 0.5714 - val_accuracy: 0.4286
Epoch 7/100
```

In [48]:
```
model1.summary()
```

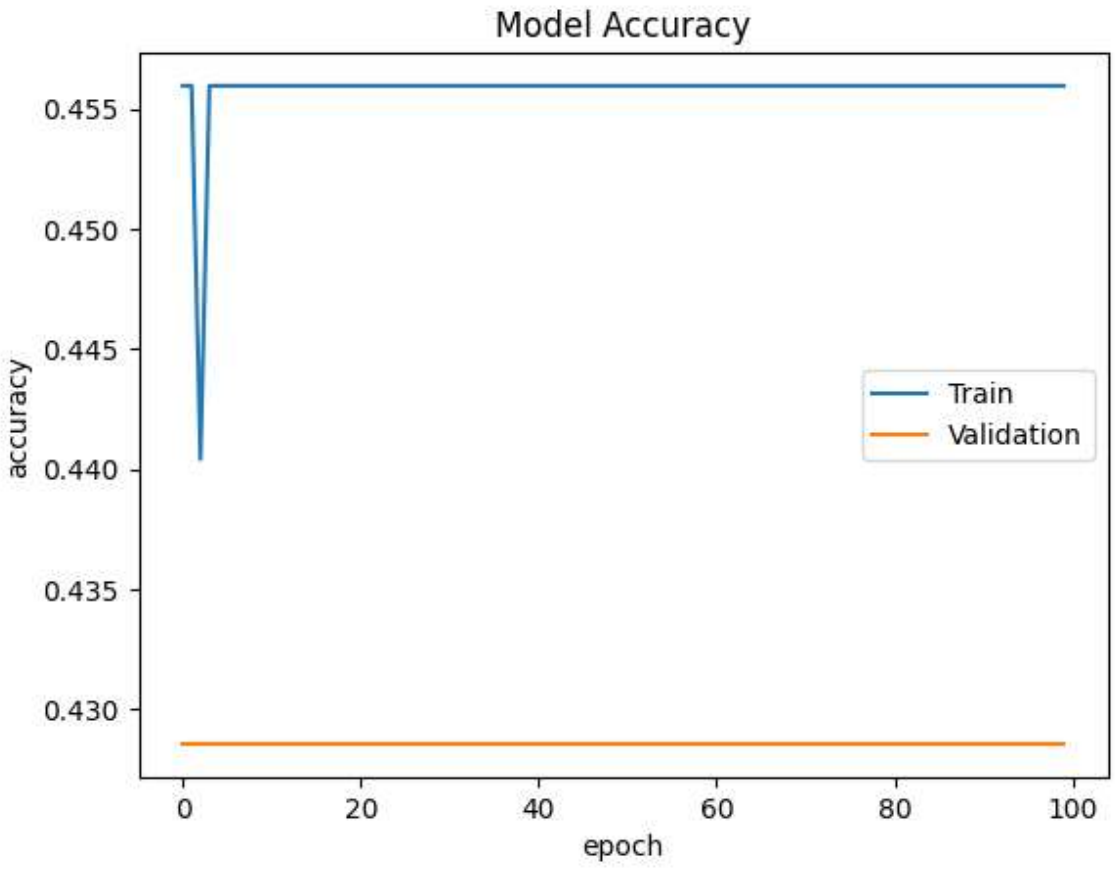
```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_2 (Dense)             (None, 16)                224

 dense_3 (Dense)             (None, 8)                 136

 dense_4 (Dense)             (None, 1)                 9

=================================================================
Total params: 369
Trainable params: 369
Non-trainable params: 0
_________________________________________________________________
```

In [52]:
```
import matplotlib.pyplot as plt
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['Train', 'Validation'])
plt.show()
```



In [54]:
```
model3 = Sequential()
model3.add(Dense(64, input_dim=13, activation='relu'))
model3.add(Dense(32, activation='relu'))
model3.add(Dense(16, activation='relu'))
model3.add(Dense(8, activation='relu'))
model3.add(Dense(1, activation='sigmoid'))
```

In [55]:
```
model3.compile(loss='mse', optimizer=optimizer, metrics=['accuracy'])
model3.fit(X_train, y_train, epochs=10, batch_size=30, verbose=1)
```

```
Epoch 1/10
9/9 [==============================] - 1s 2ms/step - loss: 0.4807 - accura
cy: 0.5124
Epoch 2/10
9/9 [==============================] - 0s 2ms/step - loss: 0.4310 - accura
cy: 0.5496
Epoch 3/10
9/9 [==============================] - 0s 2ms/step - loss: 0.4160 - accura
cy: 0.5579
Epoch 4/10
9/9 [==============================] - 0s 2ms/step - loss: 0.4544 - accura
cy: 0.5331
Epoch 5/10
9/9 [==============================] - 0s 2ms/step - loss: 0.3918 - accura
cy: 0.5702
Epoch 6/10
9/9 [==============================] - 0s 2ms/step - loss: 0.3785 - accura
cy: 0.5950
Epoch 7/10
9/9 [==============================] - 0s 2ms/step - loss: 0.3262 - accura
cy: 0.6281
Epoch 8/10
9/9 [==============================] - 0s 2ms/step - loss: 0.2949 - accura
cy: 0.6405
Epoch 9/10
9/9 [==============================] - 0s 4ms/step - loss: 0.2737 - accura
cy: 0.6322
Epoch 10/10
9/9 [==============================] - 0s 2ms/step - loss: 0.2963 - accura
cy: 0.5909
```

Out[55]:
```
<keras.callbacks.History at 0x1f953a8b4c0>
```

In [56]:
```
model3.evaluate(X_test, y_test)
```

```
2/2 [==============================] - 0s 4ms/step - loss: 0.2396 - accura
cy: 0.6721
```

Out[56]:
```
[0.239635169506073, 0.6721311211585999]
```

In [57]:
```
model3.summary()
```

```
Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_10 (Dense)            (None, 64)                896

 dense_11 (Dense)            (None, 32)                2080

 dense_12 (Dense)            (None, 16)                528

 dense_13 (Dense)            (None, 8)                 136

 dense_14 (Dense)            (None, 1)                 9

=================================================================
Total params: 3,649
Trainable params: 3,649
Non-trainable params: 0
_________________________________________________________________
```

Change Epochs

In [ ]:
```

```