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Roll No. : 225229103

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

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 [4]:

```
df.describe()
```

Out[4]:

	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 [5]:

```
df.value_counts()
```

Out[5]:

```
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
Length: 302, dtype: int64
```

Split Dataset

In [6]:

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

In [7]:

```
X.sample(5)
```

Out[7]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal
160	56	1	1	120	240	0	1	169	0	0.0	0	0	2
39	65	0	2	160	360	0	0	151	0	0.8	2	0	2
71	51	1	2	94	227	0	1	154	1	0.0	2	1	3
165	67	1	0	160	286	0	0	108	1	1.5	1	3	2
115	37	0	2	120	215	0	1	170	0	0.0	2	0	2

In [8]:

```
y = df['target']
```

In [9]:

```
y
```

Out[9]:

```
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 [10]:

```
y.value_counts()
```

Out[10]:

```
1    165
0    138
Name: target, dtype: int64
```

In [11]:

```
from sklearn.model_selection import train_test_split
```

In [12]:

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42
```

In [13]:

```
X_train.shape
```

Out[13]:

```
(242, 13)
```

Create neural network

In [14]:

```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
```

In [15]:

```
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 [16]:

```
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 (484.00 Byte)
Trainable params: 121 (484.00 Byte)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

Compile model

In [17]:

```
from tensorflow import keras
```

In [18]:

```
optimizer = keras.optimizers.RMSprop(learning_rate=0.001)
```

In [19]:

```
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, verbose=1)
    return model
```

In [20]:

```
epochs = 200
batch_size = 10
```

In [21]:

```
trained_model = train_neural_network(model, X_train, y_train, epochs, batch_size)
```

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25/25 [==============================] - 0s 4ms/step - loss: 0.4504 - accu
racy: 0.5496
Epoch 145/200
25/25 [==============================] - 0s 4ms/step - loss: 0.4504 - accu
racy: 0.5496
Epoch 146/200
25/25 [==============================] - 0s 4ms/step - loss: 0.4504 - accu
racy: 0.5496
Epoch 147/200
25/25 [==============================] - 0s 4ms/step - loss: 0.4504 - accu
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Epoch 148/200
25/25 [==============================] - 0s 4ms/step - loss: 0.4504 - accu
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Epoch 149/200
25/25 [==============================] - 0s 5ms/step - loss: 0.4504 - accu
racy: 0.5496
Epoch 150/200
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racy: 0.5496
Epoch 151/200
25/25 [==============================] - 0s 4ms/step - loss: 0.4504 - accu
racy: 0.5496
Epoch 152/200
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Epoch 153/200
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Epoch 154/200
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Epoch 155/200
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racy: 0.5496
Epoch 156/200
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Epoch 157/200
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Epoch 158/200
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Epoch 159/200
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Epoch 160/200
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Epoch 161/200
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Epoch 162/200
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Epoch 163/200
25/25 [==============================] - 0s 3ms/step - loss: 0.4504 - accu
racy: 0.5496
Epoch 164/200
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25/25 [==============================] - 0s 3ms/step - loss: 0.4504 - accu
racy: 0.5496
Epoch 165/200
25/25 [==============================] - 0s 3ms/step - loss: 0.4504 - accu
racy: 0.5496
Epoch 166/200
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Epoch 167/200
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Epoch 173/200
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Epoch 174/200
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Epoch 183/200
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Epoch 184/200
25/25 [==============================] - 0s 4ms/step - loss: 0.4504 - accu
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racy: 0.5496
Epoch 185/200
25/25 [==============================] - 0s 5ms/step - loss: 0.4504 - accu
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Epoch 187/200
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Epoch 188/200
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Epoch 189/200
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Epoch 190/200
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Epoch 191/200
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Epoch 192/200
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Epoch 193/200
25/25 [==============================] - 0s 4ms/step - loss: 0.4504 - accu
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Epoch 194/200
25/25 [==============================] - 0s 6ms/step - loss: 0.4504 - accu
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Epoch 195/200
25/25 [==============================] - 0s 3ms/step - loss: 0.4504 - accu
racy: 0.5496
Epoch 196/200
25/25 [==============================] - 0s 4ms/step - loss: 0.4504 - accu
racy: 0.5496
Epoch 197/200
25/25 [==============================] - 0s 4ms/step - loss: 0.4504 - accu
racy: 0.5496
Epoch 198/200
25/25 [==============================] - 0s 4ms/step - loss: 0.4504 - accu
racy: 0.5496
Epoch 199/200
25/25 [==============================] - 0s 4ms/step - loss: 0.4504 - accu
racy: 0.5496
Epoch 200/200
25/25 [==============================] - 0s 5ms/step - loss: 0.4504 - accu
racy: 0.5496

Save the trained model

In [22]:
```
history = model.fit(X_train, y_train, validation_split=0.2, epochs=100, batch_size=10, v
```

```
Epoch 1/100
20/20 [==============================] - 1s 38ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 2/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 3/100
20/20 [==============================] - 0s 12ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 4/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 5/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 6/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 7/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 8/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 9/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 10/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 11/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 12/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 13/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 14/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 15/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 16/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 17/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 18/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 19/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 20/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 21/100
```

```
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 22/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 23/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 24/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 25/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 26/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 27/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 28/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 29/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 30/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 31/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 32/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 33/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 34/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 35/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 36/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 37/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 38/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 39/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 40/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 41/100
20/20 [==============================] - 0s 11ms/step - loss: 0.4560 - acc
```

```
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 42/100
20/20 [==============================] - 0s 11ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 43/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 44/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 45/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 46/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 47/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 48/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 49/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 50/100
20/20 [==============================] - 0s 6ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 51/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 52/100
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racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 53/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
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Epoch 54/100
20/20 [==============================] - 0s 6ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 55/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 56/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 57/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 58/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
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Epoch 59/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 60/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 61/100
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Epoch 62/100
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Epoch 63/100
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Epoch 64/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
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Epoch 65/100
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Epoch 66/100
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Epoch 67/100
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Epoch 68/100
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Epoch 69/100
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Epoch 70/100
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Epoch 71/100
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Epoch 72/100
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Epoch 73/100
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Epoch 74/100
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Epoch 75/100
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racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 76/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 77/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 78/100
20/20 [==============================] - 0s 11ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 79/100
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```
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 80/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 81/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 82/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 83/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 84/100
20/20 [==============================] - 0s 11ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 85/100
20/20 [==============================] - 0s 11ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 86/100
20/20 [==============================] - 0s 11ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 87/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 88/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 89/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 90/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 91/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 92/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 93/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 94/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 95/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 96/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 97/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 98/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 99/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
```

```
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 100/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
```

Evaluate

In [23]:

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

```
2/2 [==============================] - 0s 9ms/step - loss: 0.4754 - accura
cy: 0.5246
```

Out[23]:

```
[0.4754098355770111, 0.5245901346206665]
```

Print the model accuracy

In [24]:

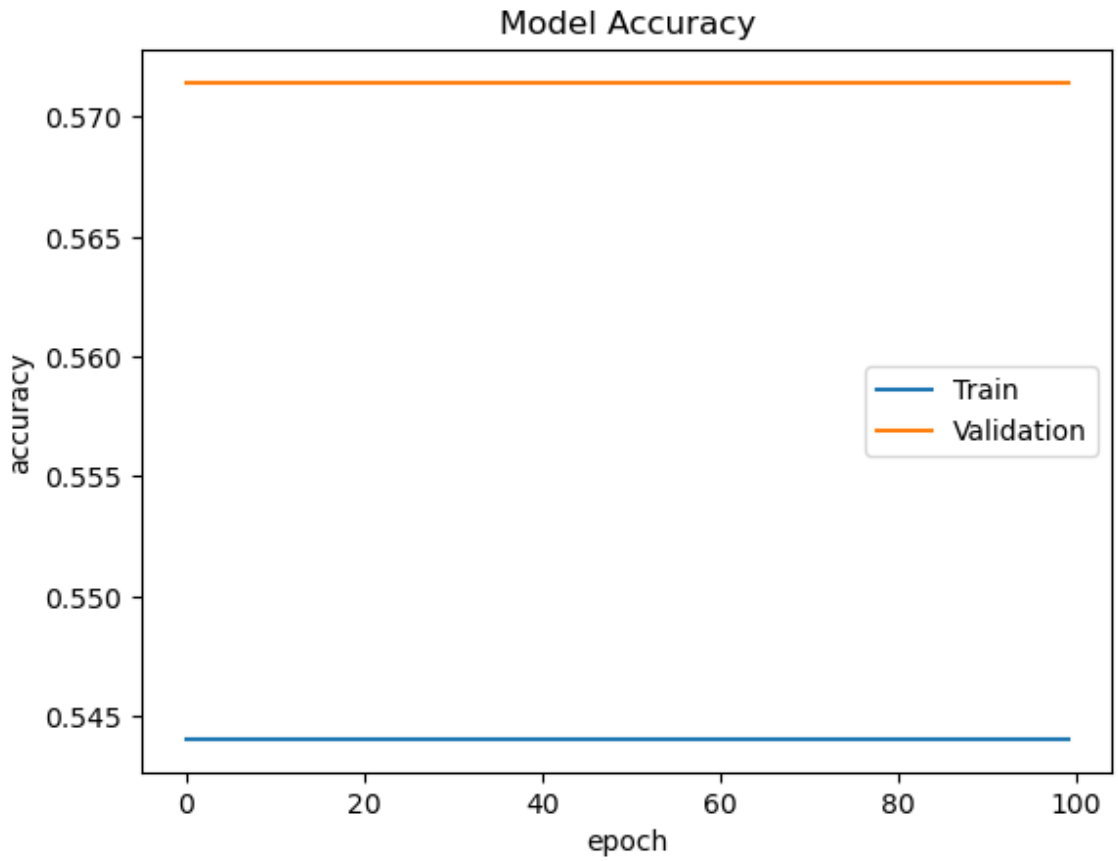
```
history.history.keys()
```

Out[24]:

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

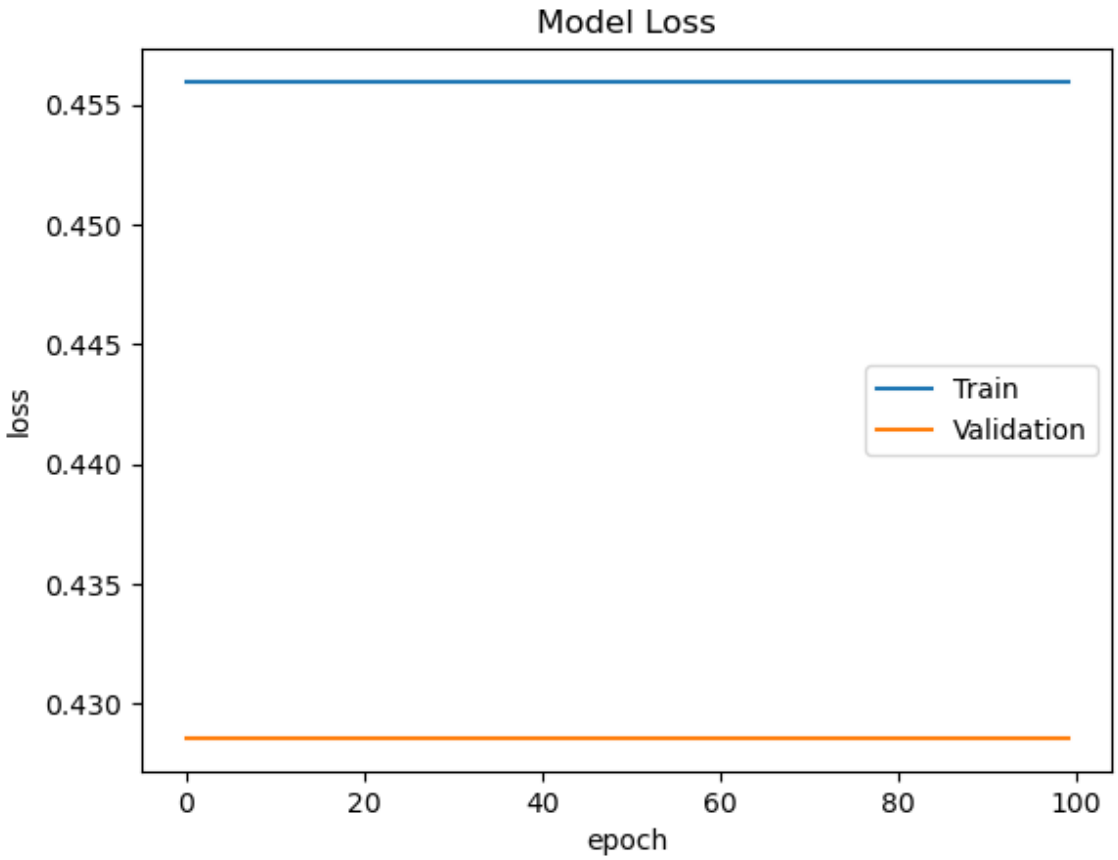
In [25]:

```
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 [26]:

```
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 [27]:

```
model1 = Sequential()
model1.add(Dense(16, input_dim=13, activation='relu'))
model1.add(Dense(8, activation='relu'))
model1.add(Dense(1, activation='sigmoid'))
```

In [28]:

```
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 4ms/step - loss: 0.3558 - accura
cy: 0.6157
Epoch 2/10
9/9 [==============================] - 0s 4ms/step - loss: 0.3184 - accura
cy: 0.6405
Epoch 3/10
9/9 [==============================] - 0s 4ms/step - loss: 0.3022 - accura
cy: 0.6570
Epoch 4/10
9/9 [==============================] - 0s 6ms/step - loss: 0.3008 - accura
cy: 0.6488
Epoch 5/10
9/9 [==============================] - 0s 5ms/step - loss: 0.3075 - accura
cy: 0.6529
Epoch 6/10
9/9 [==============================] - 0s 6ms/step - loss: 0.2892 - accura
cy: 0.6736
Epoch 7/10
9/9 [==============================] - 0s 5ms/step - loss: 0.2900 - accura
cy: 0.6777
Epoch 8/10
9/9 [==============================] - 0s 5ms/step - loss: 0.2942 - accura
cy: 0.6736
Epoch 9/10
9/9 [==============================] - 0s 4ms/step - loss: 0.2944 - accura
cy: 0.6653
Epoch 10/10
9/9 [==============================] - 0s 8ms/step - loss: 0.2798 - accura
cy: 0.6942
```

Out[28]:

```
<keras.src.callbacks.History at 0x23c98762980>
```

In [29]:

```
model1.evaluate(X_test, y_test)
```

```
2/2 [==============================] - 0s 7ms/step - loss: 0.1801 - accura
cy: 0.8033
```

Out[29]:

```
[0.18012559413909912, 0.8032786846160889]
```

In [30]:

```
history1 = model.fit(X_train, y_train, validation_split=0.2, epochs=100, batch_size=10,
```

```
Epoch 1/100
20/20 [==============================] - 0s 13ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 2/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 3/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 4/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 5/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 6/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 7/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 8/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 9/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 10/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 11/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 12/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 13/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 14/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 15/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 16/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 17/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 18/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 19/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 20/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 21/100
```

```
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 22/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 23/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 24/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 25/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 26/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 27/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 28/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 29/100
20/20 [==============================] - 0s 12ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 30/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 31/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 32/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 33/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 34/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 35/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 36/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 37/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 38/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 39/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 40/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 41/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
```

```
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 42/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 43/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 44/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 45/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 46/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 47/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 48/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 49/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 50/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 51/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 52/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 53/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 54/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 55/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 56/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 57/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 58/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
```

```
Epoch 59/100
20/20 [==============================] - 0s 11ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 60/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 61/100
20/20 [==============================] - 0s 11ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 62/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 63/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 64/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 65/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 66/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 67/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 68/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 69/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 70/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 71/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 72/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 73/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 74/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 75/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 76/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 77/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 78/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 79/100
```

```
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 80/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 81/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 82/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 83/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 84/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 85/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 86/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 87/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 88/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 89/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 90/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 91/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 92/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 93/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 94/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 95/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 96/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 97/100
20/20 [==============================] - 0s 7ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 98/100
20/20 [==============================] - 0s 9ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
Epoch 99/100
20/20 [==============================] - 0s 10ms/step - loss: 0.4560 - acc
```

```
uracy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
```

In [31]:

```
Epoch 100/100
20/20 [==============================] - 0s 8ms/step - loss: 0.4560 - accu
racy: 0.5440 - val_loss: 0.4286 - val_accuracy: 0.5714
```

```
model1.summary()
```

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

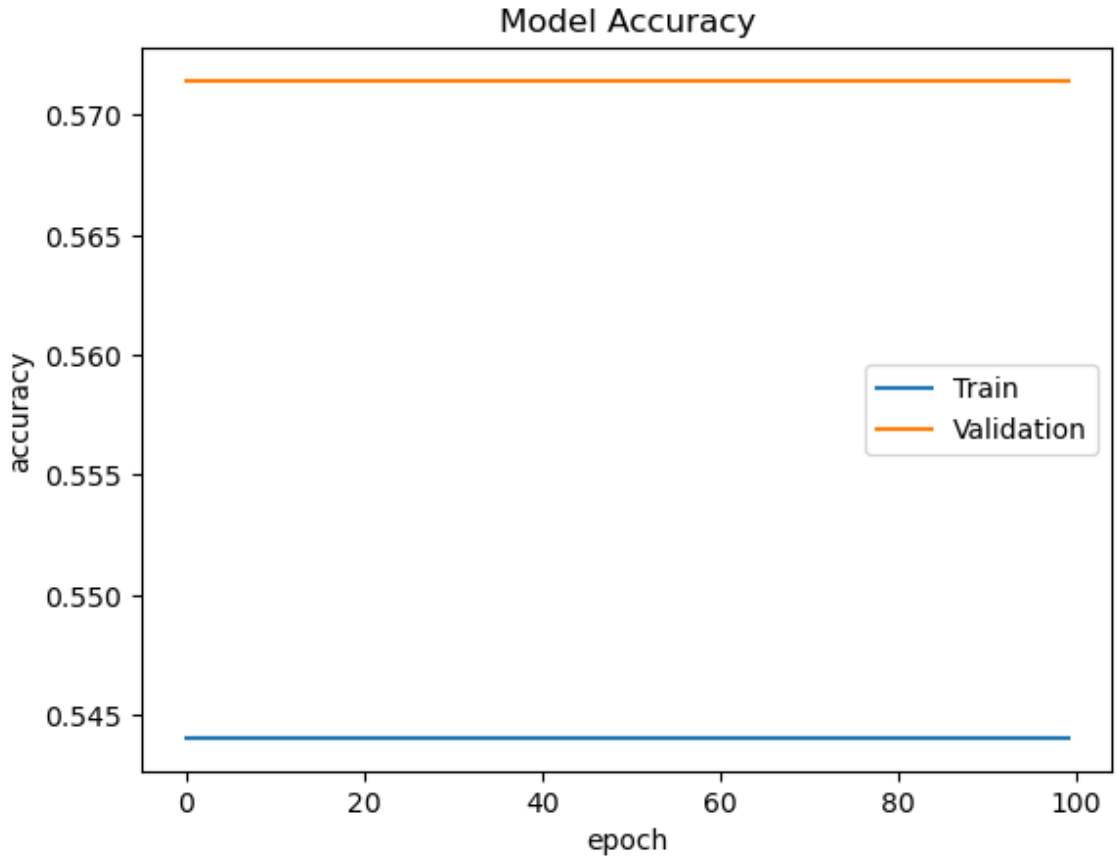
 dense_3 (Dense)             (None, 8)                 136

 dense_4 (Dense)             (None, 1)                 9

=================================================================
Total params: 369 (1.44 KB)
Trainable params: 369 (1.44 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

In [32]:

```
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 [33]:

```
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 [35]:

```
optimizer = keras.optimizers.RMSprop(learning_rate=0.001)
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 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 2/10
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 3/10
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 4/10
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 5/10
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 6/10
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 7/10
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 8/10
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 9/10
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 10/10
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
```

Out[35]:

```
<keras.src.callbacks.History at 0x23c9a2f0610>
```

In [36]:

```
model3.evaluate(X_test, y_test)
```

```
2/2 [==============================] - 0s 10ms/step - loss: 0.4754 - accur
acy: 0.5246
```

Out[36]:

```
[0.4754098355770111, 0.5245901346206665]
```

In [37]:

```
model3.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_5 (Dense)             (None, 64)                896

 dense_6 (Dense)             (None, 32)                2080

 dense_7 (Dense)             (None, 16)                528

 dense_8 (Dense)             (None, 8)                 136

 dense_9 (Dense)             (None, 1)                 9

=================================================================
Total params: 3649 (14.25 KB)
Trainable params: 3649 (14.25 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

Change Epochs

In [38]:

```
model3.compile(loss='mse', optimizer=optimizer, metrics=['accuracy'])
model3.fit(X_train, y_train, epochs=150, batch_size=30, verbose=1)
```

```
Epoch 1/150
9/9 [==============================] - 1s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 2/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 3/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 4/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 5/150
9/9 [==============================] - 0s 9ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 6/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 7/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 8/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 9/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 10/150
9/9 [==============================] - 0s 9ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 11/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 12/150
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 13/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 14/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 15/150
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 16/150
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 17/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 18/150
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 19/150
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 20/150
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 21/150
```

```
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 22/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 23/150
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 24/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 25/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 26/150
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 27/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 28/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 29/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 30/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 31/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 32/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 33/150
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 34/150
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 35/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 36/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 37/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 38/150
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 39/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 40/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 41/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
```

```
cy: 0.5496
Epoch 42/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 43/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 44/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 45/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 46/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 47/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 48/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 49/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 50/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 51/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 52/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 53/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 54/150
9/9 [==============================] - 0s 3ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 55/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 56/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 57/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 58/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 59/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 60/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 61/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
```

```
Epoch 62/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 63/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 64/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 65/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 66/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 67/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 68/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 69/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 70/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 71/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 72/150
9/9 [==============================] - 0s 10ms/step - loss: 0.4504 - accur
acy: 0.5496
Epoch 73/150
9/9 [==============================] - 0s 3ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 74/150
9/9 [==============================] - 0s 3ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 75/150
9/9 [==============================] - 0s 3ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 76/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 77/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 78/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 79/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 80/150
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 81/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 82/150
```

```
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 83/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 84/150
```

```
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 85/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 86/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 87/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 88/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 89/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 90/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 91/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 92/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 93/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 94/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 95/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 96/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 97/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 98/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 99/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 100/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 101/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 102/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 103/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 104/150
9/9 [==============================] - 0s 3ms/step - loss: 0.4504 - accura
```

```
cy: 0.5496
Epoch 105/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 106/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 107/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 108/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 109/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 110/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 111/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 112/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 113/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 114/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 115/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 116/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 117/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 118/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 119/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 120/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 121/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 122/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 123/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 124/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
```

```
Epoch 125/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 126/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 127/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 128/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 129/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 130/150
9/9 [==============================] - 0s 3ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 131/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 132/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 133/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 134/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 135/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 136/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 137/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 138/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 139/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 140/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 141/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 142/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 143/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 144/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 145/150
```

In [39]:

```
model3.evaluate(X_test, y_test)
```

```
2/2 [==============================] - 0s 10ms/step - loss: 0.4754 - accur
acy: 0.5246
```

Out[39]:

```
[0.4754098355770111, 0.5245901346206665]
```

In [40]:

```
model3.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_5 (Dense)             (None, 64)                896

 dense_6 (Dense)             (None, 32)                2080

 dense_7 (Dense)             (None, 16)                528

 dense_8 (Dense)             (None, 8)                 136

 dense_9 (Dense)             (None, 1)                 9

=================================================================
Total params: 3649 (14.25 KB)
Trainable params: 3649 (14.25 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

```
9/9 [==============================] - 0s 10ms/step - loss: 0.4504 - accur
acy: 0.5496
Epoch 146/150
9/9 [==============================] - 0s 3ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 147/150
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 148/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 149/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 150/150
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
```

In [41]:

```
optimizer = keras.optimizers.RMSprop(learning_rate=0.001)
model3.compile(loss='mse', optimizer=optimizer, metrics=['accuracy'])
model3.fit(X_train, y_train, epochs=100, batch_size=30, verbose=1)
```

Out[38]:

```
<keras.src.callbacks.History at 0x23c986c2320>
```

```
Epoch 1/100
9/9 [==============================] - 1s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 2/100
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 3/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 4/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 5/100
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 6/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 7/100
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 8/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 9/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 10/100
9/9 [==============================] - 0s 7ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 11/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 12/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 13/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 14/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 15/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 16/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 17/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 18/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 19/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 20/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 21/100
```

```
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 22/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 23/100
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 24/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 25/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 26/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 27/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 28/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 29/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 30/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 31/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 32/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 33/100
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 34/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 35/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 36/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 37/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 38/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 39/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 40/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 41/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
```

```
cy: 0.5496
Epoch 42/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 43/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 44/100
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 45/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 46/100
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 47/100
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 48/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 49/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 50/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 51/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 52/100
9/9 [==============================] - 0s 7ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 53/100
9/9 [==============================] - 0s 11ms/step - loss: 0.4504 - accur
acy: 0.5496
Epoch 54/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 55/100
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cy: 0.5496
Epoch 56/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 57/100
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cy: 0.5496
Epoch 58/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 59/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 60/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 61/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
```

```
Epoch 62/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 63/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 64/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 65/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 66/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 67/100
9/9 [==============================] - 0s 3ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 68/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 69/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 70/100
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Epoch 72/100
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cy: 0.5496
Epoch 73/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 74/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 75/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 76/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 77/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 78/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 79/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 80/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 81/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 82/100
```

```
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 83/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 84/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 85/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 86/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 87/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 88/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 89/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 90/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 91/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 92/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 93/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 94/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 95/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 96/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 97/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 98/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 99/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 100/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
```

Out[41]:

```
<keras.src.callbacks.History at 0x23c98ff4d00>
```

In [42]:

```
model3.evaluate(X_test, y_test)
```

```
2/2 [==============================] - 0s 9ms/step - loss: 0.4754 - accura
cy: 0.5246
```

Out[42]:

```
[0.4754098355770111, 0.5245901346206665]
```

In [43]:

```
model3.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_5 (Dense)             (None, 64)                896

 dense_6 (Dense)             (None, 32)                2080

 dense_7 (Dense)             (None, 16)                528

 dense_8 (Dense)             (None, 8)                 136

 dense_9 (Dense)             (None, 1)                 9

=================================================================
Total params: 3649 (14.25 KB)
Trainable params: 3649 (14.25 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

In [44]:

```
optimizer = keras.optimizers.RMSprop(learning_rate=0.001)
model3.compile(loss='mse', optimizer=optimizer, metrics=['accuracy'])
model3.fit(X_train, y_train, epochs=100, batch_size=30, verbose=1)
```

```
Epoch 1/100
9/9 [==============================] - 2s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 2/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 3/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 4/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 5/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 6/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 7/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 8/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 9/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 10/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 11/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 12/100
9/9 [==============================] - 0s 8ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 13/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 14/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 15/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 16/100
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 17/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 18/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 19/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 20/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 21/100
```

```
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 22/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 23/100
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 24/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 25/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 26/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 27/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 28/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 29/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 30/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 31/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 32/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 33/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 34/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 35/100
9/9 [==============================] - 0s 3ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 36/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 37/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 38/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 39/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 40/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 41/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
```

```
cy: 0.5496
Epoch 42/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 43/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 44/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 45/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 46/100
9/9 [==============================] - 0s 3ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 47/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 48/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 49/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 50/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 51/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 52/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 53/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 54/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 55/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 56/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 57/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 58/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 59/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 60/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 61/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
```

```
Epoch 62/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 63/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 64/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 65/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 66/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 67/100
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 68/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 69/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 70/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 71/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 72/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 73/100
9/9 [==============================] - 0s 7ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 74/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 75/100
9/9 [==============================] - 0s 3ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 76/100
9/9 [==============================] - 0s 3ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 77/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 78/100
9/9 [==============================] - 0s 3ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 79/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 80/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 81/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 82/100
```

```
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 83/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 84/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 85/100
9/9 [==============================] - 0s 3ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 86/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 87/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 88/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 89/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 90/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 91/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 92/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 93/100
9/9 [==============================] - 0s 7ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 94/100
9/9 [==============================] - 0s 6ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 95/100
9/9 [==============================] - 0s 7ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 96/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 97/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 98/100
9/9 [==============================] - 0s 5ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 99/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
Epoch 100/100
9/9 [==============================] - 0s 4ms/step - loss: 0.4504 - accura
cy: 0.5496
```

Out[44]:

```
<keras.src.callbacks.History at 0x23c9a565f00>
```

In [45]:

```
model3.evaluate(X_test, y_test)
```

```
WARNING:tensorflow:5 out of the last 509 calls to <function Model.make_tes
t_function.<locals>.test_function at 0x0000023C96733760> triggered tf.func
tion retracing. Tracing is expensive and the excessive number of tracings
could be due to (1) creating @tf.function repeatedly in a loop, (2) passin
g tensors with different shapes, (3) passing Python objects instead of ten
sors. For (1), please define your @tf.function outside of the loop. For
(2), @tf.function has reduce_retracing=True option that can avoid unnecess
ary retracing. For (3), please refer to https://www.tensorflow.org/guide/f
unction#controlling_retracing (https://www.tensorflow.org/guide/function#c
ontrolling_retracing) and https://www.tensorflow.org/api_docs/python/tf/fu
nction (https://www.tensorflow.org/api_docs/python/tf/function) for  more
details.
2/2 [==============================] - 0s 20ms/step - loss: 0.4754 - accur
acy: 0.5246
```

Out[45]:

```
[0.4754098355770111, 0.5245901346206665]
```

In [46]:

```
model3.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_5 (Dense)             (None, 64)                896

 dense_6 (Dense)             (None, 32)                2080

 dense_7 (Dense)             (None, 16)                528

 dense_8 (Dense)             (None, 8)                 136

 dense_9 (Dense)             (None, 1)                 9

=================================================================
Total params: 3649 (14.25 KB)
Trainable params: 3649 (14.25 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```