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1 Question 1:

2 Part II: XOR Gate Implementation

1. XOR Truth Table Dataset:

```
[1]: import numpy as np

# XOR gate truth table
X = np.array([[0, 0], [0, 1], [1, 0], [1, 1]]) # Inputs
y = np.array([0, 1, 1, 0]) # XOR output
```

2. Single-Layer Perceptron Implementation:

```
[2]: import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense

# Create a simple perceptron model
single_layer_model = Sequential()
single_layer_model.add(Dense(1, input_dim=2, activation='hard_sigmoid')) #
    ↪Single layer

# Compile the model
single_layer_model.compile(loss='binary_crossentropy', optimizer='adam',
    ↪metrics=['accuracy'])

# Train the perceptron on the XOR data
single_layer_model.fit(X, y, epochs=100, verbose=1)

# Evaluate the performance
loss, accuracy = single_layer_model.evaluate(X, y)
print(f'Single Layer Perceptron Accuracy: {accuracy * 100:.2f}%')
```

Epoch 1/100

/usr/local/lib/python3.10/dist-packages/keras/src/layers/core/dense.py:87:
UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When
using Sequential models, prefer using an `Input(shape)` object as the first

layer in the model instead.

```
super().__init__(activity_regularizer=activity_regularizer, **kwargs)

1/1          1s 728ms/step -
accuracy: 0.7500 - loss: 0.7305
Epoch 2/100
1/1          0s 42ms/step -
accuracy: 0.5000 - loss: 0.7304
Epoch 3/100
1/1          0s 25ms/step -
accuracy: 0.5000 - loss: 0.7302
Epoch 4/100
1/1          0s 58ms/step -
accuracy: 0.5000 - loss: 0.7301
Epoch 5/100
1/1          0s 56ms/step -
accuracy: 0.5000 - loss: 0.7299
Epoch 6/100
1/1          0s 26ms/step -
accuracy: 0.5000 - loss: 0.7298
Epoch 7/100
1/1          0s 24ms/step -
accuracy: 0.5000 - loss: 0.7296
Epoch 8/100
1/1          0s 62ms/step -
accuracy: 0.5000 - loss: 0.7295
Epoch 9/100
1/1          0s 28ms/step -
accuracy: 0.5000 - loss: 0.7293
Epoch 10/100
1/1          0s 23ms/step -
accuracy: 0.5000 - loss: 0.7291
Epoch 11/100
1/1          0s 60ms/step -
accuracy: 0.5000 - loss: 0.7290
Epoch 12/100
1/1          0s 25ms/step -
accuracy: 0.5000 - loss: 0.7288
Epoch 13/100
1/1          0s 23ms/step -
accuracy: 0.5000 - loss: 0.7287
Epoch 14/100
1/1          0s 30ms/step -
accuracy: 0.5000 - loss: 0.7285
Epoch 15/100
1/1          0s 25ms/step -
accuracy: 0.5000 - loss: 0.7284
Epoch 16/100
```

1/1 0s 25ms/step -
accuracy: 0.5000 - loss: 0.7282
Epoch 17/100
1/1 0s 23ms/step -
accuracy: 0.5000 - loss: 0.7281
Epoch 18/100
1/1 0s 24ms/step -
accuracy: 0.5000 - loss: 0.7279
Epoch 19/100
1/1 0s 25ms/step -
accuracy: 0.5000 - loss: 0.7278
Epoch 20/100
1/1 0s 25ms/step -
accuracy: 0.5000 - loss: 0.7277
Epoch 21/100
1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7275
Epoch 22/100
1/1 0s 28ms/step -
accuracy: 0.5000 - loss: 0.7274
Epoch 23/100
1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7272
Epoch 24/100
1/1 0s 25ms/step -
accuracy: 0.5000 - loss: 0.7271
Epoch 25/100
1/1 0s 55ms/step -
accuracy: 0.5000 - loss: 0.7269
Epoch 26/100
1/1 0s 29ms/step -
accuracy: 0.5000 - loss: 0.7268
Epoch 27/100
1/1 0s 25ms/step -
accuracy: 0.5000 - loss: 0.7267
Epoch 28/100
1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7265
Epoch 29/100
1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7264
Epoch 30/100
1/1 0s 24ms/step -
accuracy: 0.5000 - loss: 0.7262
Epoch 31/100
1/1 0s 58ms/step -
accuracy: 0.5000 - loss: 0.7261
Epoch 32/100

1/1 0s 27ms/step -
accuracy: 0.5000 - loss: 0.7260
Epoch 33/100
1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7258
Epoch 34/100
1/1 0s 27ms/step -
accuracy: 0.5000 - loss: 0.7257
Epoch 35/100
1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7256
Epoch 36/100
1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7254
Epoch 37/100
1/1 0s 27ms/step -
accuracy: 0.5000 - loss: 0.7253
Epoch 38/100
1/1 0s 31ms/step -
accuracy: 0.5000 - loss: 0.7252
Epoch 39/100
1/1 0s 27ms/step -
accuracy: 0.5000 - loss: 0.7250
Epoch 40/100
1/1 0s 27ms/step -
accuracy: 0.5000 - loss: 0.7249
Epoch 41/100
1/1 0s 27ms/step -
accuracy: 0.5000 - loss: 0.7248
Epoch 42/100
1/1 0s 27ms/step -
accuracy: 0.5000 - loss: 0.7246
Epoch 43/100
1/1 0s 25ms/step -
accuracy: 0.5000 - loss: 0.7245
Epoch 44/100
1/1 0s 27ms/step -
accuracy: 0.5000 - loss: 0.7244
Epoch 45/100
1/1 0s 27ms/step -
accuracy: 0.5000 - loss: 0.7242
Epoch 46/100
1/1 0s 27ms/step -
accuracy: 0.5000 - loss: 0.7241
Epoch 47/100
1/1 0s 25ms/step -
accuracy: 0.5000 - loss: 0.7240
Epoch 48/100

1/1 0s 27ms/step -
 accuracy: 0.5000 - loss: 0.7239
 Epoch 49/100
 1/1 0s 27ms/step -
 accuracy: 0.5000 - loss: 0.7237
 Epoch 50/100
 1/1 0s 25ms/step -
 accuracy: 0.5000 - loss: 0.7236
 Epoch 51/100
 1/1 0s 26ms/step -
 accuracy: 0.5000 - loss: 0.7235
 Epoch 52/100
 1/1 0s 25ms/step -
 accuracy: 0.5000 - loss: 0.7234
 Epoch 53/100
 1/1 0s 26ms/step -
 accuracy: 0.5000 - loss: 0.7232
 Epoch 54/100
 1/1 0s 25ms/step -
 accuracy: 0.5000 - loss: 0.7231
 Epoch 55/100
 1/1 0s 25ms/step -
 accuracy: 0.5000 - loss: 0.7230
 Epoch 56/100
 1/1 0s 26ms/step -
 accuracy: 0.5000 - loss: 0.7229
 Epoch 57/100
 1/1 0s 27ms/step -
 accuracy: 0.5000 - loss: 0.7228
 Epoch 58/100
 1/1 0s 25ms/step -
 accuracy: 0.5000 - loss: 0.7226
 Epoch 59/100
 1/1 0s 27ms/step -
 accuracy: 0.5000 - loss: 0.7225
 Epoch 60/100
 1/1 0s 58ms/step -
 accuracy: 0.5000 - loss: 0.7224
 Epoch 61/100
 1/1 0s 25ms/step -
 accuracy: 0.5000 - loss: 0.7223
 Epoch 62/100
 1/1 0s 25ms/step -
 accuracy: 0.5000 - loss: 0.7222
 Epoch 63/100
 1/1 0s 26ms/step -
 accuracy: 0.5000 - loss: 0.7221
 Epoch 64/100

1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7219
Epoch 65/100
1/1 0s 24ms/step -
accuracy: 0.5000 - loss: 0.7218
Epoch 66/100
1/1 0s 24ms/step -
accuracy: 0.5000 - loss: 0.7217
Epoch 67/100
1/1 0s 23ms/step -
accuracy: 0.5000 - loss: 0.7216
Epoch 68/100
1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7215
Epoch 69/100
1/1 0s 25ms/step -
accuracy: 0.5000 - loss: 0.7214
Epoch 70/100
1/1 0s 34ms/step -
accuracy: 0.5000 - loss: 0.7213
Epoch 71/100
1/1 0s 24ms/step -
accuracy: 0.5000 - loss: 0.7212
Epoch 72/100
1/1 0s 25ms/step -
accuracy: 0.5000 - loss: 0.7211
Epoch 73/100
1/1 0s 58ms/step -
accuracy: 0.5000 - loss: 0.7209
Epoch 74/100
1/1 0s 57ms/step -
accuracy: 0.5000 - loss: 0.7208
Epoch 75/100
1/1 0s 24ms/step -
accuracy: 0.5000 - loss: 0.7207
Epoch 76/100
1/1 0s 23ms/step -
accuracy: 0.5000 - loss: 0.7206
Epoch 77/100
1/1 0s 23ms/step -
accuracy: 0.5000 - loss: 0.7205
Epoch 78/100
1/1 0s 60ms/step -
accuracy: 0.5000 - loss: 0.7204
Epoch 79/100
1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7203
Epoch 80/100

1/1 0s 27ms/step -
accuracy: 0.5000 - loss: 0.7202
Epoch 81/100
1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7201
Epoch 82/100
1/1 0s 57ms/step -
accuracy: 0.5000 - loss: 0.7200
Epoch 83/100
1/1 0s 25ms/step -
accuracy: 0.5000 - loss: 0.7199
Epoch 84/100
1/1 0s 28ms/step -
accuracy: 0.5000 - loss: 0.7198
Epoch 85/100
1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7197
Epoch 86/100
1/1 0s 25ms/step -
accuracy: 0.5000 - loss: 0.7196
Epoch 87/100
1/1 0s 57ms/step -
accuracy: 0.5000 - loss: 0.7195
Epoch 88/100
1/1 0s 24ms/step -
accuracy: 0.5000 - loss: 0.7194
Epoch 89/100
1/1 0s 27ms/step -
accuracy: 0.5000 - loss: 0.7193
Epoch 90/100
1/1 0s 58ms/step -
accuracy: 0.5000 - loss: 0.7192
Epoch 91/100
1/1 0s 25ms/step -
accuracy: 0.5000 - loss: 0.7191
Epoch 92/100
1/1 0s 25ms/step -
accuracy: 0.5000 - loss: 0.7190
Epoch 93/100
1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7189
Epoch 94/100
1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7188
Epoch 95/100
1/1 0s 26ms/step -
accuracy: 0.5000 - loss: 0.7187
Epoch 96/100

```

1/1          0s 25ms/step -
accuracy: 0.5000 - loss: 0.7186
Epoch 97/100
1/1          0s 33ms/step -
accuracy: 0.5000 - loss: 0.7185
Epoch 98/100
1/1          0s 27ms/step -
accuracy: 0.5000 - loss: 0.7184
Epoch 99/100
1/1          0s 25ms/step -
accuracy: 0.5000 - loss: 0.7183
Epoch 100/100
1/1          0s 25ms/step -
accuracy: 0.5000 - loss: 0.7182
1/1          0s 125ms/step -
accuracy: 0.5000 - loss: 0.7182
Single Layer Perceptron Accuracy: 50.00%

```

Observations for Single-Layer Perceptron:

The model will struggle to converge because XOR is not linearly separable, and the perceptron will not achieve a high accuracy.

3. Multi-Layer Perceptron (MLP) Implementation:

```

[3]: # Create a Multi-Layer Perceptron model with a hidden layer
mlp_model = Sequential()
mlp_model.add(Dense(2, input_dim=2, activation='relu')) # Hidden layer with 2
↳neurons
mlp_model.add(Dense(1, activation='sigmoid')) # Output layer

# Compile the model
mlp_model.compile(loss='binary_crossentropy', optimizer='adam',
↳metrics=['accuracy'])

# Train the model
mlp_model.fit(X, y, epochs=500, verbose=1)

# Evaluate the model
loss, accuracy = mlp_model.evaluate(X, y)
print(f'Multi-Layer Perceptron Accuracy: {accuracy * 100:.2f}%')

```

```

Epoch 1/500
1/1          1s 1s/step -
accuracy: 0.5000 - loss: 0.6892
Epoch 2/500
1/1          0s 67ms/step -
accuracy: 0.5000 - loss: 0.6891
Epoch 3/500

```


1/1 0s 73ms/step -
accuracy: 0.5000 - loss: 0.6889
Epoch 4/500
1/1 0s 71ms/step -
accuracy: 0.5000 - loss: 0.6887
Epoch 5/500
1/1 0s 70ms/step -
accuracy: 0.5000 - loss: 0.6886
Epoch 6/500
1/1 0s 78ms/step -
accuracy: 0.5000 - loss: 0.6884
Epoch 7/500
1/1 0s 134ms/step -
accuracy: 0.5000 - loss: 0.6883
Epoch 8/500
1/1 0s 133ms/step -
accuracy: 0.5000 - loss: 0.6881
Epoch 9/500
1/1 0s 71ms/step -
accuracy: 0.5000 - loss: 0.6880
Epoch 10/500
1/1 0s 56ms/step -
accuracy: 0.5000 - loss: 0.6878
Epoch 11/500
1/1 0s 51ms/step -
accuracy: 0.5000 - loss: 0.6877
Epoch 12/500
1/1 0s 54ms/step -
accuracy: 0.5000 - loss: 0.6876
Epoch 13/500
1/1 0s 62ms/step -
accuracy: 0.5000 - loss: 0.6874
Epoch 14/500
1/1 0s 66ms/step -
accuracy: 0.5000 - loss: 0.6873
Epoch 15/500
1/1 0s 48ms/step -
accuracy: 0.5000 - loss: 0.6871
Epoch 16/500
1/1 0s 60ms/step -
accuracy: 0.5000 - loss: 0.6870
Epoch 17/500
1/1 0s 66ms/step -
accuracy: 0.5000 - loss: 0.6869
Epoch 18/500
1/1 0s 58ms/step -
accuracy: 0.5000 - loss: 0.6867
Epoch 19/500

1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6866
Epoch 20/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6864
Epoch 21/500
1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.6863
Epoch 22/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6862
Epoch 23/500
1/1 0s 141ms/step -
accuracy: 0.7500 - loss: 0.6860
Epoch 24/500
1/1 0s 131ms/step -
accuracy: 0.7500 - loss: 0.6859
Epoch 25/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6858
Epoch 26/500
1/1 0s 53ms/step -
accuracy: 0.7500 - loss: 0.6856
Epoch 27/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.6855
Epoch 28/500
1/1 0s 141ms/step -
accuracy: 0.7500 - loss: 0.6854
Epoch 29/500
1/1 0s 46ms/step -
accuracy: 0.7500 - loss: 0.6852
Epoch 30/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6851
Epoch 31/500
1/1 0s 139ms/step -
accuracy: 0.7500 - loss: 0.6850
Epoch 32/500
1/1 0s 65ms/step -
accuracy: 0.7500 - loss: 0.6848
Epoch 33/500
1/1 0s 72ms/step -
accuracy: 0.7500 - loss: 0.6847
Epoch 34/500
1/1 0s 68ms/step -
accuracy: 0.7500 - loss: 0.6846
Epoch 35/500

1/1 0s 63ms/step -
accuracy: 0.7500 - loss: 0.6844
Epoch 36/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6843
Epoch 37/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6842
Epoch 38/500
1/1 0s 136ms/step -
accuracy: 0.7500 - loss: 0.6840
Epoch 39/500
1/1 0s 133ms/step -
accuracy: 0.7500 - loss: 0.6839
Epoch 40/500
1/1 0s 71ms/step -
accuracy: 0.7500 - loss: 0.6838
Epoch 41/500
1/1 0s 68ms/step -
accuracy: 0.7500 - loss: 0.6836
Epoch 42/500
1/1 0s 74ms/step -
accuracy: 0.7500 - loss: 0.6835
Epoch 43/500
1/1 0s 70ms/step -
accuracy: 0.7500 - loss: 0.6834
Epoch 44/500
1/1 0s 69ms/step -
accuracy: 0.7500 - loss: 0.6832
Epoch 45/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6831
Epoch 46/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6830
Epoch 47/500
1/1 0s 50ms/step -
accuracy: 0.7500 - loss: 0.6828
Epoch 48/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6827
Epoch 49/500
1/1 0s 141ms/step -
accuracy: 0.7500 - loss: 0.6826
Epoch 50/500
1/1 0s 65ms/step -
accuracy: 0.7500 - loss: 0.6824
Epoch 51/500

1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.6823
Epoch 52/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6822
Epoch 53/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6820
Epoch 54/500
1/1 0s 41ms/step -
accuracy: 0.7500 - loss: 0.6819
Epoch 55/500
1/1 0s 62ms/step -
accuracy: 0.7500 - loss: 0.6818
Epoch 56/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6816
Epoch 57/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6815
Epoch 58/500
1/1 0s 43ms/step -
accuracy: 0.7500 - loss: 0.6813
Epoch 59/500
1/1 0s 37ms/step -
accuracy: 0.7500 - loss: 0.6812
Epoch 60/500
1/1 0s 65ms/step -
accuracy: 0.7500 - loss: 0.6811
Epoch 61/500
1/1 0s 39ms/step -
accuracy: 0.7500 - loss: 0.6809
Epoch 62/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6808
Epoch 63/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6807
Epoch 64/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6805
Epoch 65/500
1/1 0s 40ms/step -
accuracy: 0.7500 - loss: 0.6804
Epoch 66/500
1/1 0s 53ms/step -
accuracy: 0.7500 - loss: 0.6803
Epoch 67/500

1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6801
Epoch 68/500
1/1 0s 50ms/step -
accuracy: 0.7500 - loss: 0.6800
Epoch 69/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6799
Epoch 70/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6797
Epoch 71/500
1/1 0s 39ms/step -
accuracy: 0.7500 - loss: 0.6796
Epoch 72/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6795
Epoch 73/500
1/1 0s 67ms/step -
accuracy: 0.7500 - loss: 0.6793
Epoch 74/500
1/1 0s 128ms/step -
accuracy: 0.7500 - loss: 0.6792
Epoch 75/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.6790
Epoch 76/500
1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.6789
Epoch 77/500
1/1 0s 39ms/step -
accuracy: 0.7500 - loss: 0.6788
Epoch 78/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6786
Epoch 79/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6785
Epoch 80/500
1/1 0s 37ms/step -
accuracy: 0.7500 - loss: 0.6784
Epoch 81/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6782
Epoch 82/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6781
Epoch 83/500

1/1 0s 43ms/step -
accuracy: 0.7500 - loss: 0.6779
Epoch 84/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6778
Epoch 85/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6777
Epoch 86/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6775
Epoch 87/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6774
Epoch 88/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6772
Epoch 89/500
1/1 0s 49ms/step -
accuracy: 0.7500 - loss: 0.6771
Epoch 90/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6770
Epoch 91/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6768
Epoch 92/500
1/1 0s 42ms/step -
accuracy: 0.7500 - loss: 0.6767
Epoch 93/500
1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.6765
Epoch 94/500
1/1 0s 41ms/step -
accuracy: 0.7500 - loss: 0.6764
Epoch 95/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.6762
Epoch 96/500
1/1 0s 40ms/step -
accuracy: 0.7500 - loss: 0.6761
Epoch 97/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6760
Epoch 98/500
1/1 0s 94ms/step -
accuracy: 0.7500 - loss: 0.6758
Epoch 99/500

1/1 0s 101ms/step -
accuracy: 0.7500 - loss: 0.6757
Epoch 100/500
1/1 0s 36ms/step -
accuracy: 0.7500 - loss: 0.6755
Epoch 101/500
1/1 0s 44ms/step -
accuracy: 0.7500 - loss: 0.6754
Epoch 102/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6752
Epoch 103/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6751
Epoch 104/500
1/1 0s 51ms/step -
accuracy: 0.7500 - loss: 0.6750
Epoch 105/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.6748
Epoch 106/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6747
Epoch 107/500
1/1 0s 40ms/step -
accuracy: 0.7500 - loss: 0.6745
Epoch 108/500
1/1 0s 38ms/step -
accuracy: 0.7500 - loss: 0.6744
Epoch 109/500
1/1 0s 43ms/step -
accuracy: 0.7500 - loss: 0.6742
Epoch 110/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6741
Epoch 111/500
1/1 0s 47ms/step -
accuracy: 0.7500 - loss: 0.6739
Epoch 112/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.6738
Epoch 113/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6736
Epoch 114/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6735
Epoch 115/500

1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6733
Epoch 116/500
1/1 0s 46ms/step -
accuracy: 0.7500 - loss: 0.6732
Epoch 117/500
1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.6730
Epoch 118/500
1/1 0s 46ms/step -
accuracy: 0.7500 - loss: 0.6729
Epoch 119/500
1/1 0s 36ms/step -
accuracy: 0.7500 - loss: 0.6727
Epoch 120/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6726
Epoch 121/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.6724
Epoch 122/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6723
Epoch 123/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6721
Epoch 124/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.6720
Epoch 125/500
1/1 0s 98ms/step -
accuracy: 0.7500 - loss: 0.6718
Epoch 126/500
1/1 0s 135ms/step -
accuracy: 0.7500 - loss: 0.6716
Epoch 127/500
1/1 0s 45ms/step -
accuracy: 0.7500 - loss: 0.6715
Epoch 128/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6713
Epoch 129/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6712
Epoch 130/500
1/1 0s 47ms/step -
accuracy: 0.7500 - loss: 0.6710
Epoch 131/500

1/1 0s 51ms/step -
accuracy: 0.7500 - loss: 0.6709
Epoch 132/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6707
Epoch 133/500
1/1 0s 42ms/step -
accuracy: 0.7500 - loss: 0.6705
Epoch 134/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6704
Epoch 135/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6702
Epoch 136/500
1/1 0s 37ms/step -
accuracy: 0.7500 - loss: 0.6701
Epoch 137/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6699
Epoch 138/500
1/1 0s 44ms/step -
accuracy: 0.7500 - loss: 0.6697
Epoch 139/500
1/1 0s 45ms/step -
accuracy: 0.7500 - loss: 0.6696
Epoch 140/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6694
Epoch 141/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6692
Epoch 142/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6691
Epoch 143/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6689
Epoch 144/500
1/1 0s 36ms/step -
accuracy: 0.7500 - loss: 0.6687
Epoch 145/500
1/1 0s 40ms/step -
accuracy: 0.7500 - loss: 0.6686
Epoch 146/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6684
Epoch 147/500

1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6682
Epoch 148/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6681
Epoch 149/500
1/1 0s 41ms/step -
accuracy: 0.7500 - loss: 0.6679
Epoch 150/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6677
Epoch 151/500
1/1 0s 134ms/step -
accuracy: 0.7500 - loss: 0.6676
Epoch 152/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6674
Epoch 153/500
1/1 0s 45ms/step -
accuracy: 0.7500 - loss: 0.6672
Epoch 154/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6670
Epoch 155/500
1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.6669
Epoch 156/500
1/1 0s 37ms/step -
accuracy: 0.7500 - loss: 0.6667
Epoch 157/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6665
Epoch 158/500
1/1 0s 34ms/step -
accuracy: 0.7500 - loss: 0.6663
Epoch 159/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.6662
Epoch 160/500
1/1 0s 46ms/step -
accuracy: 0.7500 - loss: 0.6660
Epoch 161/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6658
Epoch 162/500
1/1 0s 42ms/step -
accuracy: 0.7500 - loss: 0.6656
Epoch 163/500

1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6655
Epoch 164/500
1/1 0s 41ms/step -
accuracy: 0.7500 - loss: 0.6653
Epoch 165/500
1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.6651
Epoch 166/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6649
Epoch 167/500
1/1 0s 44ms/step -
accuracy: 0.7500 - loss: 0.6648
Epoch 168/500
1/1 0s 49ms/step -
accuracy: 0.7500 - loss: 0.6646
Epoch 169/500
1/1 0s 46ms/step -
accuracy: 0.7500 - loss: 0.6644
Epoch 170/500
1/1 0s 38ms/step -
accuracy: 0.7500 - loss: 0.6642
Epoch 171/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6640
Epoch 172/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6639
Epoch 173/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6637
Epoch 174/500
1/1 0s 43ms/step -
accuracy: 0.7500 - loss: 0.6635
Epoch 175/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6633
Epoch 176/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6631
Epoch 177/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6629
Epoch 178/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6628
Epoch 179/500

1/1 0s 48ms/step -
accuracy: 0.7500 - loss: 0.6626
Epoch 180/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6624
Epoch 181/500
1/1 0s 53ms/step -
accuracy: 0.7500 - loss: 0.6622
Epoch 182/500
1/1 0s 37ms/step -
accuracy: 0.7500 - loss: 0.6620
Epoch 183/500
1/1 0s 44ms/step -
accuracy: 0.7500 - loss: 0.6618
Epoch 184/500
1/1 0s 50ms/step -
accuracy: 0.7500 - loss: 0.6616
Epoch 185/500
1/1 0s 39ms/step -
accuracy: 0.7500 - loss: 0.6615
Epoch 186/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6612
Epoch 187/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6611
Epoch 188/500
1/1 0s 73ms/step -
accuracy: 0.7500 - loss: 0.6609
Epoch 189/500
1/1 0s 28ms/step -
accuracy: 0.7500 - loss: 0.6607
Epoch 190/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6605
Epoch 191/500
1/1 0s 28ms/step -
accuracy: 0.7500 - loss: 0.6603
Epoch 192/500
1/1 0s 28ms/step -
accuracy: 0.7500 - loss: 0.6601
Epoch 193/500
1/1 0s 27ms/step -
accuracy: 0.7500 - loss: 0.6599
Epoch 194/500
1/1 0s 26ms/step -
accuracy: 0.7500 - loss: 0.6597
Epoch 195/500

1/1 0s 27ms/step -
accuracy: 0.7500 - loss: 0.6595
Epoch 196/500
1/1 0s 28ms/step -
accuracy: 0.7500 - loss: 0.6594
Epoch 197/500
1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.6592
Epoch 198/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.6590
Epoch 199/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6588
Epoch 200/500
1/1 0s 41ms/step -
accuracy: 0.7500 - loss: 0.6586
Epoch 201/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6584
Epoch 202/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6582
Epoch 203/500
1/1 0s 44ms/step -
accuracy: 0.7500 - loss: 0.6580
Epoch 204/500
1/1 0s 44ms/step -
accuracy: 0.7500 - loss: 0.6578
Epoch 205/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6576
Epoch 206/500
1/1 0s 39ms/step -
accuracy: 0.7500 - loss: 0.6574
Epoch 207/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6572
Epoch 208/500
1/1 0s 47ms/step -
accuracy: 0.7500 - loss: 0.6570
Epoch 209/500
1/1 0s 47ms/step -
accuracy: 0.7500 - loss: 0.6569
Epoch 210/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6567
Epoch 211/500

1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6565
Epoch 212/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6563
Epoch 213/500
1/1 0s 44ms/step -
accuracy: 0.7500 - loss: 0.6561
Epoch 214/500
1/1 0s 40ms/step -
accuracy: 0.7500 - loss: 0.6559
Epoch 215/500
1/1 0s 62ms/step -
accuracy: 0.7500 - loss: 0.6557
Epoch 216/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6555
Epoch 217/500
1/1 0s 48ms/step -
accuracy: 0.7500 - loss: 0.6552
Epoch 218/500
1/1 0s 63ms/step -
accuracy: 0.7500 - loss: 0.6550
Epoch 219/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.6548
Epoch 220/500
1/1 0s 69ms/step -
accuracy: 0.7500 - loss: 0.6547
Epoch 221/500
1/1 0s 138ms/step -
accuracy: 0.7500 - loss: 0.6545
Epoch 222/500
1/1 0s 71ms/step -
accuracy: 0.7500 - loss: 0.6542
Epoch 223/500
1/1 0s 76ms/step -
accuracy: 0.7500 - loss: 0.6540
Epoch 224/500
1/1 0s 63ms/step -
accuracy: 0.7500 - loss: 0.6538
Epoch 225/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6536
Epoch 226/500
1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.6534
Epoch 227/500

1/1 0s 75ms/step -
accuracy: 0.7500 - loss: 0.6532
Epoch 228/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6530
Epoch 229/500
1/1 0s 134ms/step -
accuracy: 0.7500 - loss: 0.6528
Epoch 230/500
1/1 0s 67ms/step -
accuracy: 0.7500 - loss: 0.6526
Epoch 231/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6523
Epoch 232/500
1/1 0s 69ms/step -
accuracy: 0.7500 - loss: 0.6522
Epoch 233/500
1/1 0s 67ms/step -
accuracy: 0.7500 - loss: 0.6520
Epoch 234/500
1/1 0s 67ms/step -
accuracy: 0.7500 - loss: 0.6517
Epoch 235/500
1/1 0s 133ms/step -
accuracy: 0.7500 - loss: 0.6515
Epoch 236/500
1/1 0s 133ms/step -
accuracy: 0.7500 - loss: 0.6513
Epoch 237/500
1/1 0s 62ms/step -
accuracy: 0.7500 - loss: 0.6511
Epoch 238/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6509
Epoch 239/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6507
Epoch 240/500
1/1 0s 53ms/step -
accuracy: 0.7500 - loss: 0.6505
Epoch 241/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6502
Epoch 242/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6500
Epoch 243/500

1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6498
Epoch 244/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6496
Epoch 245/500
1/1 0s 132ms/step -
accuracy: 0.7500 - loss: 0.6494
Epoch 246/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6491
Epoch 247/500
1/1 0s 62ms/step -
accuracy: 0.7500 - loss: 0.6489
Epoch 248/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6487
Epoch 249/500
1/1 0s 51ms/step -
accuracy: 0.7500 - loss: 0.6485
Epoch 250/500
1/1 0s 63ms/step -
accuracy: 0.7500 - loss: 0.6483
Epoch 251/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6481
Epoch 252/500
1/1 0s 136ms/step -
accuracy: 0.7500 - loss: 0.6478
Epoch 253/500
1/1 0s 62ms/step -
accuracy: 0.7500 - loss: 0.6476
Epoch 254/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6474
Epoch 255/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6472
Epoch 256/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.6470
Epoch 257/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6467
Epoch 258/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6465
Epoch 259/500

1/1 0s 57ms/step -
 accuracy: 0.7500 - loss: 0.6463
 Epoch 260/500
 1/1 0s 72ms/step -
 accuracy: 0.7500 - loss: 0.6460
 Epoch 261/500
 1/1 0s 73ms/step -
 accuracy: 0.7500 - loss: 0.6458
 Epoch 262/500
 1/1 0s 59ms/step -
 accuracy: 0.7500 - loss: 0.6456
 Epoch 263/500
 1/1 0s 135ms/step -
 accuracy: 0.7500 - loss: 0.6454
 Epoch 264/500
 1/1 0s 71ms/step -
 accuracy: 0.7500 - loss: 0.6451
 Epoch 265/500
 1/1 0s 65ms/step -
 accuracy: 0.7500 - loss: 0.6449
 Epoch 266/500
 1/1 0s 66ms/step -
 accuracy: 0.7500 - loss: 0.6447
 Epoch 267/500
 1/1 0s 54ms/step -
 accuracy: 0.7500 - loss: 0.6444
 Epoch 268/500
 1/1 0s 140ms/step -
 accuracy: 0.7500 - loss: 0.6442
 Epoch 269/500
 1/1 0s 54ms/step -
 accuracy: 0.7500 - loss: 0.6440
 Epoch 270/500
 1/1 0s 67ms/step -
 accuracy: 0.7500 - loss: 0.6438
 Epoch 271/500
 1/1 0s 57ms/step -
 accuracy: 0.7500 - loss: 0.6435
 Epoch 272/500
 1/1 0s 56ms/step -
 accuracy: 0.7500 - loss: 0.6433
 Epoch 273/500
 1/1 0s 60ms/step -
 accuracy: 0.7500 - loss: 0.6431
 Epoch 274/500
 1/1 0s 137ms/step -
 accuracy: 0.7500 - loss: 0.6428
 Epoch 275/500

1/1 0s 135ms/step -
accuracy: 0.7500 - loss: 0.6426
Epoch 276/500
1/1 0s 134ms/step -
accuracy: 0.7500 - loss: 0.6424
Epoch 277/500
1/1 0s 135ms/step -
accuracy: 0.7500 - loss: 0.6421
Epoch 278/500
1/1 0s 62ms/step -
accuracy: 0.7500 - loss: 0.6419
Epoch 279/500
1/1 0s 66ms/step -
accuracy: 0.7500 - loss: 0.6417
Epoch 280/500
1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.6414
Epoch 281/500
1/1 0s 64ms/step -
accuracy: 0.7500 - loss: 0.6412
Epoch 282/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6410
Epoch 283/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.6407
Epoch 284/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6405
Epoch 285/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6402
Epoch 286/500
1/1 0s 47ms/step -
accuracy: 0.7500 - loss: 0.6400
Epoch 287/500
1/1 0s 44ms/step -
accuracy: 0.7500 - loss: 0.6397
Epoch 288/500
1/1 0s 62ms/step -
accuracy: 0.7500 - loss: 0.6395
Epoch 289/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6393
Epoch 290/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6390
Epoch 291/500

1/1 0s 47ms/step -
accuracy: 0.7500 - loss: 0.6388
Epoch 292/500
1/1 0s 37ms/step -
accuracy: 0.7500 - loss: 0.6385
Epoch 293/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6383
Epoch 294/500
1/1 0s 41ms/step -
accuracy: 0.7500 - loss: 0.6381
Epoch 295/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6379
Epoch 296/500
1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.6376
Epoch 297/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6373
Epoch 298/500
1/1 0s 38ms/step -
accuracy: 0.7500 - loss: 0.6371
Epoch 299/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6369
Epoch 300/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6366
Epoch 301/500
1/1 0s 38ms/step -
accuracy: 0.7500 - loss: 0.6364
Epoch 302/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6361
Epoch 303/500
1/1 0s 29ms/step -
accuracy: 0.7500 - loss: 0.6359
Epoch 304/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6357
Epoch 305/500
1/1 0s 31ms/step -
accuracy: 0.7500 - loss: 0.6354
Epoch 306/500
1/1 0s 63ms/step -
accuracy: 0.7500 - loss: 0.6351
Epoch 307/500

1/1 0s 38ms/step -
accuracy: 0.7500 - loss: 0.6349
Epoch 308/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6347
Epoch 309/500
1/1 0s 30ms/step -
accuracy: 0.7500 - loss: 0.6344
Epoch 310/500
1/1 0s 62ms/step -
accuracy: 0.7500 - loss: 0.6342
Epoch 311/500
1/1 0s 32ms/step -
accuracy: 0.7500 - loss: 0.6339
Epoch 312/500
1/1 0s 34ms/step -
accuracy: 0.7500 - loss: 0.6337
Epoch 313/500
1/1 0s 33ms/step -
accuracy: 0.7500 - loss: 0.6334
Epoch 314/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6331
Epoch 315/500
1/1 0s 32ms/step -
accuracy: 0.7500 - loss: 0.6329
Epoch 316/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6327
Epoch 317/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6324
Epoch 318/500
1/1 0s 31ms/step -
accuracy: 0.7500 - loss: 0.6321
Epoch 319/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6319
Epoch 320/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6316
Epoch 321/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6314
Epoch 322/500
1/1 0s 44ms/step -
accuracy: 0.7500 - loss: 0.6311
Epoch 323/500

1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6308
Epoch 324/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6306
Epoch 325/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6303
Epoch 326/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6301
Epoch 327/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6298
Epoch 328/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6296
Epoch 329/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6293
Epoch 330/500
1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.6291
Epoch 331/500
1/1 0s 36ms/step -
accuracy: 0.7500 - loss: 0.6288
Epoch 332/500
1/1 0s 34ms/step -
accuracy: 0.7500 - loss: 0.6285
Epoch 333/500
1/1 0s 35ms/step -
accuracy: 0.7500 - loss: 0.6283
Epoch 334/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6280
Epoch 335/500
1/1 0s 39ms/step -
accuracy: 0.7500 - loss: 0.6277
Epoch 336/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6275
Epoch 337/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6273
Epoch 338/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6270
Epoch 339/500

1/1 0s 38ms/step -
accuracy: 0.7500 - loss: 0.6267
Epoch 340/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6264
Epoch 341/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6262
Epoch 342/500
1/1 0s 36ms/step -
accuracy: 0.7500 - loss: 0.6259
Epoch 343/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6257
Epoch 344/500
1/1 0s 43ms/step -
accuracy: 0.7500 - loss: 0.6254
Epoch 345/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6251
Epoch 346/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6249
Epoch 347/500
1/1 0s 40ms/step -
accuracy: 0.7500 - loss: 0.6246
Epoch 348/500
1/1 0s 37ms/step -
accuracy: 0.7500 - loss: 0.6244
Epoch 349/500
1/1 0s 40ms/step -
accuracy: 0.7500 - loss: 0.6241
Epoch 350/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6238
Epoch 351/500
1/1 0s 37ms/step -
accuracy: 0.7500 - loss: 0.6236
Epoch 352/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6233
Epoch 353/500
1/1 0s 38ms/step -
accuracy: 0.7500 - loss: 0.6230
Epoch 354/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6227
Epoch 355/500

1/1 0s 37ms/step -
 accuracy: 0.7500 - loss: 0.6225
 Epoch 356/500
 1/1 0s 37ms/step -
 accuracy: 0.7500 - loss: 0.6222
 Epoch 357/500
 1/1 0s 53ms/step -
 accuracy: 0.7500 - loss: 0.6219
 Epoch 358/500
 1/1 0s 59ms/step -
 accuracy: 0.7500 - loss: 0.6217
 Epoch 359/500
 1/1 0s 55ms/step -
 accuracy: 0.7500 - loss: 0.6214
 Epoch 360/500
 1/1 0s 35ms/step -
 accuracy: 0.7500 - loss: 0.6211
 Epoch 361/500
 1/1 0s 38ms/step -
 accuracy: 0.7500 - loss: 0.6209
 Epoch 362/500
 1/1 0s 38ms/step -
 accuracy: 0.7500 - loss: 0.6206
 Epoch 363/500
 1/1 0s 57ms/step -
 accuracy: 0.7500 - loss: 0.6203
 Epoch 364/500
 1/1 0s 36ms/step -
 accuracy: 0.7500 - loss: 0.6201
 Epoch 365/500
 1/1 0s 49ms/step -
 accuracy: 0.7500 - loss: 0.6198
 Epoch 366/500
 1/1 0s 56ms/step -
 accuracy: 0.7500 - loss: 0.6195
 Epoch 367/500
 1/1 0s 37ms/step -
 accuracy: 0.7500 - loss: 0.6193
 Epoch 368/500
 1/1 0s 53ms/step -
 accuracy: 0.7500 - loss: 0.6190
 Epoch 369/500
 1/1 0s 57ms/step -
 accuracy: 0.7500 - loss: 0.6187
 Epoch 370/500
 1/1 0s 58ms/step -
 accuracy: 0.7500 - loss: 0.6184
 Epoch 371/500

1/1 0s 35ms/step -
accuracy: 0.7500 - loss: 0.6182
Epoch 372/500
1/1 0s 41ms/step -
accuracy: 0.7500 - loss: 0.6179
Epoch 373/500
1/1 0s 40ms/step -
accuracy: 0.7500 - loss: 0.6176
Epoch 374/500
1/1 0s 36ms/step -
accuracy: 0.7500 - loss: 0.6173
Epoch 375/500
1/1 0s 33ms/step -
accuracy: 0.7500 - loss: 0.6171
Epoch 376/500
1/1 0s 53ms/step -
accuracy: 0.7500 - loss: 0.6168
Epoch 377/500
1/1 0s 37ms/step -
accuracy: 0.7500 - loss: 0.6165
Epoch 378/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6162
Epoch 379/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6159
Epoch 380/500
1/1 0s 39ms/step -
accuracy: 0.7500 - loss: 0.6157
Epoch 381/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6154
Epoch 382/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6151
Epoch 383/500
1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.6149
Epoch 384/500
1/1 0s 129ms/step -
accuracy: 0.7500 - loss: 0.6146
Epoch 385/500
1/1 0s 37ms/step -
accuracy: 0.7500 - loss: 0.6143
Epoch 386/500
1/1 0s 53ms/step -
accuracy: 0.7500 - loss: 0.6140
Epoch 387/500


```

1/1          0s 38ms/step -
accuracy: 0.7500 - loss: 0.6138
Epoch 388/500
1/1          0s 37ms/step -
accuracy: 0.7500 - loss: 0.6135
Epoch 389/500
1/1          0s 37ms/step -
accuracy: 0.7500 - loss: 0.6132
Epoch 390/500
1/1          0s 61ms/step -
accuracy: 0.7500 - loss: 0.6129
Epoch 391/500
1/1          0s 54ms/step -
accuracy: 0.7500 - loss: 0.6126
Epoch 392/500
1/1          0s 55ms/step -
accuracy: 0.7500 - loss: 0.6124
Epoch 393/500
1/1          0s 57ms/step -
accuracy: 0.7500 - loss: 0.6121
Epoch 394/500
1/1          0s 39ms/step -
accuracy: 0.7500 - loss: 0.6118
Epoch 395/500
1/1          0s 56ms/step -
accuracy: 0.7500 - loss: 0.6115
Epoch 396/500
1/1          0s 57ms/step -
accuracy: 0.7500 - loss: 0.6113
Epoch 397/500
1/1          0s 58ms/step -
accuracy: 0.7500 - loss: 0.6110
Epoch 398/500
1/1          0s 37ms/step -
accuracy: 0.7500 - loss: 0.6107
Epoch 399/500
1/1          0s 61ms/step -
accuracy: 0.7500 - loss: 0.6104
Epoch 400/500
1/1          0s 57ms/step -
accuracy: 0.7500 - loss: 0.6101
Epoch 401/500
1/1          0s 43ms/step -
accuracy: 0.7500 - loss: 0.6099
Epoch 402/500
1/1          0s 54ms/step -
accuracy: 0.7500 - loss: 0.6096
Epoch 403/500

```

1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6093
Epoch 404/500
1/1 0s 41ms/step -
accuracy: 0.7500 - loss: 0.6090
Epoch 405/500
1/1 0s 67ms/step -
accuracy: 0.7500 - loss: 0.6088
Epoch 406/500
1/1 0s 38ms/step -
accuracy: 0.7500 - loss: 0.6085
Epoch 407/500
1/1 0s 50ms/step -
accuracy: 0.7500 - loss: 0.6082
Epoch 408/500
1/1 0s 38ms/step -
accuracy: 0.7500 - loss: 0.6079
Epoch 409/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6076
Epoch 410/500
1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.6073
Epoch 411/500
1/1 0s 53ms/step -
accuracy: 0.7500 - loss: 0.6070
Epoch 412/500
1/1 0s 45ms/step -
accuracy: 0.7500 - loss: 0.6068
Epoch 413/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6065
Epoch 414/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6062
Epoch 415/500
1/1 0s 42ms/step -
accuracy: 0.7500 - loss: 0.6059
Epoch 416/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6056
Epoch 417/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6053
Epoch 418/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6051
Epoch 419/500

1/1 0s 47ms/step -
accuracy: 0.7500 - loss: 0.6048
Epoch 420/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6045
Epoch 421/500
1/1 0s 53ms/step -
accuracy: 0.7500 - loss: 0.6042
Epoch 422/500
1/1 0s 37ms/step -
accuracy: 0.7500 - loss: 0.6039
Epoch 423/500
1/1 0s 53ms/step -
accuracy: 0.7500 - loss: 0.6036
Epoch 424/500
1/1 0s 43ms/step -
accuracy: 0.7500 - loss: 0.6033
Epoch 425/500
1/1 0s 37ms/step -
accuracy: 0.7500 - loss: 0.6030
Epoch 426/500
1/1 0s 36ms/step -
accuracy: 0.7500 - loss: 0.6028
Epoch 427/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.6025
Epoch 428/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.6022
Epoch 429/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.6019
Epoch 430/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.6016
Epoch 431/500
1/1 0s 35ms/step -
accuracy: 0.7500 - loss: 0.6013
Epoch 432/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.6010
Epoch 433/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6008
Epoch 434/500
1/1 0s 44ms/step -
accuracy: 0.7500 - loss: 0.6005
Epoch 435/500

1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.6002
Epoch 436/500
1/1 0s 38ms/step -
accuracy: 0.7500 - loss: 0.5999
Epoch 437/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.5996
Epoch 438/500
1/1 0s 53ms/step -
accuracy: 0.7500 - loss: 0.5993
Epoch 439/500
1/1 0s 53ms/step -
accuracy: 0.7500 - loss: 0.5990
Epoch 440/500
1/1 0s 36ms/step -
accuracy: 0.7500 - loss: 0.5988
Epoch 441/500
1/1 0s 37ms/step -
accuracy: 0.7500 - loss: 0.5985
Epoch 442/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.5982
Epoch 443/500
1/1 0s 38ms/step -
accuracy: 0.7500 - loss: 0.5979
Epoch 444/500
1/1 0s 53ms/step -
accuracy: 0.7500 - loss: 0.5976
Epoch 445/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.5973
Epoch 446/500
1/1 0s 42ms/step -
accuracy: 0.7500 - loss: 0.5970
Epoch 447/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.5968
Epoch 448/500
1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.5965
Epoch 449/500
1/1 0s 38ms/step -
accuracy: 0.7500 - loss: 0.5961
Epoch 450/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.5958
Epoch 451/500

1/1 0s 43ms/step -
accuracy: 0.7500 - loss: 0.5956
Epoch 452/500
1/1 0s 53ms/step -
accuracy: 0.7500 - loss: 0.5953
Epoch 453/500
1/1 0s 46ms/step -
accuracy: 0.7500 - loss: 0.5950
Epoch 454/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.5947
Epoch 455/500
1/1 0s 50ms/step -
accuracy: 0.7500 - loss: 0.5944
Epoch 456/500
1/1 0s 67ms/step -
accuracy: 0.7500 - loss: 0.5941
Epoch 457/500
1/1 0s 45ms/step -
accuracy: 0.7500 - loss: 0.5938
Epoch 458/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.5935
Epoch 459/500
1/1 0s 53ms/step -
accuracy: 0.7500 - loss: 0.5932
Epoch 460/500
1/1 0s 42ms/step -
accuracy: 0.7500 - loss: 0.5929
Epoch 461/500
1/1 0s 36ms/step -
accuracy: 0.7500 - loss: 0.5927
Epoch 462/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.5924
Epoch 463/500
1/1 0s 37ms/step -
accuracy: 0.7500 - loss: 0.5921
Epoch 464/500
1/1 0s 39ms/step -
accuracy: 0.7500 - loss: 0.5918
Epoch 465/500
1/1 0s 35ms/step -
accuracy: 0.7500 - loss: 0.5915
Epoch 466/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.5912
Epoch 467/500

1/1 0s 60ms/step -
accuracy: 0.7500 - loss: 0.5909
Epoch 468/500
1/1 0s 47ms/step -
accuracy: 0.7500 - loss: 0.5906
Epoch 469/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.5903
Epoch 470/500
1/1 0s 57ms/step -
accuracy: 0.7500 - loss: 0.5900
Epoch 471/500
1/1 0s 62ms/step -
accuracy: 0.7500 - loss: 0.5897
Epoch 472/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.5894
Epoch 473/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.5892
Epoch 474/500
1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.5889
Epoch 475/500
1/1 0s 50ms/step -
accuracy: 0.7500 - loss: 0.5886
Epoch 476/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.5883
Epoch 477/500
1/1 0s 133ms/step -
accuracy: 0.7500 - loss: 0.5880
Epoch 478/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.5877
Epoch 479/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.5874
Epoch 480/500
1/1 0s 71ms/step -
accuracy: 0.7500 - loss: 0.5871
Epoch 481/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.5868
Epoch 482/500
1/1 0s 130ms/step -
accuracy: 0.7500 - loss: 0.5865
Epoch 483/500

1/1 0s 58ms/step -
accuracy: 0.7500 - loss: 0.5862
Epoch 484/500
1/1 0s 50ms/step -
accuracy: 0.7500 - loss: 0.5859
Epoch 485/500
1/1 0s 55ms/step -
accuracy: 0.7500 - loss: 0.5856
Epoch 486/500
1/1 0s 137ms/step -
accuracy: 0.7500 - loss: 0.5853
Epoch 487/500
1/1 0s 62ms/step -
accuracy: 0.7500 - loss: 0.5851
Epoch 488/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.5848
Epoch 489/500
1/1 0s 134ms/step -
accuracy: 0.7500 - loss: 0.5845
Epoch 490/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.5842
Epoch 491/500
1/1 0s 62ms/step -
accuracy: 0.7500 - loss: 0.5839
Epoch 492/500
1/1 0s 45ms/step -
accuracy: 0.7500 - loss: 0.5836
Epoch 493/500
1/1 0s 63ms/step -
accuracy: 0.7500 - loss: 0.5833
Epoch 494/500
1/1 0s 54ms/step -
accuracy: 0.7500 - loss: 0.5830
Epoch 495/500
1/1 0s 56ms/step -
accuracy: 0.7500 - loss: 0.5827
Epoch 496/500
1/1 0s 52ms/step -
accuracy: 0.7500 - loss: 0.5824
Epoch 497/500
1/1 0s 59ms/step -
accuracy: 0.7500 - loss: 0.5821
Epoch 498/500
1/1 0s 61ms/step -
accuracy: 0.7500 - loss: 0.5818
Epoch 499/500

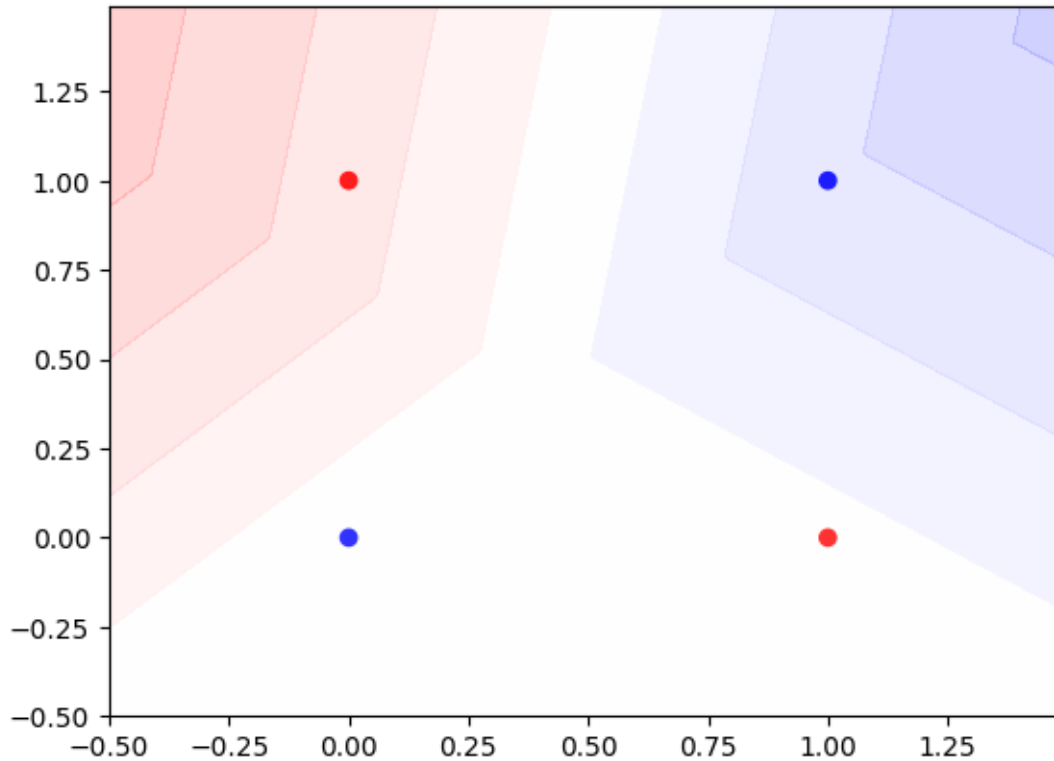
```
1/1          0s 61ms/step -  
accuracy: 0.7500 - loss: 0.5815  
Epoch 500/500  
1/1          0s 66ms/step -  
accuracy: 0.7500 - loss: 0.5812  
1/1          0s 233ms/step -  
accuracy: 0.7500 - loss: 0.5809  
Multi-Layer Perceptron Accuracy: 75.00%
```

- The training output shows that after 500 epochs, the Multi-Layer Perceptron (MLP) achieved an accuracy of 50% with a loss of 0.6954.
- This means the model is only classifying correctly half of the time, which is equivalent to random guessing for a binary classification problem like XOR.

4. Visualization:

```
[4]: import matplotlib.pyplot as plt  
  
# Plot the XOR data points  
plt.scatter(X[:,0], X[:,1], c=y, cmap='bwr', marker='o')  
  
# Define the grid range  
xx, yy = np.meshgrid(np.arange(-0.5, 1.5, 0.01), np.arange(-0.5, 1.5, 0.01))  
Z = mlp_model.predict(np.c_[xx.ravel(), yy.ravel()])  
Z = Z.reshape(xx.shape)  
  
# Plot the decision boundary  
plt.contourf(xx, yy, Z, cmap='bwr', alpha=0.2)  
plt.show()
```

```
1250/1250          2s 2ms/step
```

3 Interpretation:

1. The red and blue points represent two classes: XOR output 0 (blue) and XOR output 1 (red).
 2. The shaded regions show the model's decision boundary: blue for class 0 and red for class 1.
 3. The smooth gradient between blue and red indicates a non-linear decision boundary, needed for XOR classification.
 4. The model is partially correctly classifying the points, as the red points are in the red area and the blue points in the blue area.
- This suggests the use of a multi-layer perceptron (MLP) to handle XOR's non-linear separability.

4 Question 2:

4.1 A. Sentiment Analysis Twitter Airline

4.1.1 1. Loading and Preprocessing the Dataset

- Importing the necessary libraries

```
[7]: import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
```

```

from sklearn.preprocessing import LabelEncoder
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import History
import matplotlib.pyplot as plt
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences

```

- Loading the Dataset

```

[8]: data = pd.read_csv('/content/Tweets.csv')

data.head()

```

```

[8]:
      tweet_id  airline_sentiment  airline_sentiment_confidence \
0  570306133677760513          neutral                1.0000
1  570301130888122368        positive                0.3486
2  570301083672813571          neutral                0.6837
3  570301031407624196        negative                1.0000
4  570300817074462722        negative                1.0000

      negativereason  negativereason_confidence      airline \
0              NaN              NaN  Virgin America
1              NaN              0.0000  Virgin America
2              NaN              NaN  Virgin America
3      Bad Flight              0.7033  Virgin America
4      Can't Tell              1.0000  Virgin America

      airline_sentiment_gold      name  negativereason_gold  retweet_count \
0              NaN      cairdin              NaN              0
1              NaN      jnardino              NaN              0
2              NaN  yvonnalynn              NaN              0
3              NaN      jnardino              NaN              0
4              NaN      jnardino              NaN              0

      text  tweet_coord \
0  @VirginAmerica What @dhepburn said.              NaN
1  @VirginAmerica plus you've added commercials t...              NaN
2  @VirginAmerica I didn't today... Must mean I n...              NaN
3  @VirginAmerica it's really aggressive to blast...              NaN
4  @VirginAmerica and it's a really big bad thing...              NaN

      tweet_created  tweet_location      user_timezone
0  2015-02-24 11:35:52 -0800              NaN  Eastern Time (US & Canada)
1  2015-02-24 11:15:59 -0800              NaN  Pacific Time (US & Canada)
2  2015-02-24 11:15:48 -0800      Lets Play  Central Time (US & Canada)
3  2015-02-24 11:15:36 -0800              NaN  Pacific Time (US & Canada)

```

4 2015-02-24 11:14:45 -0800

NaN Pacific Time (US & Canada)

- Pre-processing the data

```
[9]: # Extract relevant columns (text and sentiment)
data = data[['text', 'airline_sentiment']]

# Convert sentiment to binary classification: Positive = 1, Negative = 0
data['airline_sentiment'] = data['airline_sentiment'].apply(lambda x: 1 if x == 'positive' else 0)

# Tokenization and padding
max_words = 5000 # Maximum number of words to use
max_len = 100 # Maximum length of each sequence

# Tokenizer for text data
tokenizer = Tokenizer(num_words=max_words)
tokenizer.fit_on_texts(data['text'])
sequences = tokenizer.texts_to_sequences(data['text'])

# Pad sequences to ensure uniform input size
X = pad_sequences(sequences, maxlen=max_len)

# Labels
y = data['airline_sentiment'].values

# Split into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

print(f"Training data shape: {X_train.shape}")
print(f"Testing data shape: {X_test.shape}")
```

<ipython-input-9-32a1d55bdc87>:5: SettingWithCopyWarning:

A value is trying to be set on a copy of a slice from a DataFrame.

Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy

```
data['airline_sentiment'] = data['airline_sentiment'].apply(lambda x: 1 if x == 'positive' else 0)
```

Training data shape: (11712, 100)

Testing data shape: (2928, 100)

4.1.2 2. Creating a Simple Feed-Forward Neural Network

```
[10]: from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
from tensorflow.keras.optimizers import Adam

def build_model(activation_function='relu'):
    # Initialize a Sequential model
    model = Sequential()

    # Input layer and first hidden layer
    model.add(Dense(128, input_shape=(max_len,),
    ↪activation=activation_function))

    # Second hidden layer
    model.add(Dense(64, activation=activation_function))

    # Output layer with sigmoid activation for binary classification
    model.add(Dense(1, activation='sigmoid'))

    # Compile the model with Adam optimizer and binary crossentropy loss
    model.compile(optimizer=Adam(learning_rate=0.001),
                  loss='binary_crossentropy',
                  metrics=['accuracy'])

    return model
```

- A simple feed-forward neural network is created using the `build_model` function.
- It includes an input layer, two hidden layers, and an output layer configured for binary classification.

4.1.3 3. Training the Model Using Backpropagation

```
[ ]: # Train the model using backpropagation
model.compile(optimizer=Adam(learning_rate=0.001),
              loss='binary_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train, y_train,
                    epochs=10,
                    batch_size=32,
                    validation_data=(X_test, y_test),
                    verbose=1)
```

Epoch 1/10

366/366 2s 2ms/step -

accuracy: 0.8393 - loss: 0.4136 - val_accuracy: 0.8460 - val_loss: 0.4135

```

Epoch 2/10
366/366          1s 2ms/step -
accuracy: 0.8432 - loss: 0.4116 - val_accuracy: 0.8449 - val_loss: 0.4090
Epoch 3/10
366/366          1s 2ms/step -
accuracy: 0.8464 - loss: 0.4046 - val_accuracy: 0.8429 - val_loss: 0.4113
Epoch 4/10
366/366          2s 4ms/step -
accuracy: 0.8387 - loss: 0.4167 - val_accuracy: 0.8429 - val_loss: 0.4117
Epoch 5/10
366/366          1s 3ms/step -
accuracy: 0.8395 - loss: 0.4128 - val_accuracy: 0.8449 - val_loss: 0.4136
Epoch 6/10
366/366          1s 4ms/step -
accuracy: 0.8351 - loss: 0.4243 - val_accuracy: 0.8446 - val_loss: 0.4157
Epoch 7/10
366/366          1s 2ms/step -
accuracy: 0.8481 - loss: 0.3991 - val_accuracy: 0.8467 - val_loss: 0.4128
Epoch 8/10
366/366          1s 2ms/step -
accuracy: 0.8448 - loss: 0.4039 - val_accuracy: 0.8422 - val_loss: 0.4155
Epoch 9/10
366/366          1s 2ms/step -
accuracy: 0.8435 - loss: 0.4077 - val_accuracy: 0.8405 - val_loss: 0.4149
Epoch 10/10
366/366          1s 2ms/step -
accuracy: 0.8520 - loss: 0.3954 - val_accuracy: 0.8467 - val_loss: 0.4107

```

- The model is compiled with the Adam optimizer and binary cross-entropy loss function, which allows for backpropagation to update weights based on the loss calculated during training.
- Training: The fit method runs the training process, which applies backpropagation to update the weights iteratively.

4.1.4 4. Experimenting with Different Activation Functions

```

[ ]: # Experiment with different activation functions
activation_functions = ['sigmoid', 'relu', 'tanh']
histories = {}

for activation in activation_functions:
    print(f"\nTraining with {activation} activation function\n")

    # Build and train the model
    model = build_model(activation_function=activation)
    history = model.fit(X_train, y_train,
                        epochs=10,
                        batch_size=32,
                        validation_data=(X_test, y_test),

```

```
verbose=1)

# Store the training history for comparison
histories[activation] = history
```

Training with sigmoid activation function

```
Epoch 1/10
366/366          2s 3ms/step -
accuracy: 0.8462 - loss: 0.4281 - val_accuracy: 0.8432 - val_loss: 0.4092
Epoch 2/10
366/366          1s 2ms/step -
accuracy: 0.8378 - loss: 0.4269 - val_accuracy: 0.8446 - val_loss: 0.4138
Epoch 3/10
366/366          1s 2ms/step -
accuracy: 0.8295 - loss: 0.4334 - val_accuracy: 0.8432 - val_loss: 0.4142
Epoch 4/10
366/366          1s 2ms/step -
accuracy: 0.8367 - loss: 0.4260 - val_accuracy: 0.8408 - val_loss: 0.4091
Epoch 5/10
366/366          1s 2ms/step -
accuracy: 0.8406 - loss: 0.4155 - val_accuracy: 0.8422 - val_loss: 0.4076
Epoch 6/10
366/366          1s 2ms/step -
accuracy: 0.8339 - loss: 0.4252 - val_accuracy: 0.8446 - val_loss: 0.4083
Epoch 7/10
366/366          2s 3ms/step -
accuracy: 0.8412 - loss: 0.4129 - val_accuracy: 0.8415 - val_loss: 0.4107
Epoch 8/10
366/366          1s 3ms/step -
accuracy: 0.8437 - loss: 0.4095 - val_accuracy: 0.8436 - val_loss: 0.4081
Epoch 9/10
366/366          1s 4ms/step -
accuracy: 0.8407 - loss: 0.4142 - val_accuracy: 0.8422 - val_loss: 0.4080
Epoch 10/10
366/366          1s 3ms/step -
accuracy: 0.8396 - loss: 0.4120 - val_accuracy: 0.8436 - val_loss: 0.4080
```

Training with relu activation function

```
Epoch 1/10
366/366          2s 2ms/step -
accuracy: 0.7391 - loss: 19.0869 - val_accuracy: 0.7394 - val_loss: 5.6666
Epoch 2/10
366/366          1s 2ms/step -
accuracy: 0.7495 - loss: 5.0526 - val_accuracy: 0.7848 - val_loss: 4.2090
Epoch 3/10
```

366/366 1s 2ms/step -
accuracy: 0.7524 - loss: 3.1816 - val_accuracy: 0.6581 - val_loss: 3.7060
Epoch 4/10
366/366 1s 2ms/step -
accuracy: 0.7616 - loss: 2.3900 - val_accuracy: 0.8122 - val_loss: 2.5926
Epoch 5/10
366/366 1s 2ms/step -
accuracy: 0.7836 - loss: 1.5729 - val_accuracy: 0.5710 - val_loss: 2.8144
Epoch 6/10
366/366 1s 2ms/step -
accuracy: 0.7741 - loss: 1.3489 - val_accuracy: 0.7517 - val_loss: 1.6440
Epoch 7/10
366/366 1s 2ms/step -
accuracy: 0.7808 - loss: 1.0910 - val_accuracy: 0.7630 - val_loss: 1.3216
Epoch 8/10
366/366 1s 2ms/step -
accuracy: 0.7946 - loss: 0.8982 - val_accuracy: 0.6783 - val_loss: 1.4057
Epoch 9/10
366/366 2s 4ms/step -
accuracy: 0.7946 - loss: 0.7920 - val_accuracy: 0.7893 - val_loss: 1.2519
Epoch 10/10
366/366 1s 4ms/step -
accuracy: 0.8120 - loss: 0.6396 - val_accuracy: 0.8023 - val_loss: 1.0295

Training with tanh activation function

Epoch 1/10
366/366 2s 3ms/step -
accuracy: 0.8089 - loss: 0.4805 - val_accuracy: 0.8426 - val_loss: 0.4136
Epoch 2/10
366/366 1s 2ms/step -
accuracy: 0.8355 - loss: 0.4275 - val_accuracy: 0.8419 - val_loss: 0.4208
Epoch 3/10
366/366 1s 2ms/step -
accuracy: 0.8416 - loss: 0.4154 - val_accuracy: 0.8453 - val_loss: 0.4186
Epoch 4/10
366/366 1s 2ms/step -
accuracy: 0.8402 - loss: 0.4175 - val_accuracy: 0.8453 - val_loss: 0.4118
Epoch 5/10
366/366 1s 2ms/step -
accuracy: 0.8401 - loss: 0.4136 - val_accuracy: 0.8432 - val_loss: 0.4109
Epoch 6/10
366/366 1s 2ms/step -
accuracy: 0.8349 - loss: 0.4242 - val_accuracy: 0.8463 - val_loss: 0.4105
Epoch 7/10
366/366 1s 2ms/step -
accuracy: 0.8362 - loss: 0.4211 - val_accuracy: 0.8429 - val_loss: 0.4129
Epoch 8/10

```

366/366          1s 2ms/step -
accuracy: 0.8400 - loss: 0.4117 - val_accuracy: 0.8439 - val_loss: 0.4130
Epoch 9/10
366/366          2s 3ms/step -
accuracy: 0.8413 - loss: 0.4118 - val_accuracy: 0.8443 - val_loss: 0.4152
Epoch 10/10
366/366          1s 3ms/step -
accuracy: 0.8385 - loss: 0.4131 - val_accuracy: 0.8436 - val_loss: 0.4141

```

4.1.5 5. Evaluating the Model and Plotting Loss over Epochs

```

[ ]: import matplotlib.pyplot as plt

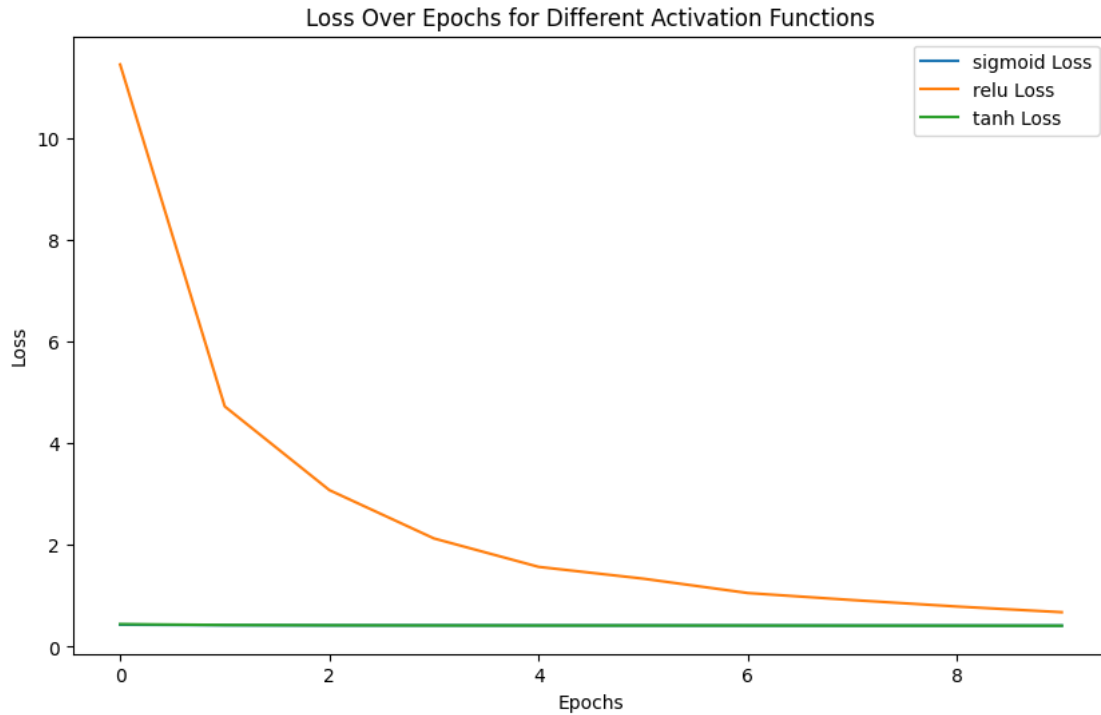
# Plot the loss for each activation function
plt.figure(figsize=(10, 6))

for activation in activation_functions:
    plt.plot(histories[activation].history['loss'], label=f'{activation} Loss')

plt.title('Loss Over Epochs for Different Activation Functions')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()

# Evaluate the models on the test set
for activation in activation_functions:
    print(f"\nEvaluating model with {activation} activation function:")
    model = build_model(activation_function=activation)
    model.fit(X_train, y_train, epochs=10, batch_size=32, verbose=0) # Retrain
    loss, accuracy = model.evaluate(X_test, y_test)
    print(f"Test Accuracy: {accuracy * 100:.2f}%")

```

Evaluating model with sigmoid activation function:

92/92 0s 2ms/step -
accuracy: 0.8357 - loss: 0.4211
Test Accuracy: 84.22%

Evaluating model with relu activation function:

92/92 0s 1ms/step -
accuracy: 0.7630 - loss: 1.0381
Test Accuracy: 77.73%

Evaluating model with tanh activation function:

92/92 0s 1ms/step -
accuracy: 0.8392 - loss: 0.4224
Test Accuracy: 84.15%

4.1.6 Sentiment Analysis Model Evaluation:

1. Sigmoid Activation Function:

- Accuracy: 84.22%
- Interpretation: The model successfully classified approximately 84.22% of the tweets as either positive or negative, indicating strong performance in identifying sentiments in the text. The low loss value (0.4211) suggests the model's predictions were quite accurate.

2. ReLU Activation Function:

- Accuracy: 77.73%
- Interpretation: The ReLU model performed the weakest among the three, accurately classifying only 78% of sentiments. The higher loss (1.0381) indicates that this model struggled more with making correct predictions compared to the others.

3. Tanh Activation Function:

- Accuracy: 84.15%
- Interpretation: The tanh model slightly outperformed the sigmoid model, achieving an accuracy of 84.15%. This indicates effective sentiment classification, with a comparable loss (0.4224), suggesting accurate predictions.

5 Summary:

- The sigmoid activation function proved to be the most effective for sentiment analysis in this context, closely followed by the tanh function. Both models demonstrated the ability to classify sentiments accurately.
- In contrast, the ReLU function showed lower performance, highlighting its potential inadequacy for this type of text classification task.