```
import pickle
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report
from nltk.tokenize import RegexpTokenizer
from gensim.models import Word2Vec
from nltk.tokenize import word_tokenize
from tensorflow import keras
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import roc_curve, auc
import matplotlib.pyplot as plt
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis

labels=pickle.load( open('labels.pkl', 'rb'))
features=pickle.load( open('features.pkl', 'rb'))
features_tfidf= pickle.load( open('features_tfidf.pkl', 'rb'))
word_tfidf_weights=pickle.load( open('word_tfidf_weights.pkl', 'rb'))
```

TFIDF vectors with non numeric features

```
scaler=StandardScaler()
norm_features=scaler.fit_transform(features_tfidf)
train_ft,test_ft,train_labels,test_labels=train_test_split(norm_featur
es,labels,test_size=0.2, train_size=0.8)
print("----------------Train data-----------------------\n")
print(" train data features shape {} \n train data labels shape {}\
n".format(train_ft.shape,train_labels.shape))
print("-----------------Test data-----------------------\n")
print(" test data features shape {} \n test data labels shape
{}".format(test_ft.shape,test_labels.shape))
```

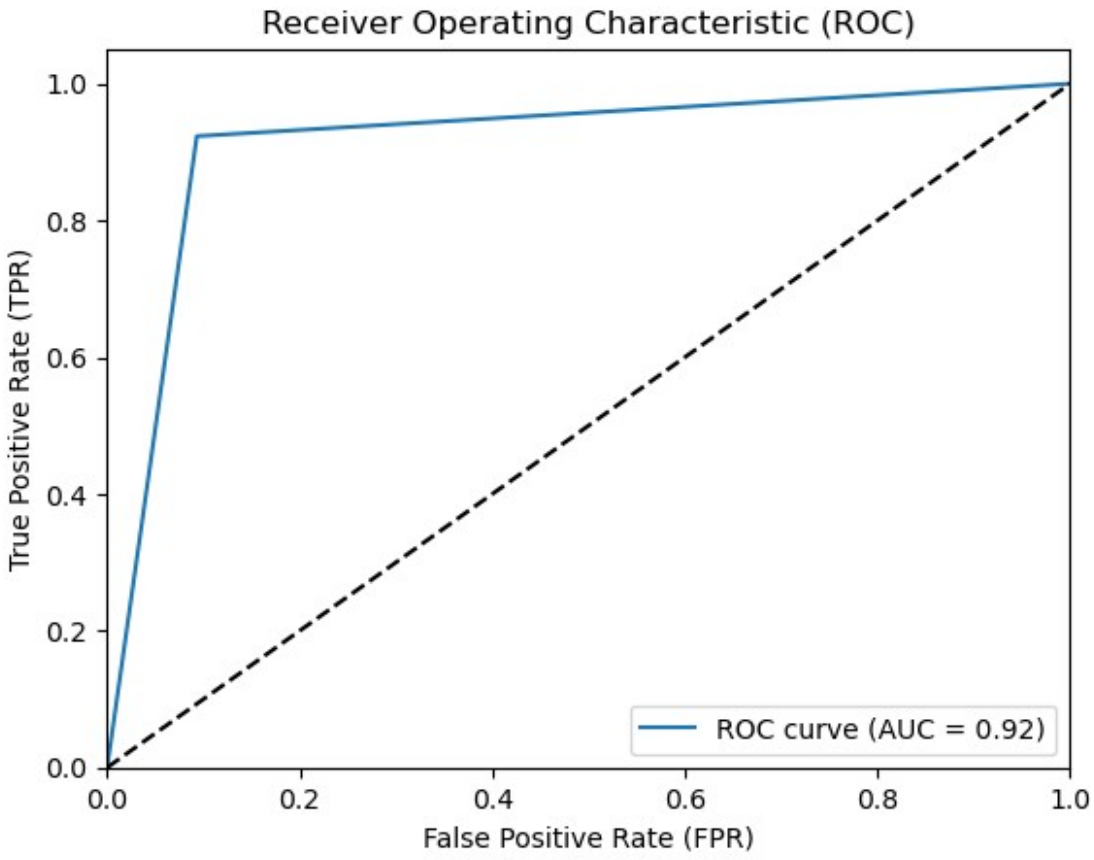
```
----------------Train data-----------------------

 train data features shape (57229, 115)
 train data labels shape (57229,)

-----------------Test data-----------------------

 test data features shape (14308, 115)
 test data labels shape (14308,)
```

```
clf = LogisticRegression(random_state=0).fit(train_ft, train_labels)

def get_metrics(clf,test_ft,test_labels):
    pred_labels=clf.predict(test_ft)
    print(classification_report(pred_labels,test_labels))
```

```
get_metrics(clf,test_ft,test_labels)
```

```
              precision    recall  f1-score   support

           0       0.91      0.92      0.91      6929
           1       0.92      0.91      0.92      7379

    accuracy                           0.92     14308
   macro avg       0.92      0.92      0.92     14308
weighted avg       0.92      0.92      0.92     14308
```

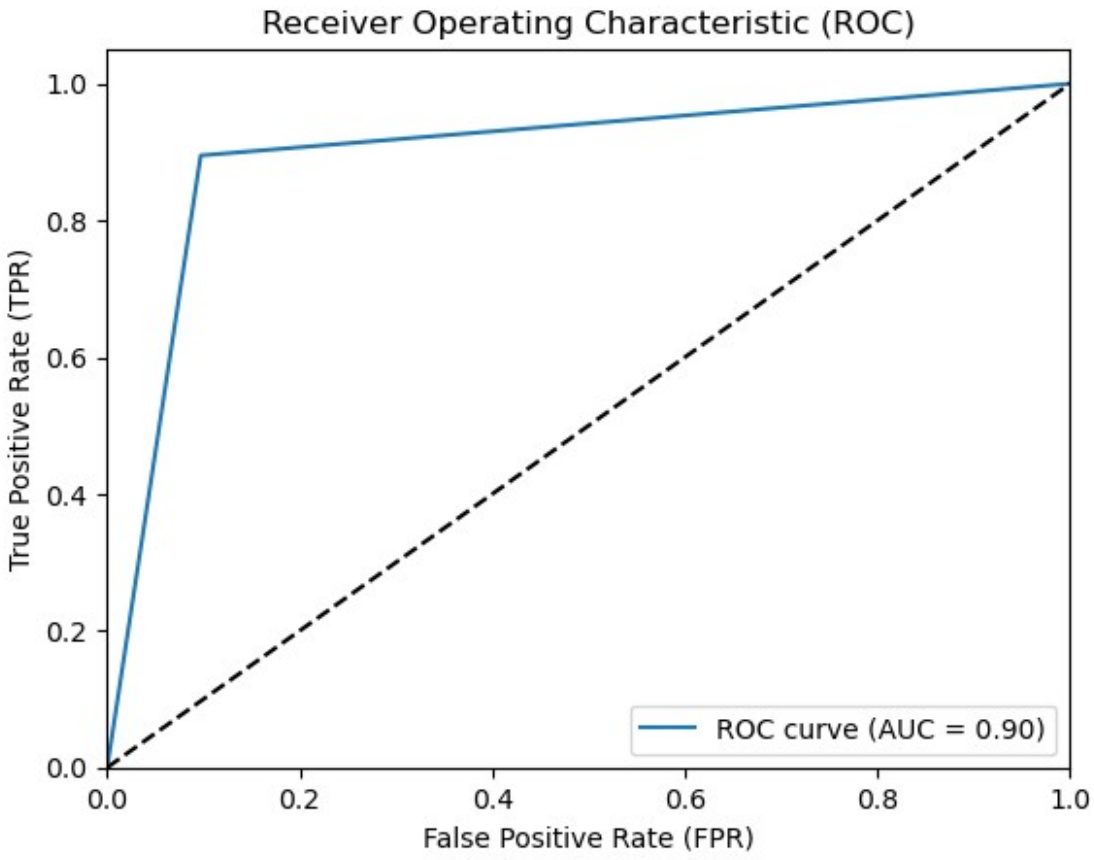
```
def plot_ROC(test):

    pred_labels=clf.predict(test_ft)
    fpr, tpr, thresholds = roc_curve(test,pred_labels)
    roc_auc = auc(fpr, tpr)

    # Plot ROC curve
    plt.plot(fpr, tpr, label='ROC curve (AUC =
{:.2f})'.format(roc_auc))
    plt.plot([0, 1], [0, 1], 'k--')  # Random guessing line
    plt.xlim([0.0, 1.0])
    plt.ylim([0.0, 1.05])
    plt.xlabel('False Positive Rate (FPR)')
    plt.ylabel('True Positive Rate (TPR)')
    plt.title('Receiver Operating Characteristic (ROC)')
    plt.legend(loc='lower right')
    plt.show()


plot_ROC(test_labels)
```




```
clf = LinearDiscriminantAnalysis().fit(train_ft, train_labels)

get_metrics(clf,test_ft,test_labels)
```

	precision	recall	f1-score	support
0	0.90	0.89	0.90	7078
1	0.90	0.91	0.90	7230
accuracy			0.90	14308
macro avg	0.90	0.90	0.90	14308
weighted avg	0.90	0.90	0.90	14308

```
plot_ROC(test_labels)
```



word2vec features with non numeric features

```
doc=list(features["combined_text"])
non_text_features = features.drop(columns=['title', 'text',
'combined_text', 'label'])
non_text_features_np=non_text_features.to_numpy()

def tokenize_words(text):
    tokenized_words,vocab=[],[]
    for i in text:
        tokenizer = RegexpTokenizer(r'\w+')     #using regular
expression tokenizer
        wrd_token=tokenizer.tokenize(i)
        tokenized_words.append(wrd_token)
        vocab.extend(wrd_token)
    return tokenized_words, vocab


doc_tokens_w2v,vocab=tokenize_words(doc)  #tokenizing the doc(ans+que)

model_doc=Word2Vec(doc_tokens_w2v,min_count=2,window=4)
```

```
sentence_vectors = []
for sentence in doc:
    tokens = word_tokenize(sentence.lower())
    sentence_vector = np.zeros(model_doc.vector_size)
    if len(tokens)==0:
        sentence_vectors.append([0]*100)
    else:
        for token in tokens:
            if token in model_doc.wv:
                token_vector = model_doc.wv[token]
                sentence_vector += token_vector
        sentence_vector /= len(tokens)
        sentence_vectors.append(sentence_vector)

# Convert the list of sentence vectors to a NumPy array
sentence_vectors = np.array(sentence_vectors)

sentence_vectors.shape
```

```
(71537, 100)
```

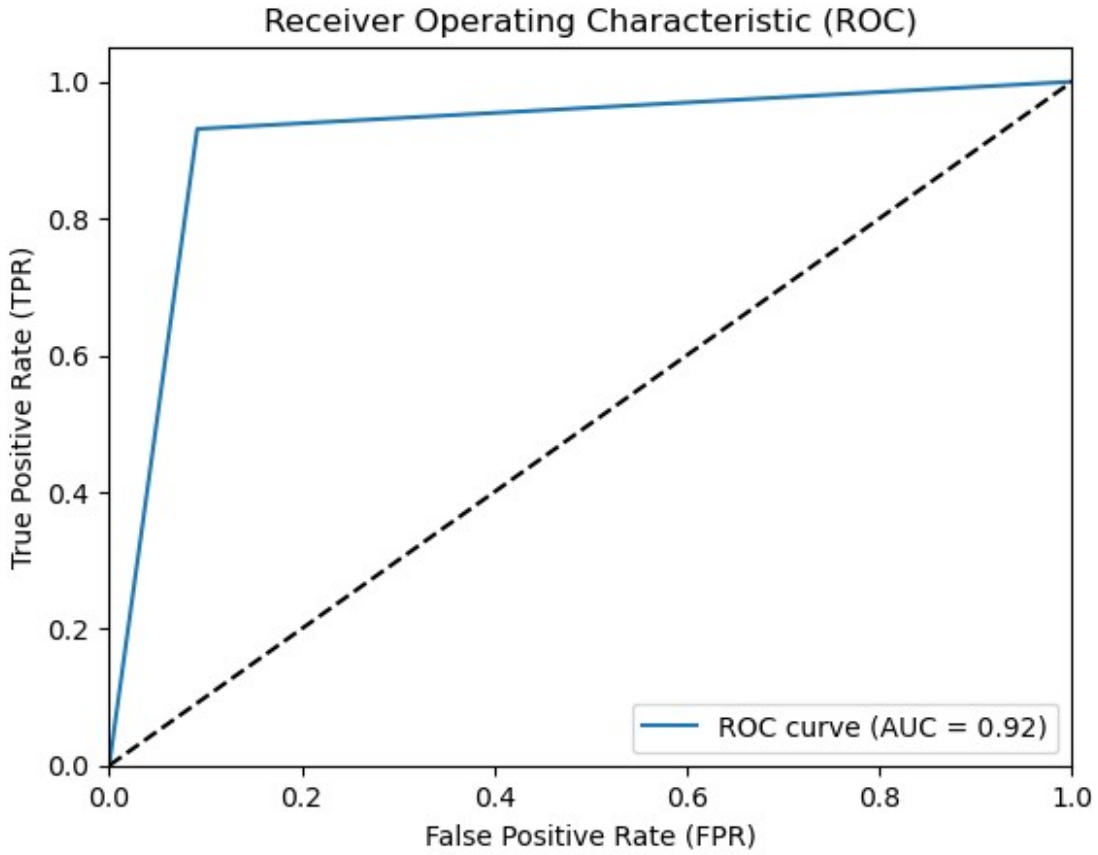
```
non_text_features = features.drop(columns=['title', 'text',
'combined_text', 'label'])
non_text_features_np=non_text_features.to_numpy()

features_w2v = np.hstack((sentence_vectors, non_text_features_np))

pickle.dump(features_w2v, open('features_w2v.pkl', 'wb'))

features_w2v = pickle.load( open('features_tfidf.pkl', 'rb'))

scaler=StandardScaler()
norm_features=scaler.fit_transform(features_w2v)
train_ft,test_ft,train_labels,test_labels=train_test_split(norm_featur
es,labels,test_size=0.2, train_size=0.8)
print("----------------Train data-----------------------\n")
print(" train data features shape {} \n train data labels shape {}\
n".format(train_ft.shape,train_labels.shape))
print("-----------------Test data-----------------------\n")
print(" test data features shape {} \n test data labels shape
{}".format(test_ft.shape,test_labels.shape))
```

```
----------------Train data-----------------------

 train data features shape (57229, 115)
 train data labels shape (57229,)

-----------------Test data-----------------------

 test data features shape (14308, 115)
 test data labels shape (14308,)
```

```
clf = LogisticRegression(random_state=0).fit(train_ft, train_labels)

get_metrics(clf,test_ft,test_labels)
```

	precision	recall	f1-score	support
0	0.91	0.92	0.92	6787
1	0.93	0.92	0.92	7521
accuracy			0.92	14308
macro avg	0.92	0.92	0.92	14308
weighted avg	0.92	0.92	0.92	14308

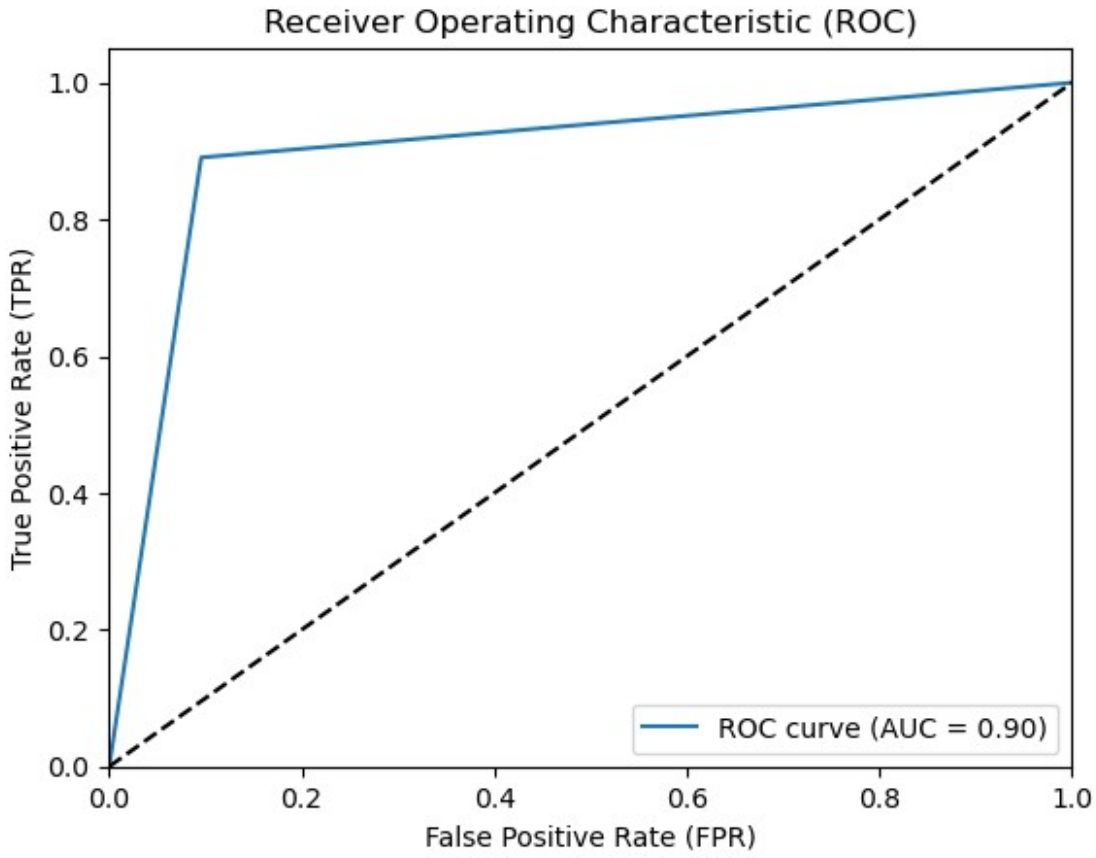
```
plot_ROC(test_labels)
```




```
clf = LinearDiscriminantAnalysis().fit(train_ft, train_labels)

get_metrics(clf,test_ft,test_labels)
```

	precision	recall	f1-score	support
0	0.90	0.89	0.90	7139
1	0.89	0.91	0.90	7169

```
    accuracy                           0.90     14308
   macro avg       0.90      0.90      0.90     14308
weighted avg       0.90      0.90      0.90     14308


plot_ROC(test_labels)
```



word2vec vector with neural networks

```
train_ft,test_ft,train_labels,test_labels=train_test_split(norm_featur
es,labels,test_size=0.2, train_size=0.8)
X_train, X_val, y_train, y_val = train_test_split(train_ft,
train_labels, test_size=0.2, random_state=42)

print("Training set shape:", X_train.shape)
print("Validation set shape:", X_val.shape)
print("Test set shape:", test_ft.shape)

Training set shape: (45783, 115)
Validation set shape: (11446, 115)
Test set shape: (14308, 115)
```

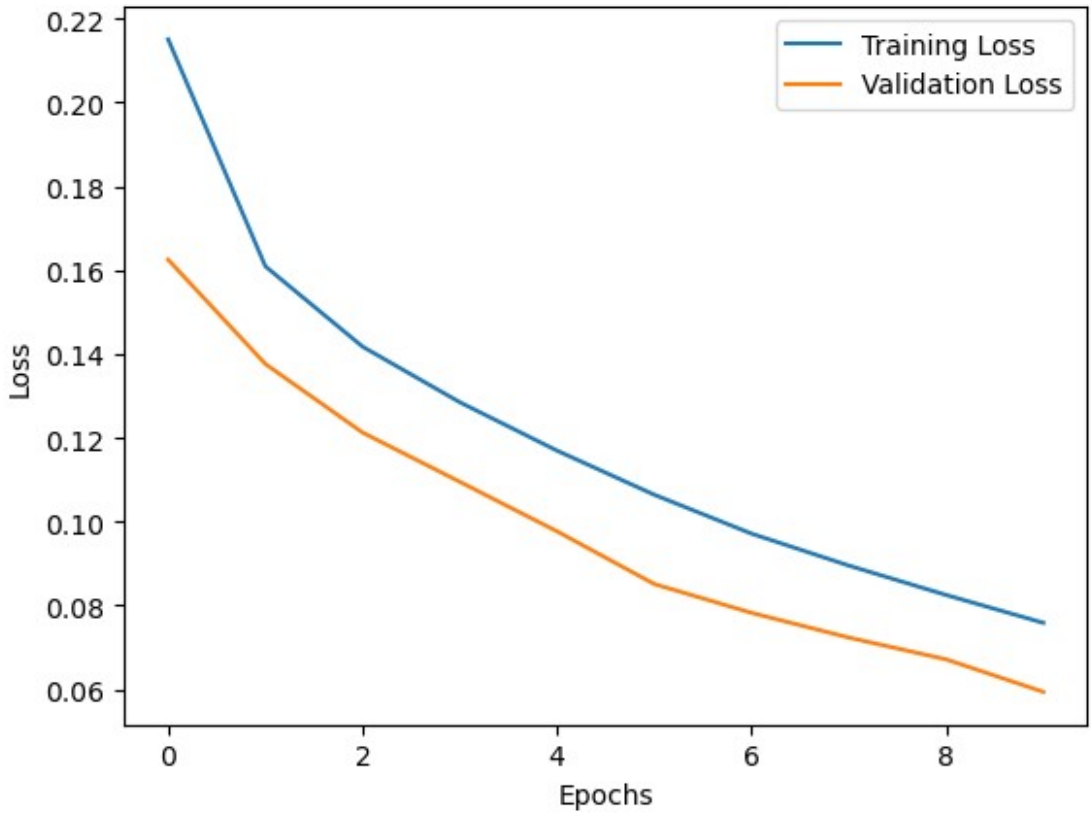
```
import numpy as np
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense

# Assuming you have already preprocessed and split your dataset into
X_train, y_train, X_val, y_val

# Define the model architecture
model = Sequential()
model.add(Dense(64, activation='relu', input_shape=(115,)))  # Input
layer
model.add(Dense(64, activation='relu'))  # Hidden layer
model.add(Dense(1, activation='sigmoid'))  # Output layer
model.summary()
```

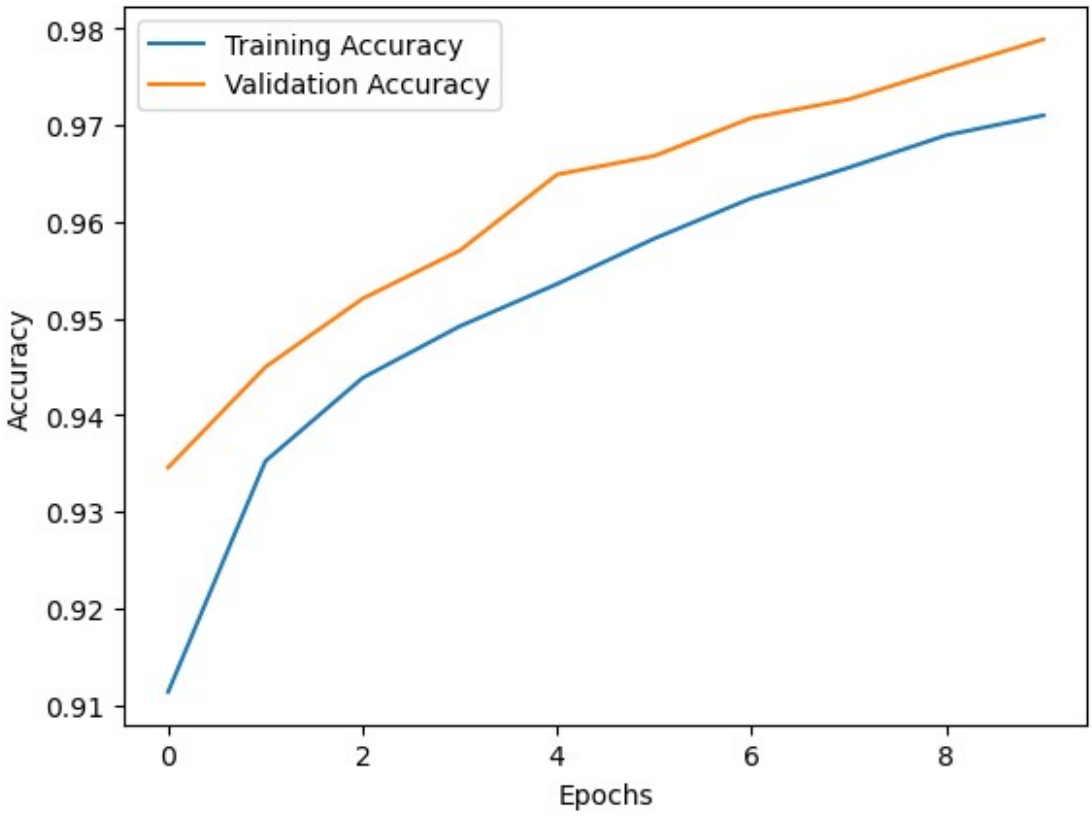
```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 64)                7424

 dense_1 (Dense)             (None, 64)                4160

 dense_2 (Dense)             (None, 1)                 65

=================================================================
Total params: 11,649
Trainable params: 11,649
Non-trainable params: 0
_________________________________________________________________
```

```
model.compile(optimizer='adam', loss='binary_crossentropy',
metrics=['accuracy'])
history=model.fit(train_ft, train_labels, epochs=10, batch_size=32,
validation_data=(X_val, y_val))
```

```
Epoch 1/10
1789/1789 [==============================] - 4s 2ms/step - loss:
0.2151 - accuracy: 0.9114 - val_loss: 0.1625 - val_accuracy: 0.9346
Epoch 2/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.1609 - accuracy: 0.9352 - val_loss: 0.1376 - val_accuracy: 0.9450
Epoch 3/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.1417 - accuracy: 0.9438 - val_loss: 0.1213 - val_accuracy: 0.9520
Epoch 4/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.1285 - accuracy: 0.9492 - val_loss: 0.1095 - val_accuracy: 0.9570
Epoch 5/10
1789/1789 [==============================] - 3s 2ms/step - loss:
```

```
0.1169 - accuracy: 0.9536 - val_loss: 0.0977 - val_accuracy: 0.9649
Epoch 6/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.1064 - accuracy: 0.9583 - val_loss: 0.0851 - val_accuracy: 0.9668
Epoch 7/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.0972 - accuracy: 0.9624 - val_loss: 0.0783 - val_accuracy: 0.9707
Epoch 8/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.0895 - accuracy: 0.9656 - val_loss: 0.0724 - val_accuracy: 0.9727
Epoch 9/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.0825 - accuracy: 0.9689 - val_loss: 0.0672 - val_accuracy: 0.9758
Epoch 10/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.0759 - accuracy: 0.9710 - val_loss: 0.0594 - val_accuracy: 0.9789

# Evaluate the model on the test set
test_loss, test_accuracy = model.evaluate(test_ft, test_labels)
print(f'Test Loss: {test_loss}, Test Accuracy: {test_accuracy}')

448/448 [==============================] - 1s 1ms/step - loss: 0.1803
- accuracy: 0.9395
Test Loss: 0.18027165532112122, Test Accuracy: 0.9394744038581848

def plot_loss_acc(history):

    plt.plot(history.history['loss'], label='Training Loss')
    plt.plot(history.history['val_loss'], label='Validation Loss')
    plt.xlabel('Epochs')
    plt.ylabel('Loss')
    plt.legend()
    plt.show()

    plt.plot(history.history['accuracy'], label='Training Accuracy')
    plt.plot(history.history['val_accuracy'], label='Validation
Accuracy')
    plt.xlabel('Epochs')
    plt.ylabel('Accuracy')
    plt.legend()
    plt.show()

plot_loss_acc(history)
```


Training Loss
Validation Loss
Loss
Epochs
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0
2
4
6
8


Training Accuracy
Validation Accuracy
Accuracy
Epochs
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0
2
4
6
8

tfidf weighted word2vec

```
sentence_vectors_tf = []

# Process each sentence and compute its vector
for i,sentence in enumerate(doc):
    tokens = word_tokenize(sentence.lower())
    sentence_vector = np.zeros(model_doc.vector_size)
    if len(tokens)==0:
         sentence_vectors_tf.append([0]*100)
    else:
        for token in tokens:
            if token in model_doc.wv:
                token_vector = model_doc.wv[token]
                sentence_vector += token_vector

        sentence_vector /= len(tokens)
        sentence_vector *= word_tfidf_weights[i]
        sentence_vectors_tf.append(sentence_vector)

# Convert the list of sentence vectors to a NumPy array
sentence_vectors_tf = np.array(sentence_vectors)
sentence_vectors_tf = np.nan_to_num(sentence_vectors_tf, nan=0.0)

pickle.dump(sentence_vectors_tf, open('w2v_tf_vectors.pkl', 'wb'))

sentence_vectors_tf=pickle.load( open('w2v_tf_vectors.pkl', 'rb'))

sentence_vectors_tf.shape

(71537, 100)

train_ft,test_ft,train_labels,test_labels=train_test_split(sentence_ve
ctors_tf,labels,test_size=0.2, train_size=0.8)
X_train, X_val, y_train, y_val = train_test_split(train_ft,
train_labels, test_size=0.2, random_state=42)

# Print the shape of each set
print("Training set shape:", X_train.shape)
print("Validation set shape:", X_val.shape)
print("Test set shape:", test_ft.shape)

Training set shape: (45783, 100)
Validation set shape: (11446, 100)
Test set shape: (14308, 100)

model = Sequential()
model.add(Dense(32, activation='relu', input_shape=(100,)))  # Input
layer
model.add(Dense(64, activation='relu'))  # Hidden layer
```

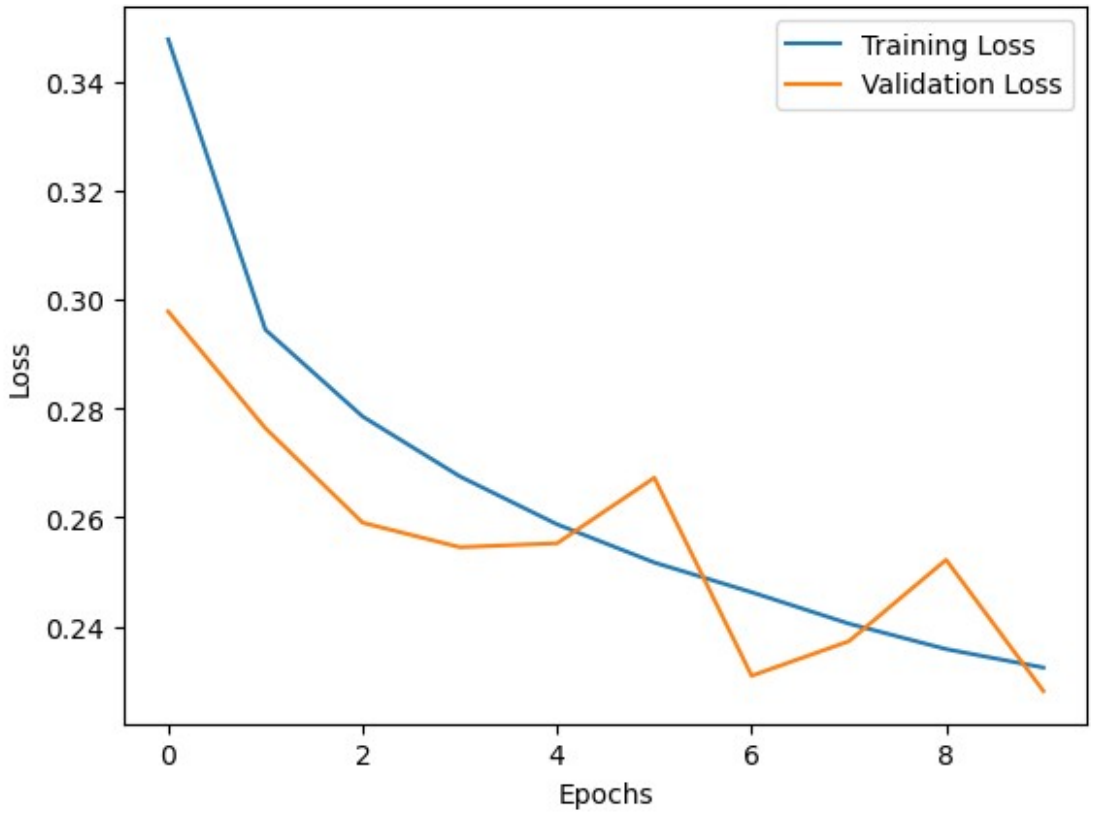
```
model.add(Dense(1, activation='sigmoid'))  # Output layer
model.summary()
```

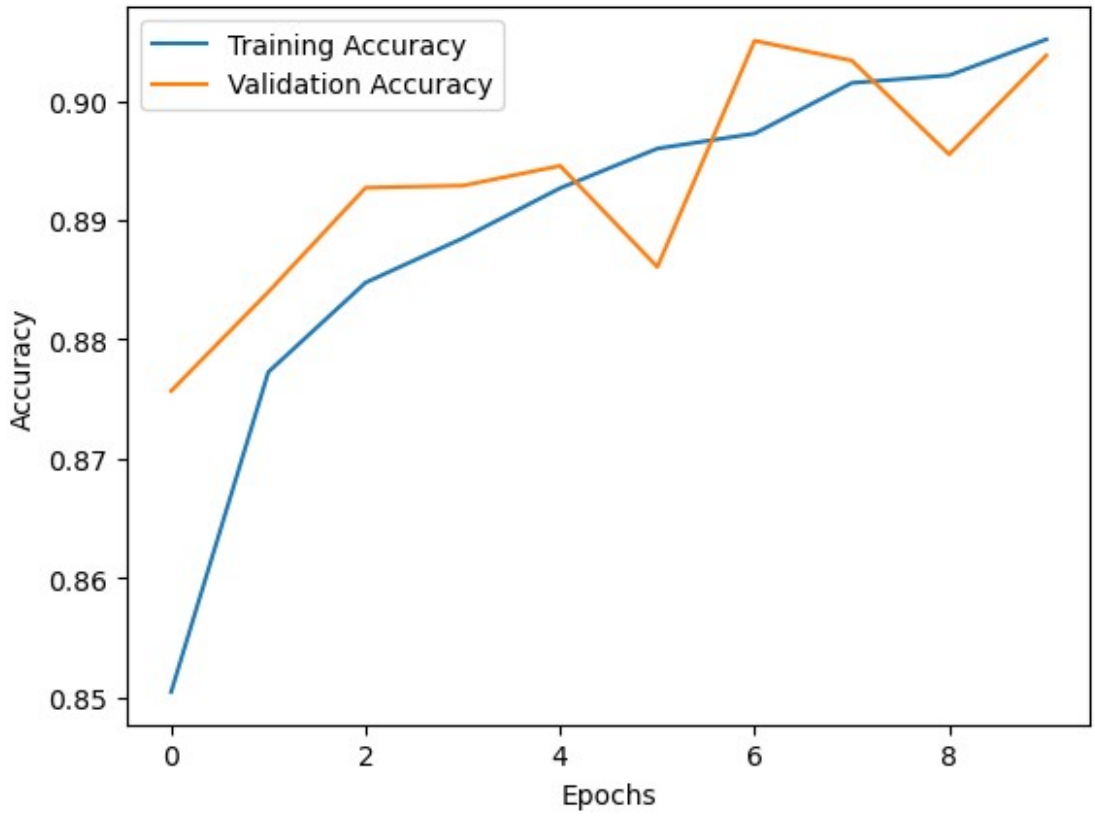
```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_3 (Dense)             (None, 32)                3232

 dense_4 (Dense)             (None, 64)                2112

 dense_5 (Dense)             (None, 1)                 65

=================================================================
Total params: 5,409
Trainable params: 5,409
Non-trainable params: 0
_________________________________________________________________
```

```
opt = keras.optimizers.SGD(learning_rate=0.1)
model.compile(optimizer=opt, loss='binary_crossentropy',
metrics=['accuracy'])
history=model.fit(train_ft, train_labels, epochs=10, batch_size=32,
validation_data=(X_val, y_val))
```

```
Epoch 1/10
1789/1789 [==============================] - 4s 2ms/step - loss:
0.3477 - accuracy: 0.8504 - val_loss: 0.2978 - val_accuracy: 0.8757
Epoch 2/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.2944 - accuracy: 0.8773 - val_loss: 0.2764 - val_accuracy: 0.8840
Epoch 3/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.2785 - accuracy: 0.8848 - val_loss: 0.2591 - val_accuracy: 0.8927
Epoch 4/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.2675 - accuracy: 0.8885 - val_loss: 0.2546 - val_accuracy: 0.8929
Epoch 5/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.2588 - accuracy: 0.8927 - val_loss: 0.2553 - val_accuracy: 0.8945
Epoch 6/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.2518 - accuracy: 0.8960 - val_loss: 0.2673 - val_accuracy: 0.8861
Epoch 7/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.2463 - accuracy: 0.8973 - val_loss: 0.2310 - val_accuracy: 0.9050
Epoch 8/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.2406 - accuracy: 0.9015 - val_loss: 0.2373 - val_accuracy: 0.9034
Epoch 9/10
```

```
1789/1789 [==============================] - 3s 2ms/step - loss:
0.2359 - accuracy: 0.9021 - val_loss: 0.2523 - val_accuracy: 0.8955
Epoch 10/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.2325 - accuracy: 0.9052 - val_loss: 0.2282 - val_accuracy: 0.9038

# Evaluate the model on the test set
test_loss, test_accuracy = model.evaluate(test_ft, test_labels)
print(f'Test Loss: {test_loss}, Test Accuracy: {test_accuracy}')

448/448 [==============================] - 1s 1ms/step - loss: 0.2482
- accuracy: 0.8947
Test Loss: 0.24815793335437775, Test Accuracy: 0.8947442173957825

plot_loss_acc(history)
```





TF-IDF weighted Word2vec with non numeric features

```
features_w2v = np.hstack((sentence_vectors_tf, non_text_features_np))
scaler=StandardScaler()
norm_features=scaler.fit_transform(features_w2v)

train_ft,test_ft,train_labels,test_labels=train_test_split(norm_featur
es,labels,test_size=0.2, train_size=0.8)
X_train, X_val, y_train, y_val = train_test_split(train_ft,
train_labels, test_size=0.2, random_state=42)

print("Training set shape:", X_train.shape)
print("Validation set shape:", X_val.shape)
print("Test set shape:", test_ft.shape)

Training set shape: (45783, 115)
Validation set shape: (11446, 115)
Test set shape: (14308, 115)

model = Sequential()
model.add(Dense(32, activation='relu', input_shape=(115,)))  # Input
```

```
layer
model.add(Dense(64, activation='relu'))  # Hidden layer
model.add(Dense(1, activation='sigmoid'))  # Output layer
model.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_6 (Dense)             (None, 32)                3712

 dense_7 (Dense)             (None, 64)                2112

 dense_8 (Dense)             (None, 1)                 65

=================================================================
Total params: 5,889
Trainable params: 5,889
Non-trainable params: 0
_________________________________________________________________
```

```
opt = keras.optimizers.SGD(learning_rate=0.1)
model.compile(optimizer=opt, loss='binary_crossentropy',
metrics=['accuracy'])
history=model.fit(train_ft, train_labels, epochs=10, batch_size=32,
validation_data=(X_val, y_val))
```

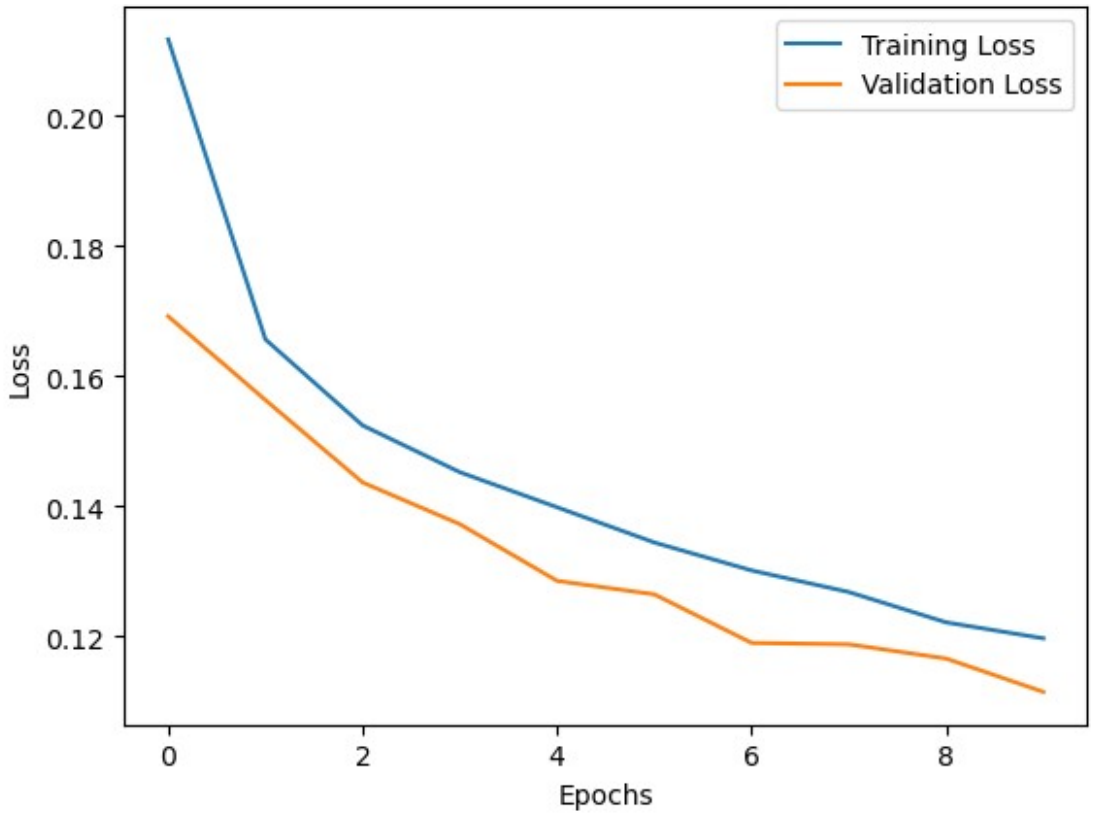
```
Epoch 1/10
1789/1789 [==============================] - 5s 2ms/step - loss:
0.2118 - accuracy: 0.9152 - val_loss: 0.1692 - val_accuracy: 0.9340
Epoch 2/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.1656 - accuracy: 0.9344 - val_loss: 0.1563 - val_accuracy: 0.9383
Epoch 3/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.1524 - accuracy: 0.9397 - val_loss: 0.1436 - val_accuracy: 0.9467
Epoch 4/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.1452 - accuracy: 0.9432 - val_loss: 0.1372 - val_accuracy: 0.9468
Epoch 5/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.1398 - accuracy: 0.9450 - val_loss: 0.1285 - val_accuracy: 0.9514
Epoch 6/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.1344 - accuracy: 0.9474 - val_loss: 0.1264 - val_accuracy: 0.9519
Epoch 7/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.1301 - accuracy: 0.9494 - val_loss: 0.1190 - val_accuracy: 0.9547
Epoch 8/10
1789/1789 [==============================] - 3s 2ms/step - loss:
```

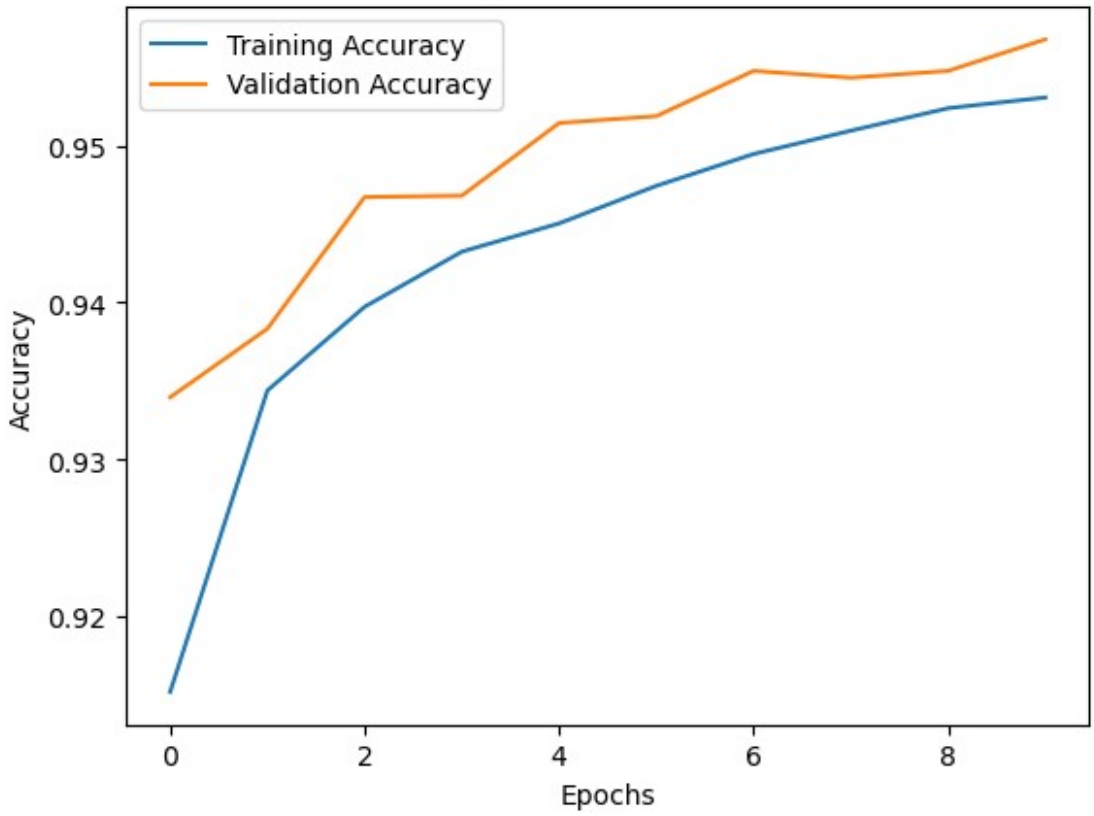
```
0.1268 - accuracy: 0.9509 - val_loss: 0.1188 - val_accuracy: 0.9543
Epoch 9/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.1221 - accuracy: 0.9524 - val_loss: 0.1166 - val_accuracy: 0.9547
Epoch 10/10
1789/1789 [==============================] - 3s 2ms/step - loss:
0.1197 - accuracy: 0.9530 - val_loss: 0.1114 - val_accuracy: 0.9568
```

```
# Evaluate the model on the test set
test_loss, test_accuracy = model.evaluate(test_ft, test_labels)
print(f'Test Loss: {test_loss}, Test Accuracy: {test_accuracy}')
```

```
448/448 [==============================] - 1s 1ms/step - loss: 0.1572
- accuracy: 0.9417
Test Loss: 0.1571870893239975, Test Accuracy: 0.9417109489440918
```

```
plot_loss_acc(history)
```




Training Accuracy
Validation Accuracy
0.95
0.94
0.93
0.92
Accuracy
0
2
4
6
8
Epochs