models

December 7, 2023

[33]:
```python
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 tensorflow as tf
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
from tensorflow.keras.layers import Input, Dense
```

1 Generic Fucntions

[2]:
```python
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'))
non_text_features_np = features.drop(columns=['title', 'text', 'combined_text',␣
 ↪'label']).to_numpy()
```

[3]:
```python
def get_metrics(clf,test_ft,test_labels):
    pred_labels=clf.predict(test_ft)
   ␣
 ↪print(classification_report(pred_labels,test_labels,target_names=["fake","real"]))
```

[4]:
```python
def plot_ROC(test):

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

```python
    # 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()
```

[101]:
```python
class ANN_model(tf.keras.models.Model):
    def __init__(self):
        super(ANN_model,self).__init__()
        self.layer1= Dense(64, activation="relu")
        self.layer2= Dense(32,activation="relu")
        self.label= Dense(1,activation="sigmoid")

    def call(self,inputs):
        x=self.layer1(inputs)
        x=self.layer2(x)
        x=self.label(x)

        return x
```

[8]:
```python
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()
```

[10]:
```python
def split_data_ml(features,labels):

    scaler=StandardScaler()
    norm_features=scaler.fit_transform(features_tfidf)
```

```
    ␣
  ↪train_ft,test_ft,train_labels,test_labels=train_test_split(norm_features,labels,test_size=0
  ↪2, train_size=0.8)
    print("----------------Train data------------------------\n")
    print(f" train data features shape {train_ft.shape} \n train data labels␣
  ↪shape {train_labels.shape}\n")
    print("-----------------Test data-------------------------\n")
    print(f" test data features shape {test_ft.shape} \n test data labels shape␣
  ↪{test_labels.shape}")

    return train_ft,test_ft,train_labels,test_labels
```

[30]:
```
def split_data_dl(features,labels):

    ␣
  ↪train_ft,test_ft,train_labels,test_labels=train_test_split(norm_features,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)

    return X_train,y_train,X_val,y_val,test_ft,test_labels
```

2 1. TF-IDF vectors + text characteristics

2.1 Machine Learning models

[21]:
```
features_tfidf_txt = np.hstack((features_tfidf, non_text_features_np))
```

[46]:
```
pickle.dump(features_tfidf_txt, open('features_tfidf_txt.pkl', 'wb'))
features_tfidf_txt = pickle.load( open('features_tfidf_txt.pkl', 'rb'))
```

2.1.1 Logistic Regression

[22]:
```
train_ft,test_ft,train_labels,test_labels=split_data_ml(features_tfidf_txt,labels)
```

```
----------------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,)
```

[23]:
```
log_clf = LogisticRegression(random_state=0).fit(train_ft, train_labels)
```

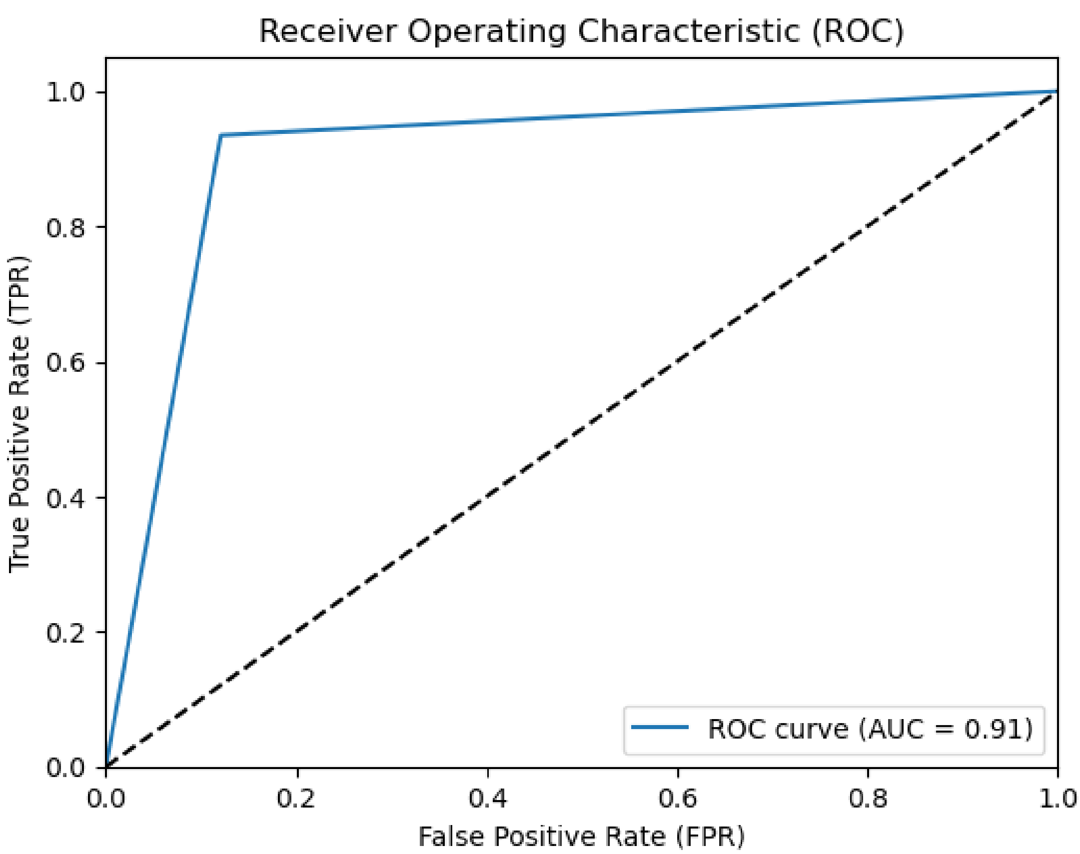
[24]:
```
get_metrics(log_clf,test_ft,test_labels)
```

```
              precision    recall  f1-score   support

        fake       0.90      0.93      0.91      6762
        real       0.93      0.91      0.92      7546

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

[25]:
```
plot_ROC(test_labels)
```



2.1.2 Linear Discriminant Analysis

[26]:
```
clf = LinearDiscriminantAnalysis().fit(train_ft, train_labels)
```

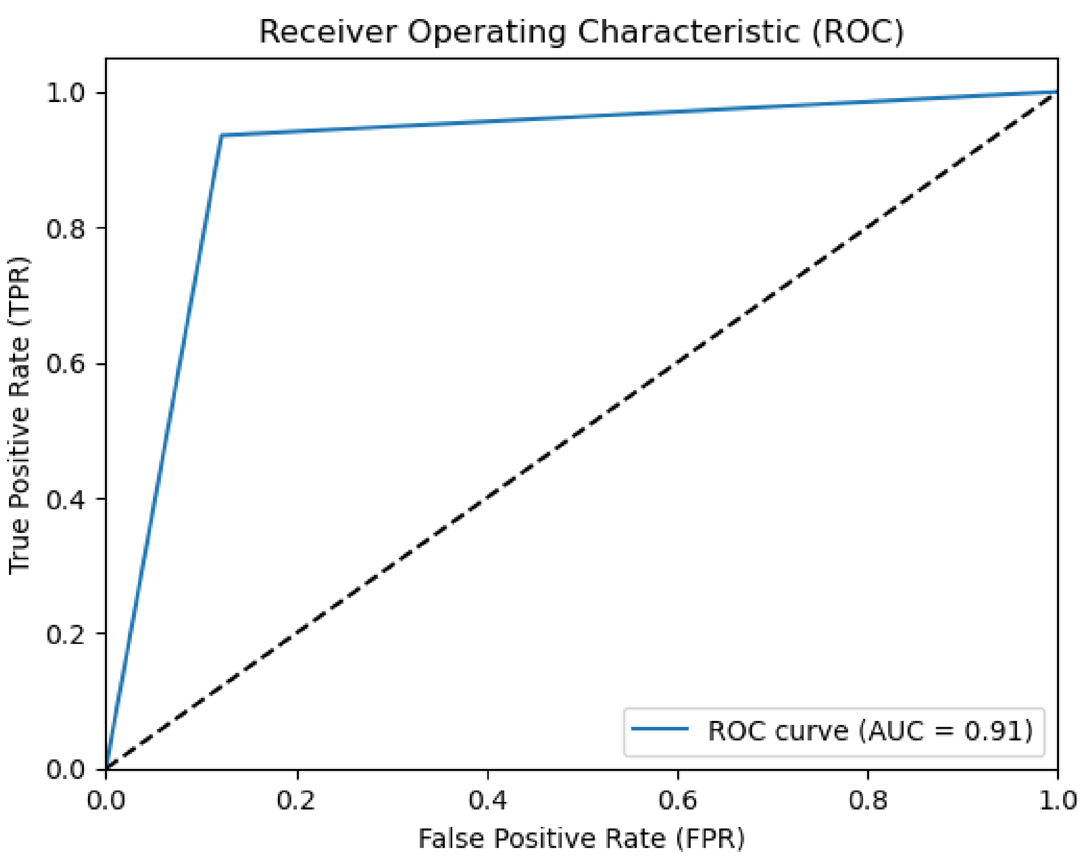
[27]:
```
get_metrics(clf,test_ft,test_labels)
```

```
              precision    recall  f1-score   support

        fake       0.88      0.93      0.90      6580
        real       0.94      0.89      0.91      7728

    accuracy                           0.91     14308
   macro avg       0.91      0.91      0.91     14308
weighted avg       0.91      0.91      0.91     14308
```

[28]:
```
plot_ROC(test_labels)
```



2.1.3 Artificial Neural network

[31]:
```
x_train,y_train,X_val,y_val,test_ft,test_labels=split_data_dl(features_tfidf_txt,labels)
```

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

[34]:
```
tfidf_txt_model= ANN_model()
tfidf_txt_model.build((None,115))
print(tfidf_txt_model.summary())
```

```
Model: "ann_model_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               multiple                  7424

 dense_1 (Dense)             multiple                  2080

 dense_2 (Dense)             multiple                  33

=================================================================
Total params: 9,537
Trainable params: 9,537
Non-trainable params: 0
_________________________________________________________________
None
```

[102]:
```
tb_callback=tf.keras.callbacks.TensorBoard(log_dir="log/",histogram_freq=1)
tfidf_txt_model.compile(optimizer='adam', loss='binary_crossentropy',␣
 ↪metrics=['accuracy'])
history=tfidf_txt_model.fit(train_ft, train_labels, epochs=10, batch_size=32,␣
 ↪validation_data=(X_val, y_val),callbacks=[tb_callback])
```

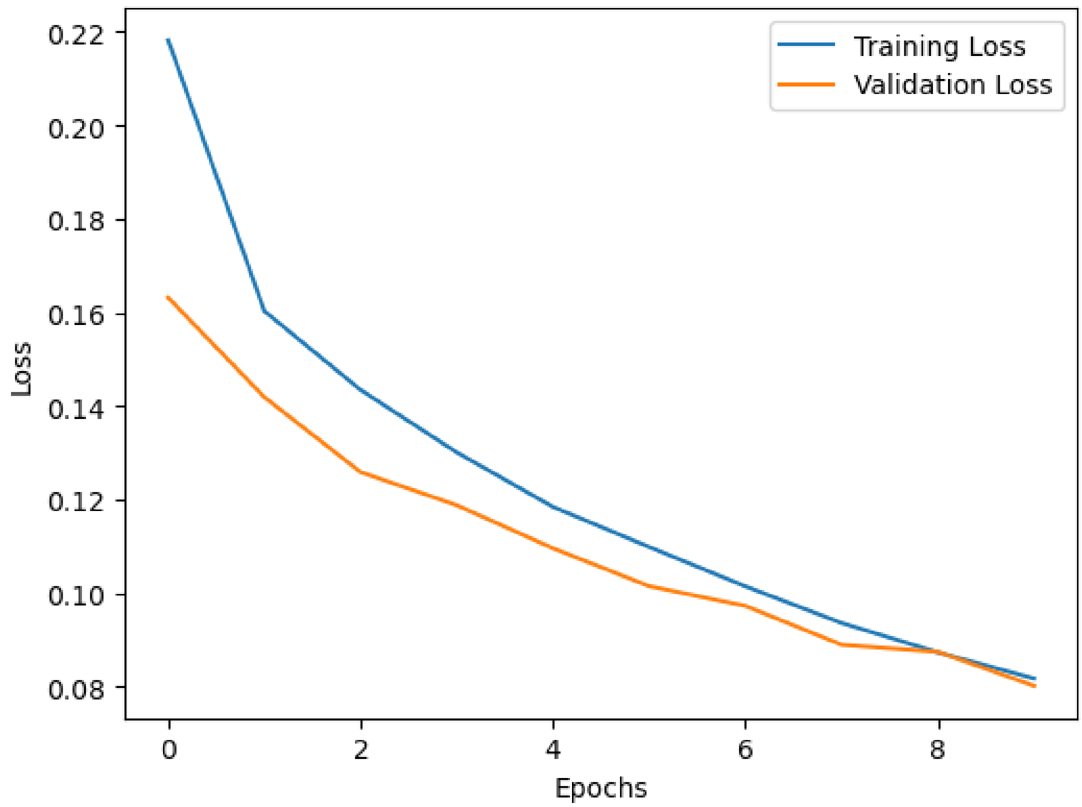
```
Epoch 1/10
1789/1789 [==============================] - 4s 2ms/step - loss: 0.0969 -
accuracy: 0.9642 - val_loss: 0.0852 - val_accuracy: 0.9678
Epoch 2/10
1789/1789 [==============================] - 3s 2ms/step - loss: 0.0854 -
accuracy: 0.9678 - val_loss: 0.0751 - val_accuracy: 0.9727
Epoch 3/10
1789/1789 [==============================] - 3s 2ms/step - loss: 0.0783 -
accuracy: 0.9713 - val_loss: 0.0723 - val_accuracy: 0.9754
Epoch 4/10
1789/1789 [==============================] - 3s 2ms/step - loss: 0.0729 -
accuracy: 0.9736 - val_loss: 0.0692 - val_accuracy: 0.9746
Epoch 5/10
```

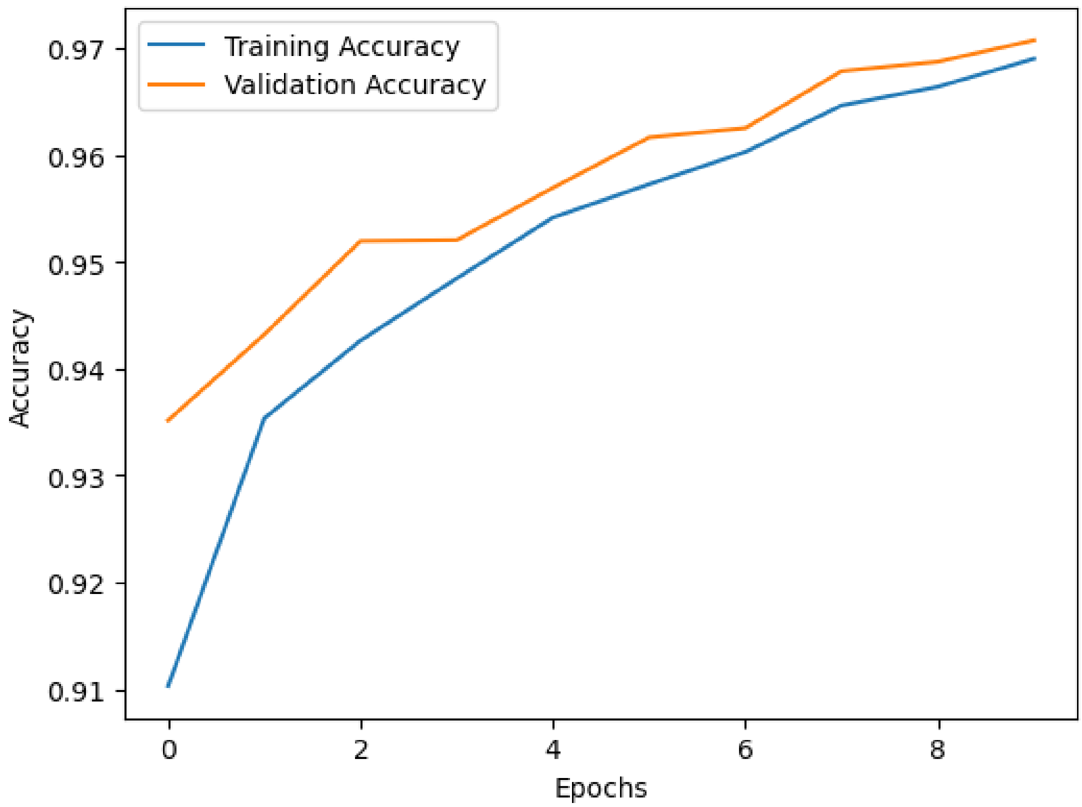
```
1789/1789 [==============================] - 3s 2ms/step - loss: 0.0680 -
accuracy: 0.9752 - val_loss: 0.0716 - val_accuracy: 0.9765
Epoch 6/10
1789/1789 [==============================] - 3s 2ms/step - loss: 0.0627 -
accuracy: 0.9765 - val_loss: 0.0756 - val_accuracy: 0.9716
Epoch 7/10
1789/1789 [==============================] - 3s 2ms/step - loss: 0.0581 -
accuracy: 0.9789 - val_loss: 0.0670 - val_accuracy: 0.9779
Epoch 8/10
1789/1789 [==============================] - 3s 2ms/step - loss: 0.0550 -
accuracy: 0.9797 - val_loss: 0.0693 - val_accuracy: 0.9766
Epoch 9/10
1789/1789 [==============================] - 3s 2ms/step - loss: 0.0502 -
accuracy: 0.9817 - val_loss: 0.0636 - val_accuracy: 0.9803
Epoch 10/10
1789/1789 [==============================] - 4s 2ms/step - loss: 0.0476 -
accuracy: 0.9826 - val_loss: 0.0608 - val_accuracy: 0.9812
```

[38]:
```
# Evaluate the model on the test set
test_loss, test_accuracy = tfidf_txt_model.evaluate(test_ft, test_labels)
print(f'Test Loss: {test_loss}, Test Accuracy: {test_accuracy}')
```

```
448/448 [==============================] - 1s 2ms/step - loss: 0.0924 -
accuracy: 0.9683
Test Loss: 0.09243853390216827, Test Accuracy: 0.9683393836021423
```

[39]:
```
plot_loss_acc(history)
```


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



[100]:
```
tfidf_txt_model.save_weights("tfidf_txt_model.h5")
```

3 2. Word2vec vectors + text characteristics

4 Machine Learning Models

[40]:
```
doc=list(features["combined_text"])
```

[41]:
```
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)
```

[42]:
```
model_doc=Word2Vec(doc_tokens_w2v,min_count=2,window=4)
```

[43]:
```
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)
```

[44]:
```
features_w2v_txt = np.hstack((sentence_vectors, non_text_features_np))
```

[47]:
```
pickle.dump(features_w2v, open('features_w2v_txt.pkl', 'wb'))
```

[48]:
```
features_w2v_txt = pickle.load( open('features_w2v_txt.pkl', 'rb'))
```

[49]:
```
train_ft,test_ft,train_labels,test_labels=split_data_ml(features_w2v_txt,labels)
```

```
----------------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,)
```

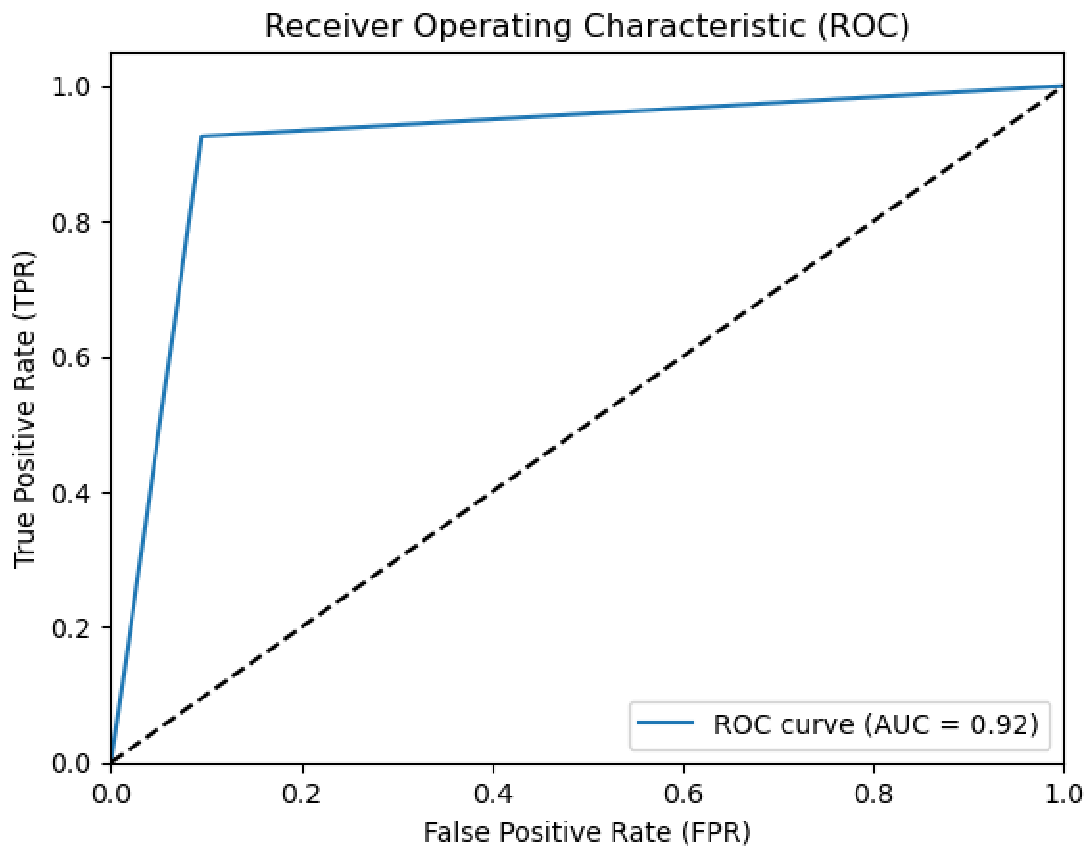
4.0.1 Logistic Regression

[50]:
```
clf = LogisticRegression(random_state=0).fit(train_ft, train_labels)
get_metrics(clf,test_ft,test_labels)
plot_ROC(test_labels)
```

```
              precision    recall  f1-score   support

        fake       0.91      0.92      0.91      6897
        real       0.93      0.91      0.92      7411
```

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



[51]:

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

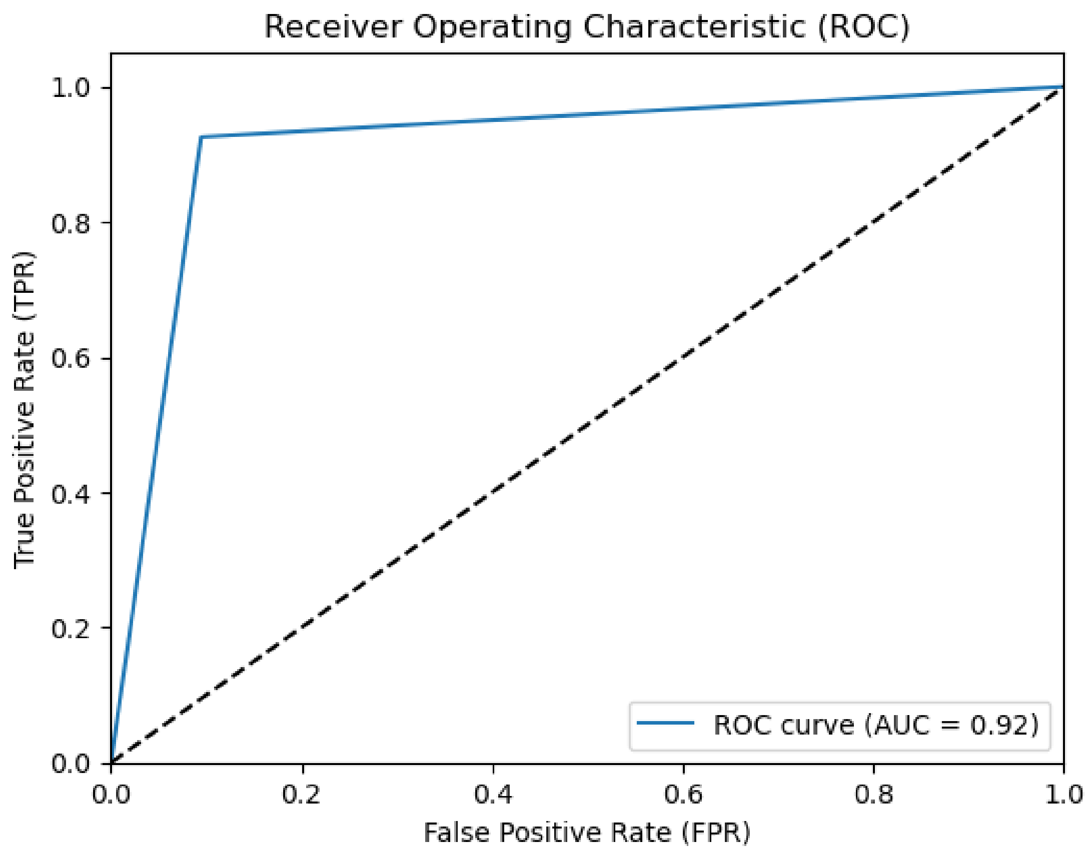
```
              precision    recall  f1-score   support

        fake       0.91      0.92      0.91      6897
        real       0.93      0.91      0.92      7411

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

[52]:

```
plot_ROC(test_labels)
```



4.0.2 Linear Discriminant Analysis

[53]:
```
clf = LinearDiscriminantAnalysis().fit(train_ft, train_labels)
```

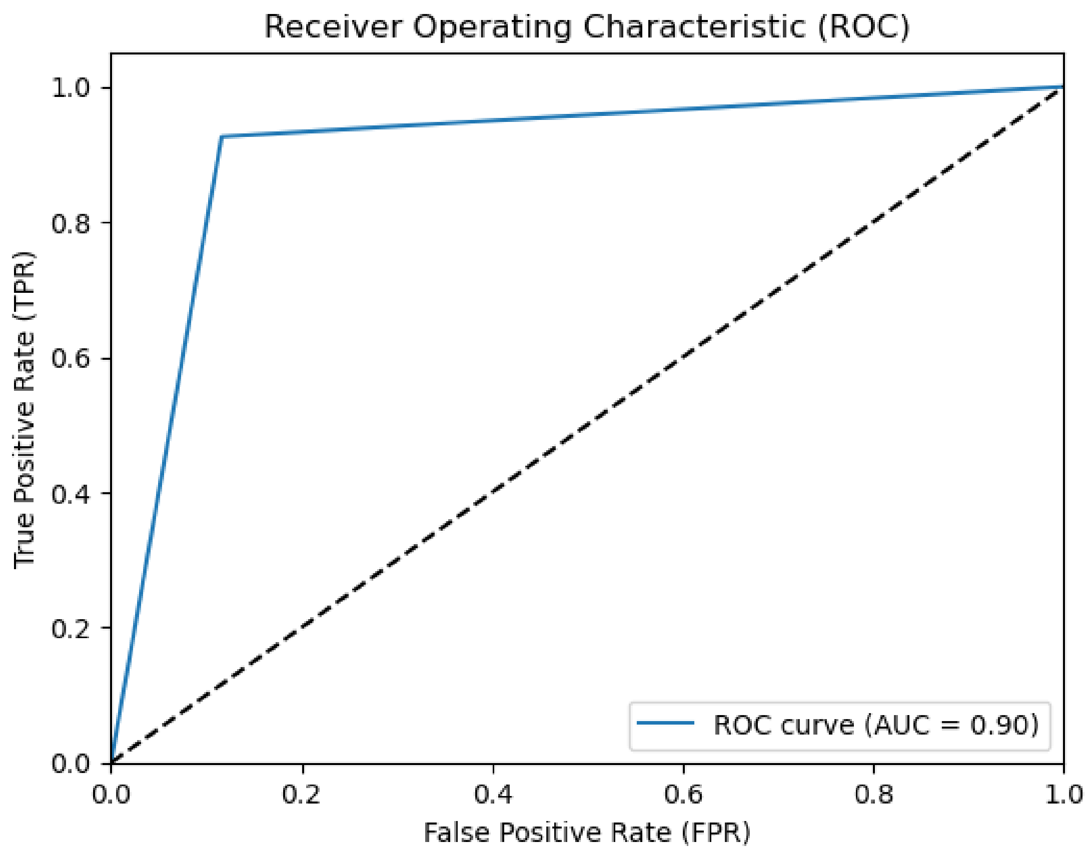
[54]:
```
get_metrics(clf,test_ft,test_labels)
```

```
              precision    recall  f1-score   support

        fake       0.88      0.92      0.90      6741
        real       0.93      0.89      0.91      7567

    accuracy                           0.91     14308
   macro avg       0.90      0.91      0.91     14308
weighted avg       0.91      0.91      0.91     14308
```

[55]:
```
plot_ROC(test_labels)
```



4.0.3 Artificial Neural Network

[56]:
```
x_train,y_train,X_val,y_val,test_ft,test_labels=split_data_dl(features_w2v_txt,labels)
```

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

[57]:
```
tfidf_w2v_model= ANN_model()
tfidf_w2v_model.build((None,115))
print(tfidf_w2v_model.summary())
```

```
Model: "ann_model_2"

_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_3 (Dense)             multiple                  7424

 dense_4 (Dense)             multiple                  2080
```

```
 dense_5 (Dense)             multiple                  33

=================================================================
Total params: 9,537
Trainable params: 9,537
Non-trainable params: 0
_________________________________________________________________
None
```

[58]:
```
tfidf_w2v_model.compile(optimizer='adam', loss='binary_crossentropy',␣
↪metrics=['accuracy'])
history=tfidf_w2v_model.fit(train_ft, train_labels, epochs=10, batch_size=32,␣
↪validation_data=(X_val, y_val))
```

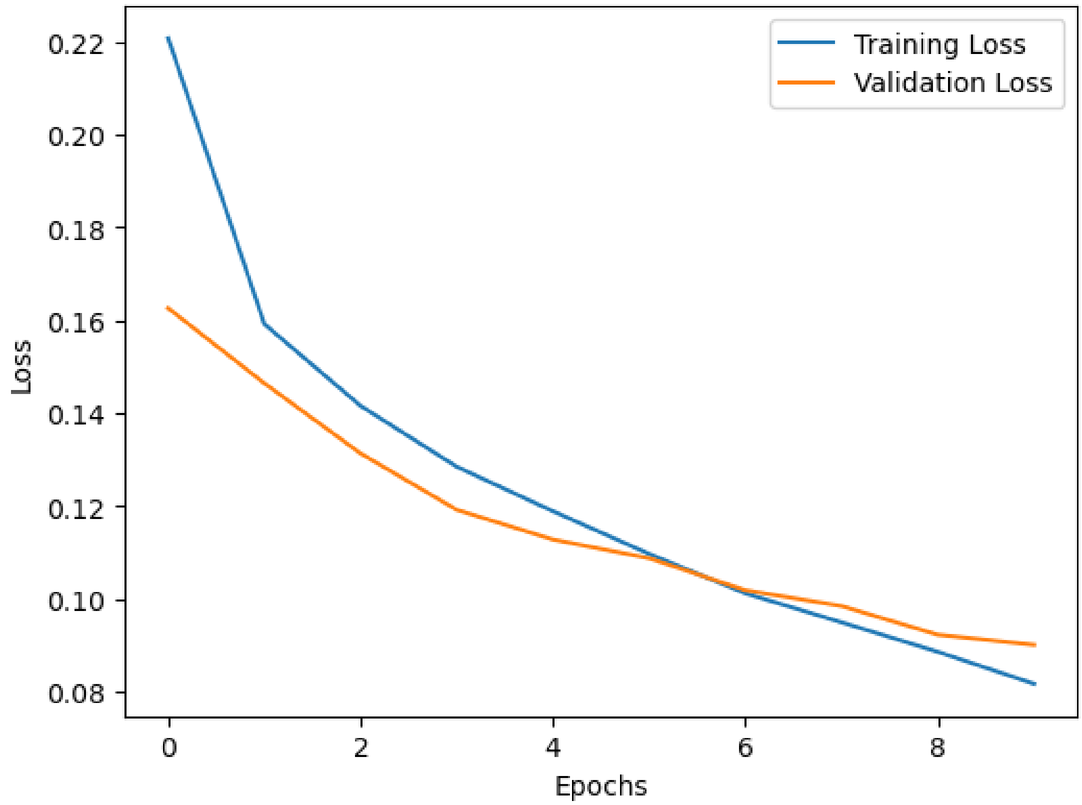
```
Epoch 1/10
1789/1789 [==============================] - 6s 3ms/step - loss: 0.2207 -
accuracy: 0.9081 - val_loss: 0.1626 - val_accuracy: 0.9355
Epoch 2/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1591 -
accuracy: 0.9368 - val_loss: 0.1464 - val_accuracy: 0.9393
Epoch 3/10
1789/1789 [==============================] - 6s 3ms/step - loss: 0.1415 -
accuracy: 0.9429 - val_loss: 0.1313 - val_accuracy: 0.9472
Epoch 4/10
1789/1789 [==============================] - 6s 3ms/step - loss: 0.1284 -
accuracy: 0.9493 - val_loss: 0.1191 - val_accuracy: 0.9540
Epoch 5/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1188 -
accuracy: 0.9535 - val_loss: 0.1127 - val_accuracy: 0.9553
Epoch 6/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1096 -
accuracy: 0.9575 - val_loss: 0.1087 - val_accuracy: 0.9597
Epoch 7/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1011 -
accuracy: 0.9612 - val_loss: 0.1018 - val_accuracy: 0.9640
Epoch 8/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.0949 -
accuracy: 0.9636 - val_loss: 0.0984 - val_accuracy: 0.9651
Epoch 9/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.0885 -
accuracy: 0.9661 - val_loss: 0.0922 - val_accuracy: 0.9676
Epoch 10/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.0816 -
accuracy: 0.9700 - val_loss: 0.0900 - val_accuracy: 0.9702
```

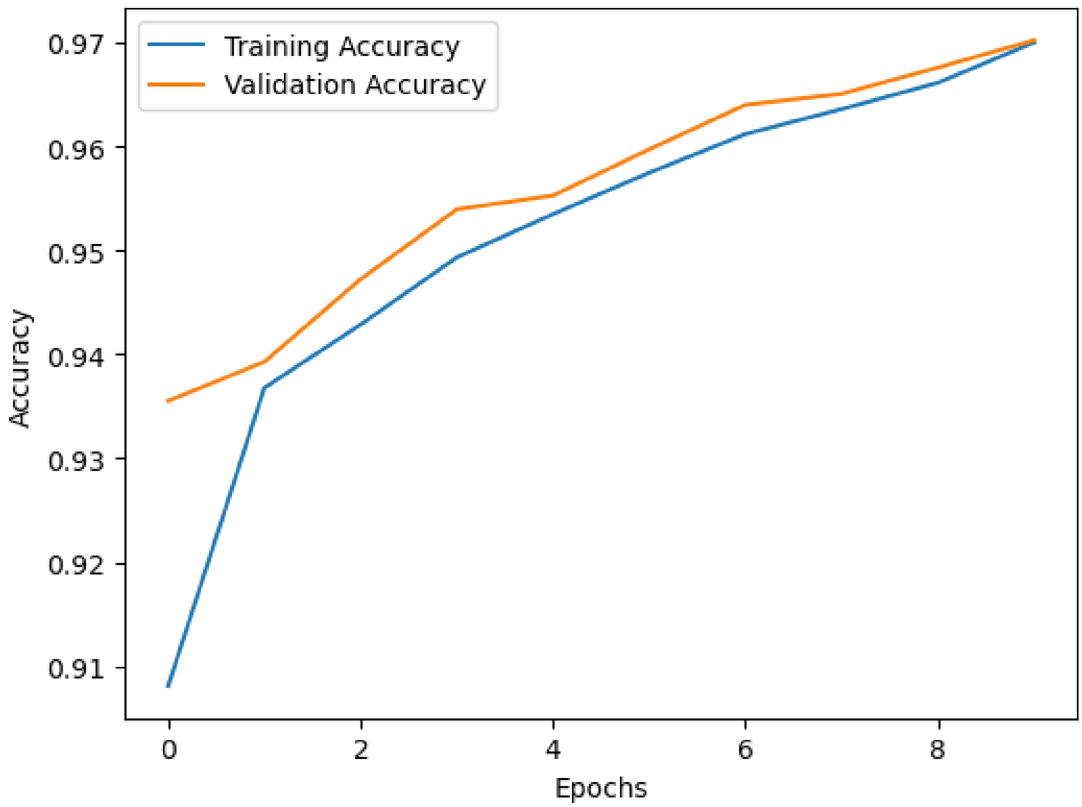
[60]:
```
# Evaluate the model on the test set
test_loss, test_accuracy = tfidf_w2v_model.evaluate(test_ft, test_labels)
```

```python
print(f'Test Loss: {test_loss}, Test Accuracy: {test_accuracy}')
```

```
448/448 [==============================] - 1s 2ms/step - loss: 0.0943 -
accuracy: 0.9678
Test Loss: 0.09433166682720184, Test Accuracy: 0.9677802920341492
```

[61]:
```python
plot_loss_acc(history)
```





[63]:
```
tfidf_w2v_model.save_weights("tfidf_w2v_model.h5")
```

5 3. TF-IDF weighted Word2vec vectors

5.1 Machine learning models

[64]:
```
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)
```

[73]:
```
sentence_vectors_tf.shape
```

[73]: (71537, 100)

[77]:
```
pickle.dump(sentence_vectors_tf, open('features_w2v_tf_wts.pkl', 'wb'))
```

[78]:
```
features_w2v_tf_wts=pickle.load( open('features_w2v_tf_wts.pkl', 'rb'))
```

[80]:
```
train_ft,test_ft,train_labels,test_labels=split_data_ml(features_w2v_tf_wts,labels)
```

```
----------------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,)
```

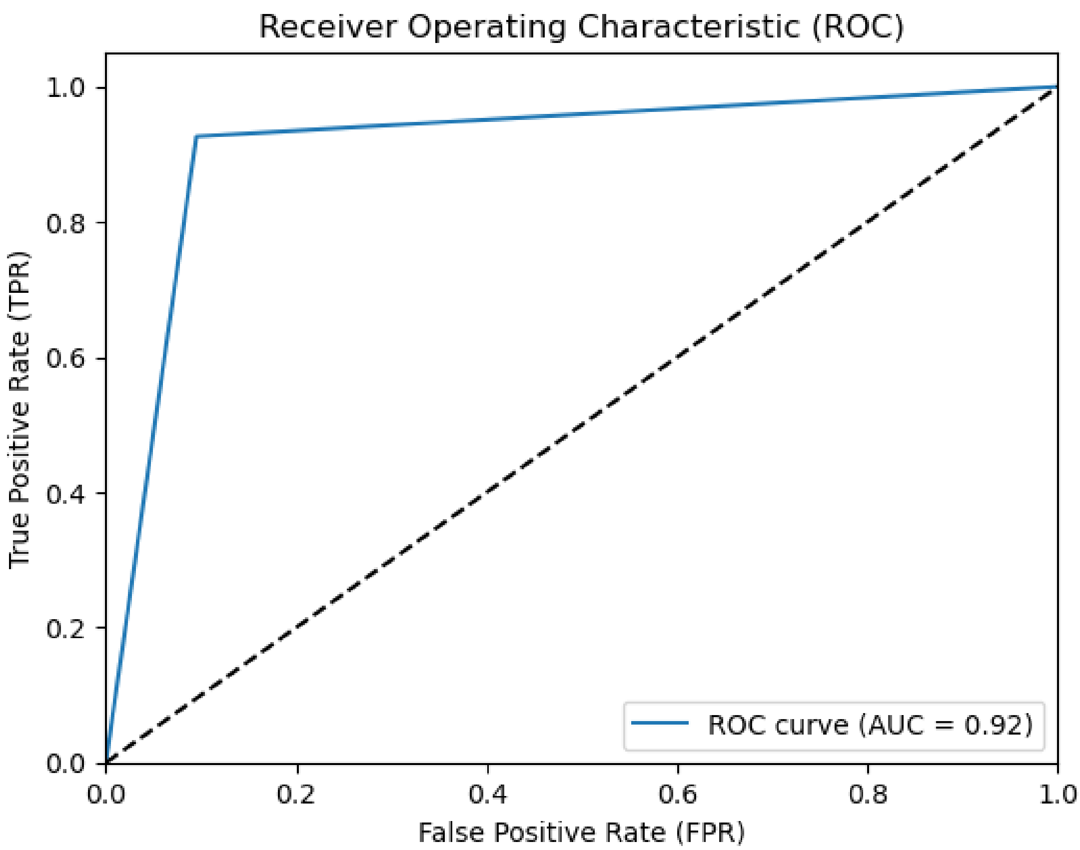
5.1.1 Logistic Regression

[81]:
```
clf = LogisticRegression(random_state=0, max_iter=300).fit(train_ft,␣
 ↪train_labels)
get_metrics(clf,test_ft,test_labels)
plot_ROC(test_labels)
```

```
              precision    recall  f1-score   support

        fake       0.90      0.92      0.91      6816
        real       0.93      0.91      0.92      7492

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



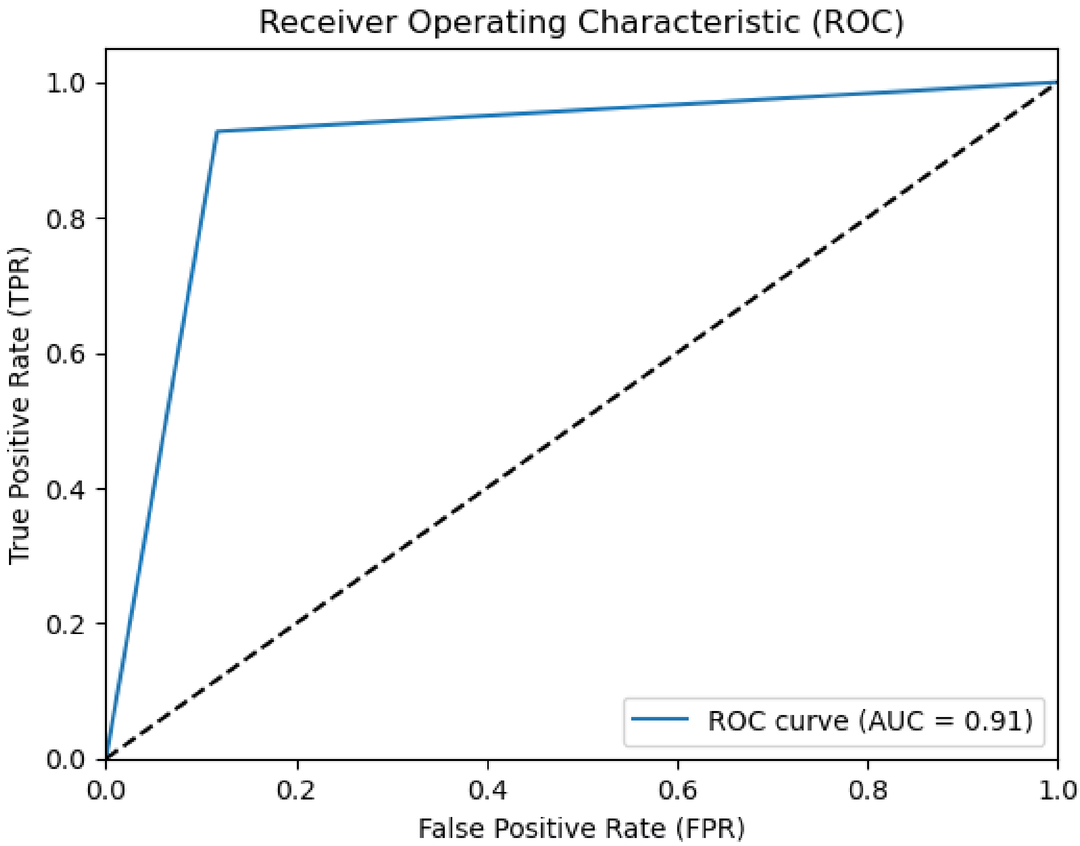
5.1.2 Linear Discriminant Analysis

[82]:
```
clf = LinearDiscriminantAnalysis().fit(train_ft, train_labels)
get_metrics(clf,test_ft,test_labels)
plot_ROC(test_labels)
```

```
              precision    recall  f1-score   support

        fake       0.88      0.92      0.90      6658
        real       0.93      0.89      0.91      7650

    accuracy                           0.91     14308
   macro avg       0.91      0.91      0.91     14308
weighted avg       0.91      0.91      0.91     14308
```



5.1.3 Artificial Neural Networks

[83]:
```
x_train,y_train,X_val,y_val,test_ft,test_labels=split_data_dl(features_w2v_tf_wts,labels)
```

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

[84]:
```
tfidf_w2v_wts_model= ANN_model()
tfidf_w2v_wts_model.build((None,115))
print(tfidf_w2v_model.summary())
```

```
Model: "ann_model_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_6 (Dense)             multiple                  7424

 dense_7 (Dense)             multiple                  2080
```

```
 dense_8 (Dense)             multiple                  33

=================================================================
Total params: 9,537
Trainable params: 9,537
Non-trainable params: 0
_________________________________________________________________
None
```

[85]:
```
opt = keras.optimizers.SGD(learning_rate=0.1)
tfidf_w2v_wts_model.compile(optimizer=opt, loss='binary_crossentropy',␣
 ↪metrics=['accuracy'])
history=tfidf_w2v_wts_model.fit(train_ft, train_labels, epochs=10,␣
 ↪batch_size=32, validation_data=(X_val, y_val))
```

```
Epoch 1/10
1789/1789 [==============================] - 7s 3ms/step - loss: 0.2162 -
accuracy: 0.9123 - val_loss: 0.1794 - val_accuracy: 0.9275
Epoch 2/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1643 -
accuracy: 0.9348 - val_loss: 0.1585 - val_accuracy: 0.9368
Epoch 3/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1486 -
accuracy: 0.9409 - val_loss: 0.1460 - val_accuracy: 0.9416
Epoch 4/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1369 -
accuracy: 0.9464 - val_loss: 0.1368 - val_accuracy: 0.9464
Epoch 5/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1271 -
accuracy: 0.9498 - val_loss: 0.1314 - val_accuracy: 0.9469
Epoch 6/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1191 -
accuracy: 0.9533 - val_loss: 0.1231 - val_accuracy: 0.9519
Epoch 7/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1123 -
accuracy: 0.9565 - val_loss: 0.1176 - val_accuracy: 0.9552
Epoch 8/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1050 -
accuracy: 0.9592 - val_loss: 0.1167 - val_accuracy: 0.9553
Epoch 9/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1015 -
accuracy: 0.9607 - val_loss: 0.1078 - val_accuracy: 0.9594
Epoch 10/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.0955 -
accuracy: 0.9633 - val_loss: 0.1046 - val_accuracy: 0.9615
```

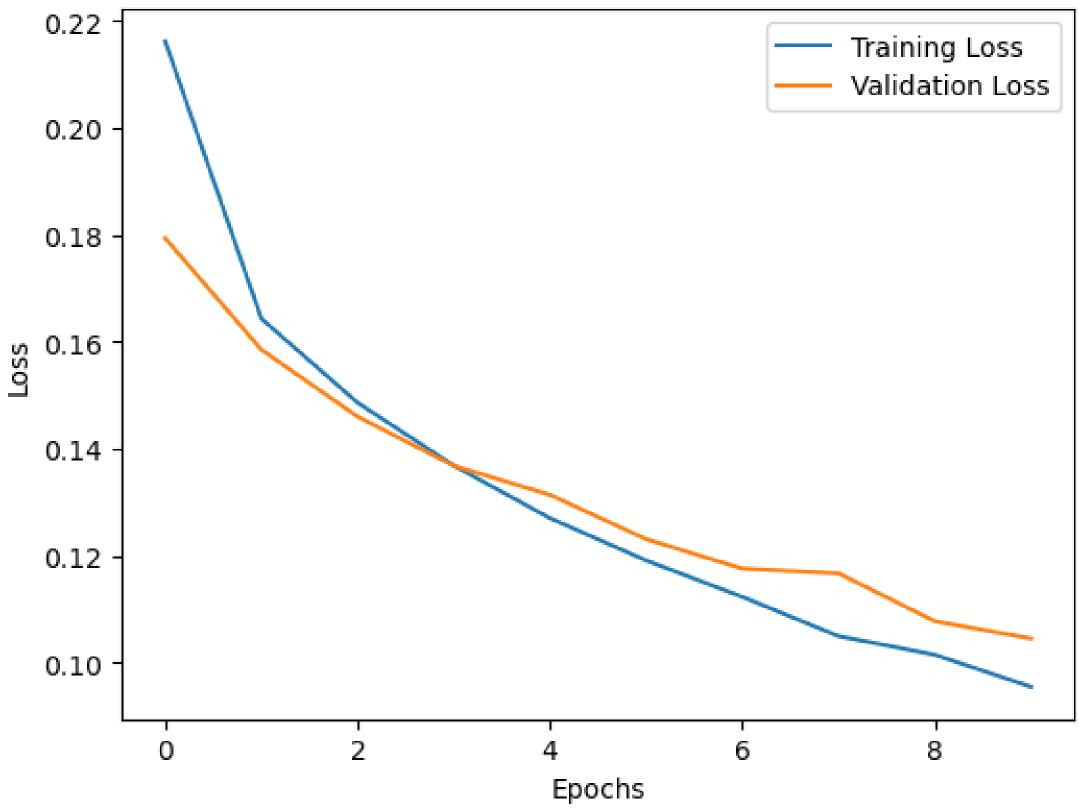
[86]:

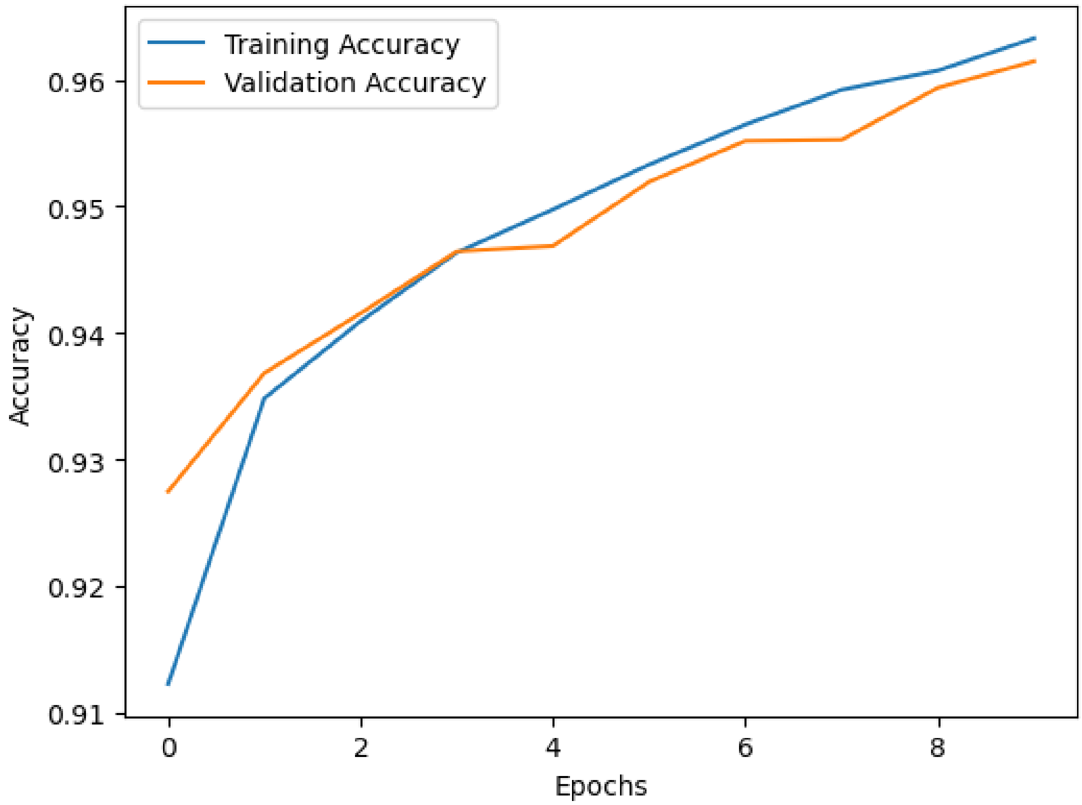
```
# Evaluate the model on the test set
test_loss, test_accuracy = tfidf_w2v_wts_model.evaluate(test_ft, test_labels)
print(f'Test Loss: {test_loss}, Test Accuracy: {test_accuracy}')
```

```
448/448 [==============================] - 1s 2ms/step - loss: 0.0964 -
accuracy: 0.9639
Test Loss: 0.09637467563152313, Test Accuracy: 0.9638663530349731
```

[87]:

```
plot_loss_acc(history)
```





[88]:
```
tfidf_w2v_wts_model.save_weights("tfidf_w2v_wts_model.h5")
```

6 4 TF-IDF weighted Word2vec with non numeric features

6.1 Machine Learning Models

[89]:
```
features_w2v_tfidf_txt = np.hstack((sentence_vectors_tf, non_text_features_np))
```

6.1.1 Logistic Regression

[90]:
```
train_ft,test_ft,train_labels,test_labels=split_data_ml(features_w2v_tfidf_txt,labels)
```

```
----------------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,)
```

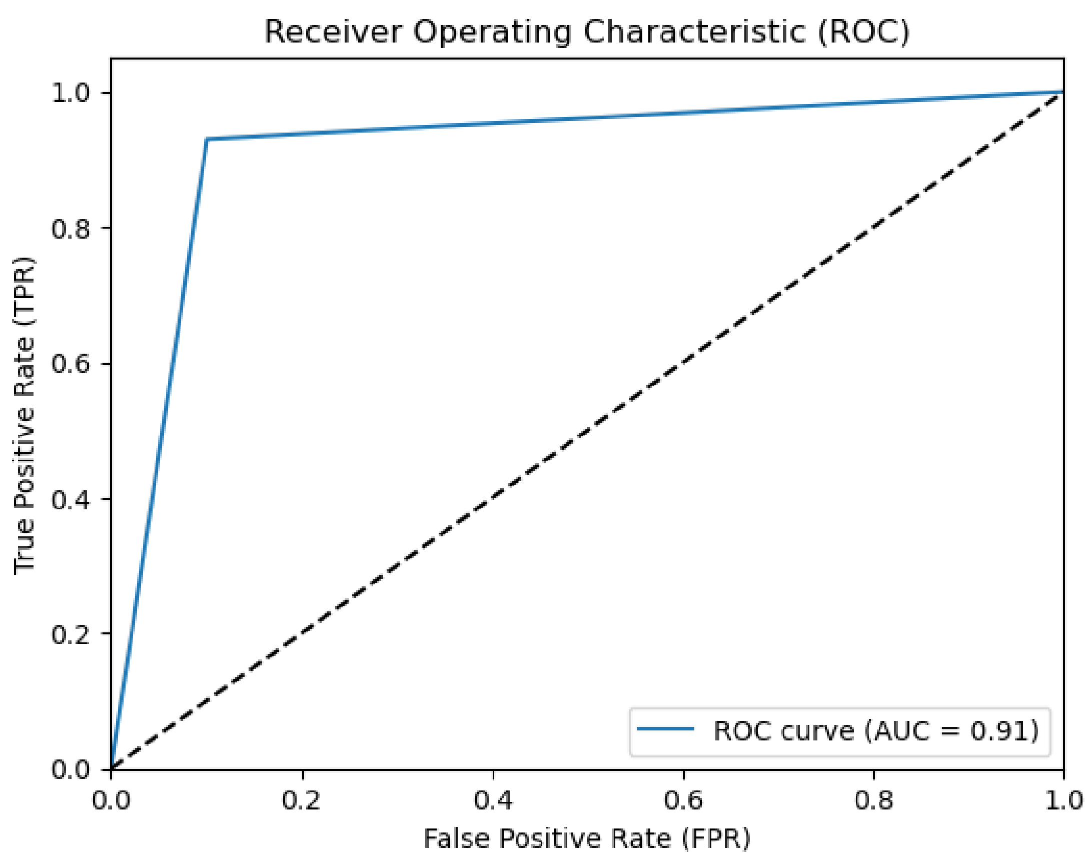
[91]:

```
clf = LogisticRegression(random_state=0, max_iter=300).fit(train_ft,␣
 ↪train_labels)
get_metrics(clf,test_ft,test_labels)
plot_ROC(test_labels)
```

```
              precision    recall  f1-score   support

        fake       0.90      0.92      0.91      6809
        real       0.93      0.91      0.92      7499

    accuracy                           0.91     14308
   macro avg       0.91      0.92      0.91     14308
weighted avg       0.92      0.91      0.91     14308
```



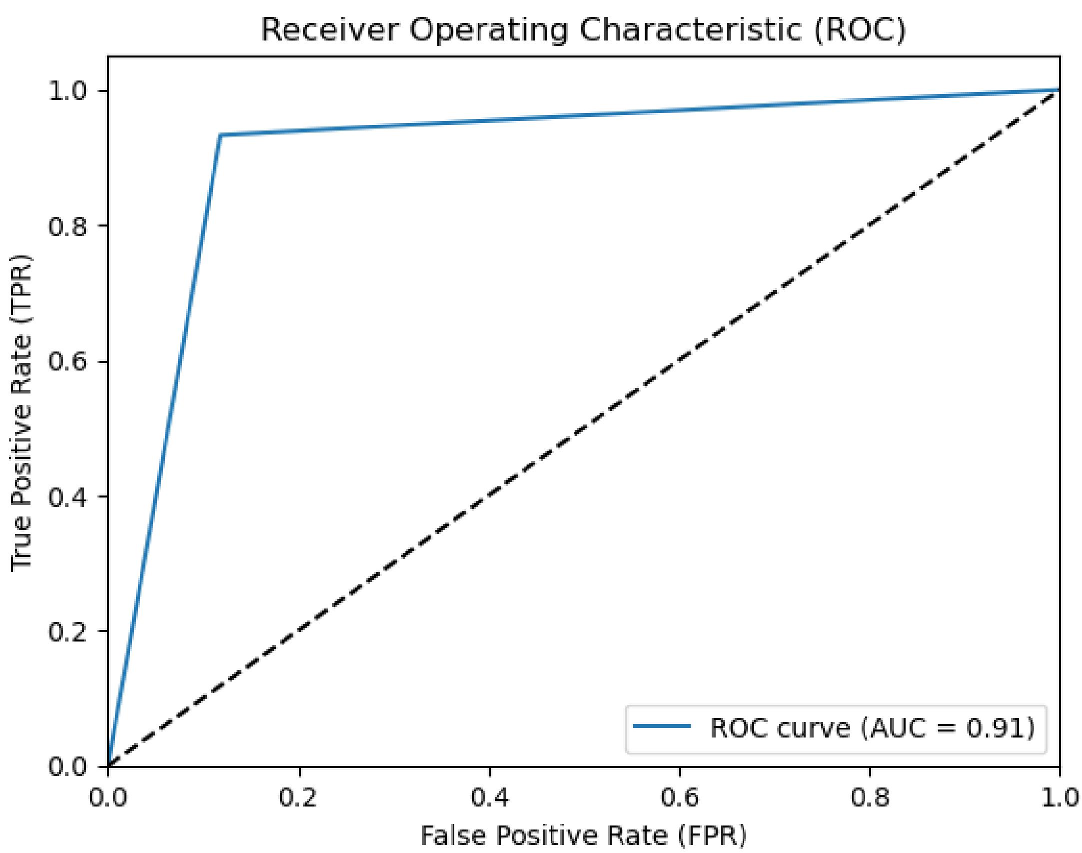
6.1.2 Linear Discriminant Analysis

[92]:
```
clf = LinearDiscriminantAnalysis().fit(train_ft, train_labels)
get_metrics(clf,test_ft,test_labels)
plot_ROC(test_labels)
```

```
              precision    recall  f1-score   support

        fake       0.88      0.93      0.90      6666
        real       0.93      0.89      0.91      7642

    accuracy                           0.91     14308
   macro avg       0.91      0.91      0.91     14308
weighted avg       0.91      0.91      0.91     14308
```



6.1.3 Artificial Neural Networks

[93]:
```
x_train,y_train,X_val,y_val,test_ft,test_labels=split_data_dl(features_w2v_tfidf_txt,labels)
```

```
Training set shape: (45783, 115)
```

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

[95]:
```
tfidf_w2v_txt_model= ANN_model()
tfidf_w2v_txt_model.build((None,115))
print(tfidf_w2v_txt_model.summary())
```

```
Model: "ann_model_6"

_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_15 (Dense)            multiple                  7424

 dense_16 (Dense)            multiple                  2080

 dense_17 (Dense)            multiple                  33

=================================================================
Total params: 9,537
Trainable params: 9,537
Non-trainable params: 0
_________________________________________________________________
None
```

[96]:
```
opt = keras.optimizers.SGD(learning_rate=0.1)
tfidf_w2v_txt_model.compile(optimizer=opt, loss='binary_crossentropy',␣
 ↪metrics=['accuracy'])
history=tfidf_w2v_txt_model.fit(train_ft, train_labels, epochs=10,␣
 ↪batch_size=32, validation_data=(X_val, y_val))
```

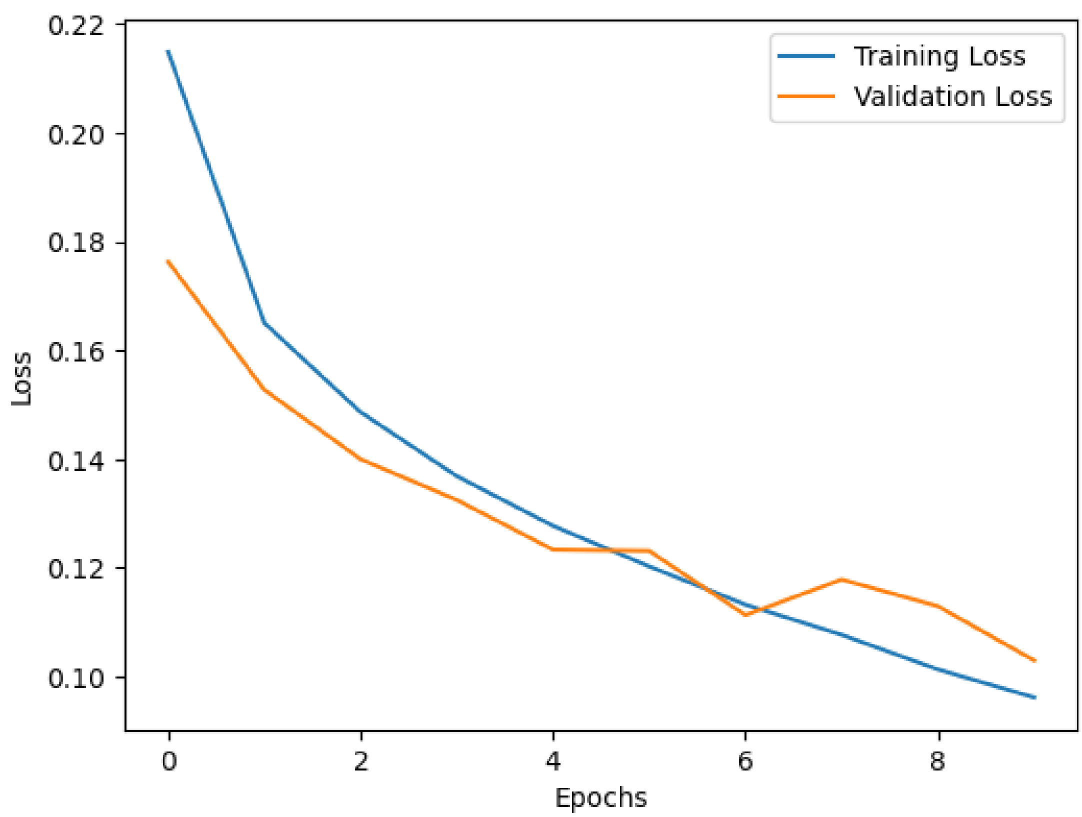
```
Epoch 1/10
1789/1789 [==============================] - 6s 3ms/step - loss: 0.2148 -
accuracy: 0.9143 - val_loss: 0.1763 - val_accuracy: 0.9291
Epoch 2/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1650 -
accuracy: 0.9348 - val_loss: 0.1527 - val_accuracy: 0.9404
Epoch 3/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1486 -
accuracy: 0.9411 - val_loss: 0.1400 - val_accuracy: 0.9446
Epoch 4/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1369 -
accuracy: 0.9463 - val_loss: 0.1325 - val_accuracy: 0.9483
Epoch 5/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1277 -
accuracy: 0.9503 - val_loss: 0.1233 - val_accuracy: 0.9521
Epoch 6/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1203 -
accuracy: 0.9530 - val_loss: 0.1231 - val_accuracy: 0.9518
```

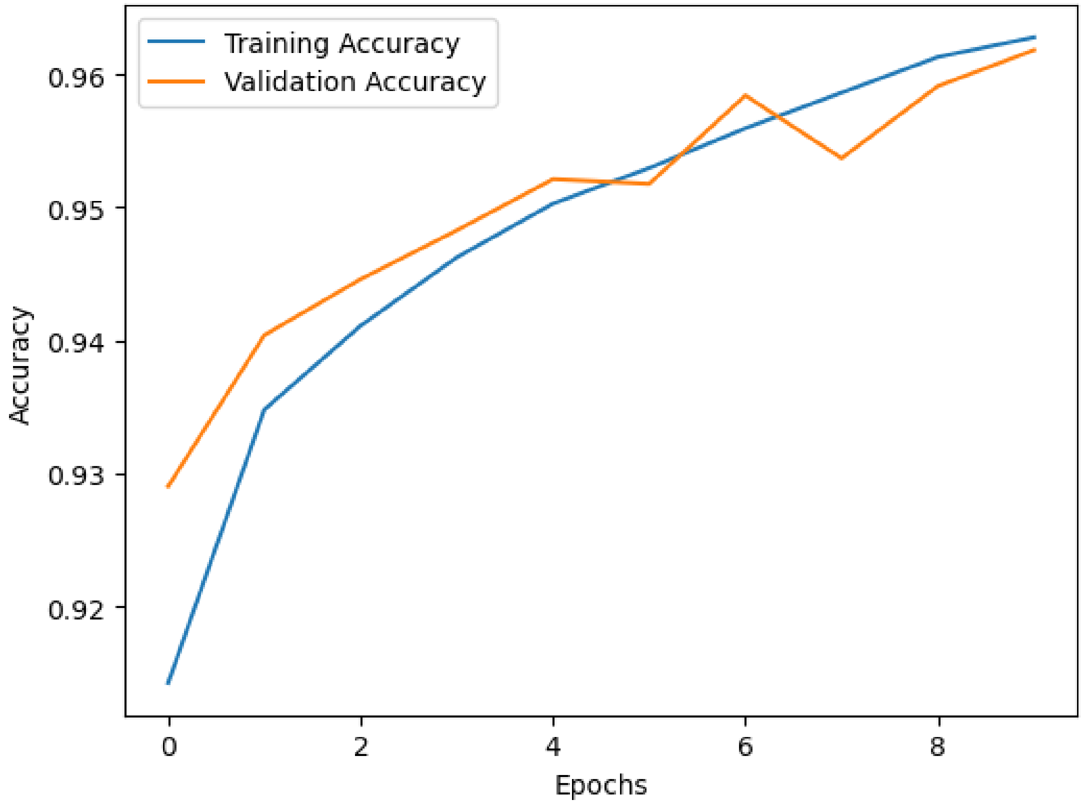
```
Epoch 7/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1132 -
accuracy: 0.9559 - val_loss: 0.1113 - val_accuracy: 0.9584
Epoch 8/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1077 -
accuracy: 0.9586 - val_loss: 0.1178 - val_accuracy: 0.9537
Epoch 9/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.1013 -
accuracy: 0.9613 - val_loss: 0.1130 - val_accuracy: 0.9591
Epoch 10/10
1789/1789 [==============================] - 5s 3ms/step - loss: 0.0962 -
accuracy: 0.9628 - val_loss: 0.1030 - val_accuracy: 0.9618
```

[97]:
```
# Evaluate the model on the test set
test_loss, test_accuracy = tfidf_w2v_txt_model.evaluate(test_ft, test_labels)
print(f'Test Loss: {test_loss}, Test Accuracy: {test_accuracy}')
```

```
448/448 [==============================] - 1s 2ms/step - loss: 0.1041 -
accuracy: 0.9605
Test Loss: 0.10413851588964462, Test Accuracy: 0.9605116248130798
```

[98]:
```
plot_loss_acc(history)
```





[99]:
```
tfidf_w2v_txt_model.save_weights("tfidf_w2v_txt_model.h5")
```

[118]:
```
%load_ext tensorboard
%tensorboard --logdir=log/train
```

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

```
<IPython.core.display.HTML object>
```

[ ]:
```

```