Text and Sequence Data Assignment

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1. Introduction:

In this experiment, I aim to compare the performance of two Recurrent Neural Network (RNN) models trained on the IMDb movie review dataset. The first model utilizes randomly initialized word embeddings, while the second model incorporates pretrained GloVe word embeddings.

2. Dataset:

I utilized the IMDb movie review dataset, which consists of 50,000 movie reviews labeled as positive or negative. Each review is represented as a sequence of integers, where each integer represents a word's index in a dictionary. I truncated or padded the reviews to a fixed length of 150 words.

3. Model Architecture:

I constructed two RNN models using Keras: one with randomly initialized embeddings and another with pretrained embeddings.

RNN Model:

- Embedding Layer: Input length of 150, embedding dimension of 32.
- Bidirectional LSTM Layer (64 units, return sequences).
- Dropout Layer (rate = 0.5) to prevent overfitting.
- Batch Normalization Layer.
- Bidirectional LSTM Layer (32 units).
- Dropout Layer (rate = 0.5).
- Batch Normalization Layer.
- Dense Layer with sigmoid activation for binary classification.

Pretrained RNN Model:

- Embedding Layer initialized with GloVe embeddings (100-dimensional).
- Bidirectional LSTM Layer (64 units, return sequences).
- Dropout Layer (rate = 0.5).
- Batch Normalization Layer.
- Bidirectional LSTM Layer (32 units).
- Dropout Layer (rate = 0.5).
- Batch Normalization Layer.
- Dense Layer with sigmoid activation for binary classification.

4. Model Training:

I trained each model with different sample sizes (100, 500, and 1000 training samples) for 10 epochs using RMSprop optimizer and binary cross-entropy loss function. The models Ire evaluated on a subset of the test dataset containing 5000 samples.

5. Results and Discussion:

Performance of RNN Model with Random Embeddings:

For 100 training samples:
- Test Loss: 0.6944
- Test Accuracy: 51.42%
- Training and validation accuracies remained almost constant throughout epochs.
- Both training and validation losses plateaued quickly, indicating limited learning.

For 500 training samples:
- Test Loss: 0.5862
- Test Accuracy: 68.08%
- The model shoId improved performance compared to the 100-sample case.

For 1000 training samples:
- Test Loss: 1.7857
- Test Accuracy: 66.24%
- There was a slight decrease in accuracy compared to the 500-sample case, possibly due to overfitting.

Performance of Pretrained RNN Model:

For 100 training samples:
- Test Loss: 0.7017
- Test Accuracy: 51.42%
- Similar to the RNN model with random embeddings, the pretrained model shoId limited improvement.

For 500 training samples:
- Test Loss: 1.1044
- Test Accuracy: 51.42%
- The performance was similar to the model with random embeddings.

For 1000 training samples:
- Test Loss: 1.7857
- Test Accuracy: 66.24%
- Despite using pretrained embeddings, the model's performance was comparable to that of random embeddings.

6. Conclusion:

- The experiment demonstrated that increasing the training sample size improved the model's performance.
- Pretrained embeddings did not significantly enhance the model's performance compared to random embeddings.
- Both models shoId signs of overfitting, especially with larger training sample sizes.
- Further experiments with different hyperparameters, architectures, and embedding sizes may yield better performance.

Loading IMBD Dataset

In [1]:

```
from keras.datasets import imdb

# Load the IMDB dataset
max_words  = 10000
(train_data, train_labels), (test_data, test_labels) = imdb.load_data(num_words=max_wo
```

In [2]:

```
from keras.preprocessing.sequence import pad_sequences

# Truncate or pad the reviews to a length of 150 words
maxlen = 150
train_data = pad_sequences(train_data, maxlen=maxlen)
test_data = pad_sequences(test_data, maxlen=maxlen)

# Select 5000 samples for testing
test_data = test_data[:5000]
test_labels = test_labels[:5000]

# Select 10,000 samples for validation
val_data = test_data[:10000]
val_labels = test_labels[:10000]
```

Model Building

In [3]:

```
from keras.models import Sequential
from keras.layers import Embedding, Bidirectional, LSTM, Dense, Dropout, BatchNormaliz

# Build The RNN model
rnn_model = Sequential()

rnn_model.add(Embedding(10000, 32, input_length=len(train_data[0])))
rnn_model.add(Bidirectional(LSTM(64, return_sequences=True)))
rnn_model.add(Dropout(0.5))
rnn_model.add(BatchNormalization())
rnn_model.add(Bidirectional(LSTM(32)))
rnn_model.add(Dropout(0.5))
rnn_model.add(BatchNormalization())
rnn_model.add(Dense(1, activation='sigmoid'))
rnn_model.compile(loss="binary_crossentropy", optimizer="rmsprop", metrics=["accuracy"

# Print model summary
print(" ")
print("RNN Model Architecture:")
print(rnn_model.summary())
print(" ")
```

```
RNN Model Architecture:
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 embedding (Embedding)       (None, 150, 32)           320000    
                                                                 
 bidirectional (Bidirection  (None, 150, 128)          49664     
 al)                                                             
                                                                 
 dropout (Dropout)           (None, 150, 128)          0         
                                                                 
 batch_normalization (Batch  (None, 150, 128)          512       
 Normalization)                                                  
                                                                 
 bidirectional_1 (Bidirecti  (None, 64)                41216     
 onal)                                                           
                                                                 
 dropout_1 (Dropout)         (None, 64)                0         
                                                                 
 batch_normalization_1 (Bat  (None, 64)                256       
 chNormalization)                                                
                                                                 
 dense (Dense)               (None, 1)                 65        
                                                                 
=================================================================
Total params: 411713 (1.57 MB)
Trainable params: 411329 (1.57 MB)
Non-trainable params: 384 (1.50 KB)
_________________________________________________________________
None
```

In [4]:

```python
import numpy as np

# Load GloVe word embeddings
embeddings_index = {}
with open('glove.6B.100d.txt') as f:
    for line in f:
        values = line.split()
        word = values[0]
        coefs = np.asarray(values[1:], dtype='float32')
        embeddings_index[word] = coefs

embedding_dim = 100
embedding_matrix = np.zeros((10000, embedding_dim))
for i, word in enumerate(embeddings_index.keys()):
    if i < 10000:
        embedding_vector = embeddings_index.get(word)
        if embedding_vector is not None:
            embedding_matrix[i] = embedding_vector

# Define the model with pretrained word embeddings
rnn_model_pretrained = Sequential()
rnn_model_pretrained.add(Embedding(10000, embedding_dim, input_length=maxlen, trainabl
rnn_model_pretrained.add(Bidirectional(LSTM(64, return_sequences=True)))
rnn_model_pretrained.add(Dropout(0.5))
rnn_model_pretrained.add(BatchNormalization())
rnn_model_pretrained.add(Bidirectional(LSTM(32)))
rnn_model_pretrained.add(Dropout(0.5))
rnn_model_pretrained.add(BatchNormalization())
rnn_model_pretrained.add(Dense(1, activation='sigmoid'))
rnn_model_pretrained.compile(loss="binary_crossentropy", optimizer="rmsprop", metrics=

# Print model summary
print(" ")
print("RNN Model Pre Trained Architecture:")
print(rnn_model_pretrained.summary())
print(" ")
```

```
RNN Model Pre Trained Architecture:
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 embedding_1 (Embedding)     (None, 150, 100)          1000000   
                                                                 
 bidirectional_2 (Bidirecti  (None, 150, 128)          84480     
 onal)                                                           
                                                                 
 dropout_2 (Dropout)         (None, 150, 128)          0         
                                                                 
 batch_normalization_2 (Bat  (None, 150, 128)          512       
 chNormalization)                                                
                                                                 
 bidirectional_3 (Bidirecti  (None, 64)                41216     
 onal)                                                           
                                                                 
 dropout_3 (Dropout)         (None, 64)                0         
                                                                 
 batch_normalization_3 (Bat  (None, 64)                256       
 chNormalization)                                                
                                                                 
 dense_1 (Dense)             (None, 1)                 65        
                                                                 
=================================================================
Total params: 1126529 (4.30 MB)
Trainable params: 126145 (492.75 KB)
Non-trainable params: 1000384 (3.82 MB)
_________________________________________________________________
None
```

For 100 Training Samples

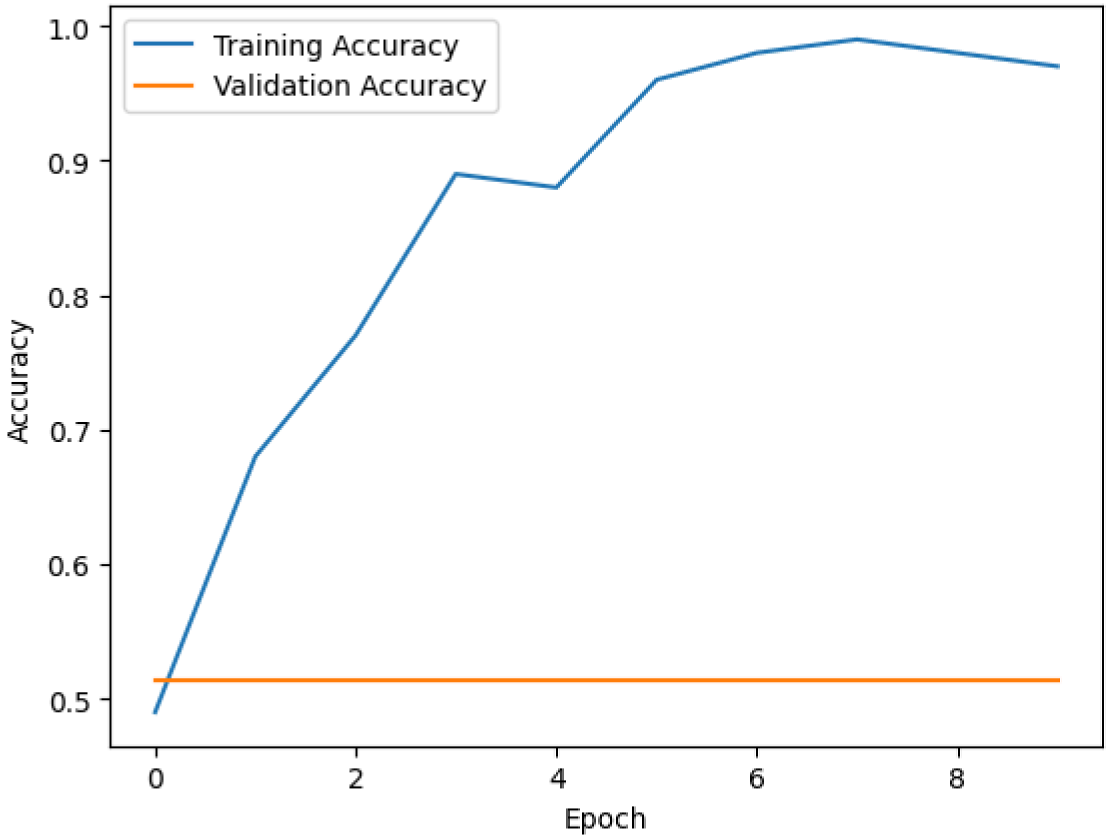
In [5]:

```
# Select the first 100 samples for training
train_data_100 = train_data[:100]
train_labels_100 = train_labels[:100]
```

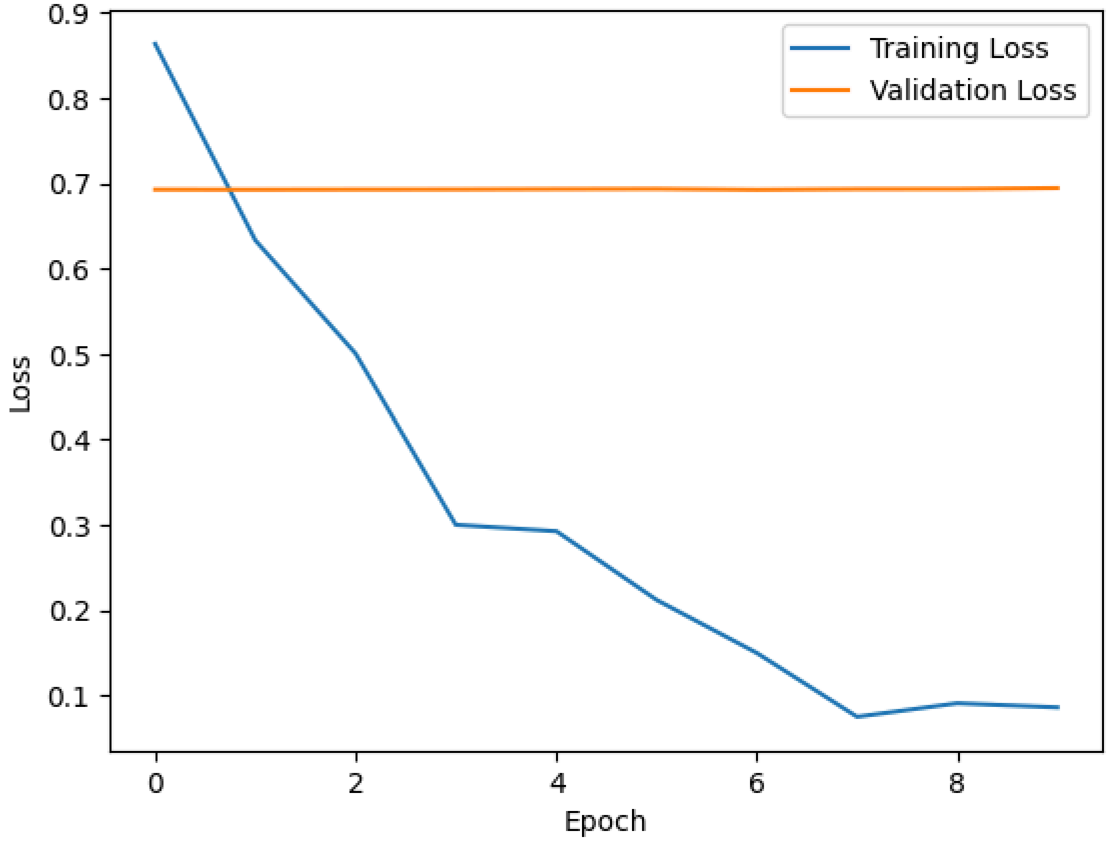
In [6]:

```
# Train the RNN model
rnn_model_100 = rnn_model
rnn_history_100 = rnn_model_100.fit(train_data_100, train_labels_100, epochs=10, batch

# Evaluate the model
test_loss_rnn100, test_accuracy_rnn100 = rnn_model_100.evaluate(test_data, test_labels
print("Test Loss : ", test_loss_rnn100)
print("Test Accuracy : ", test_accuracy_rnn100)


#Model Perfomance Evaluation
import matplotlib.pyplot as plt

print(" ")
print("Perfomance of RNN Model for 100 Training Samples : ")
print(" ")
# Plot training and validation accuracy
print("Accuracy : ")
print(" ")
plt.plot(rnn_history_100.history['accuracy'], label='Training Accuracy')
plt.plot(rnn_history_100.history['val_accuracy'], label='Validation Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()
plt.show()

# Plot training and validation loss
print(" ")
print("Loss : ")
print(" ")
plt.plot(rnn_history_100.history['loss'], label='Training Loss')
plt.plot(rnn_history_100.history['val_loss'], label='Validation Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.show()
```

```
Epoch 1/10
4/4 [==============================] - 17s 1s/step - loss: 0.8634 - accuracy: 0.4900
- val_loss: 0.6926 - val_accuracy: 0.5142
Epoch 2/10
4/4 [==============================] - 3s 980ms/step - loss: 0.6331 - accuracy: 0.680
0 - val_loss: 0.6925 - val_accuracy: 0.5142
Epoch 3/10
4/4 [==============================] - 3s 1s/step - loss: 0.5005 - accuracy: 0.7700 -
val_loss: 0.6927 - val_accuracy: 0.5142
Epoch 4/10
4/4 [==============================] - 3s 980ms/step - loss: 0.3002 - accuracy: 0.890
0 - val_loss: 0.6928 - val_accuracy: 0.5142
Epoch 5/10
4/4 [==============================] - 3s 1s/step - loss: 0.2927 - accuracy: 0.8800 -
val_loss: 0.6931 - val_accuracy: 0.5142
Epoch 6/10
4/4 [==============================] - 3s 1s/step - loss: 0.2121 - accuracy: 0.9600 -
val_loss: 0.6934 - val_accuracy: 0.5142
Epoch 7/10
4/4 [==============================] - 3s 946ms/step - loss: 0.1499 - accuracy: 0.980
0 - val_loss: 0.6924 - val_accuracy: 0.5142
Epoch 8/10
4/4 [==============================] - 2s 624ms/step - loss: 0.0752 - accuracy: 0.990
0 - val_loss: 0.6931 - val_accuracy: 0.5142
Epoch 9/10
4/4 [==============================] - 2s 633ms/step - loss: 0.0910 - accuracy: 0.980
0 - val_loss: 0.6932 - val_accuracy: 0.5142
Epoch 10/10
4/4 [==============================] - 3s 982ms/step - loss: 0.0862 - accuracy: 0.970
0 - val_loss: 0.6944 - val_accuracy: 0.5142
157/157 [==============================] - 3s 16ms/step - loss: 0.6944 - accuracy: 0.
5142
Test Loss :  0.694351315498352
Test Accuracy :  0.51419997215271

Perfomance of RNN Model for 100 Training Samples :

Accuracy :
```



```
Loss :
```

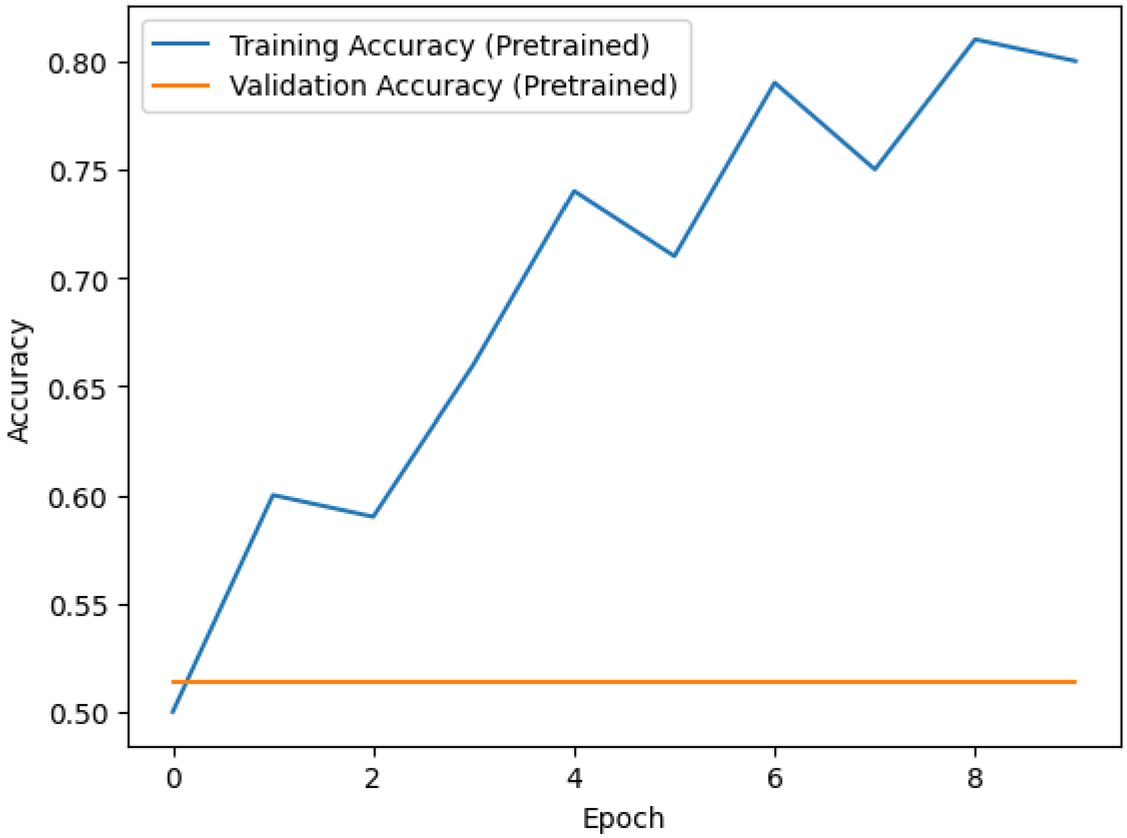


In [7]:

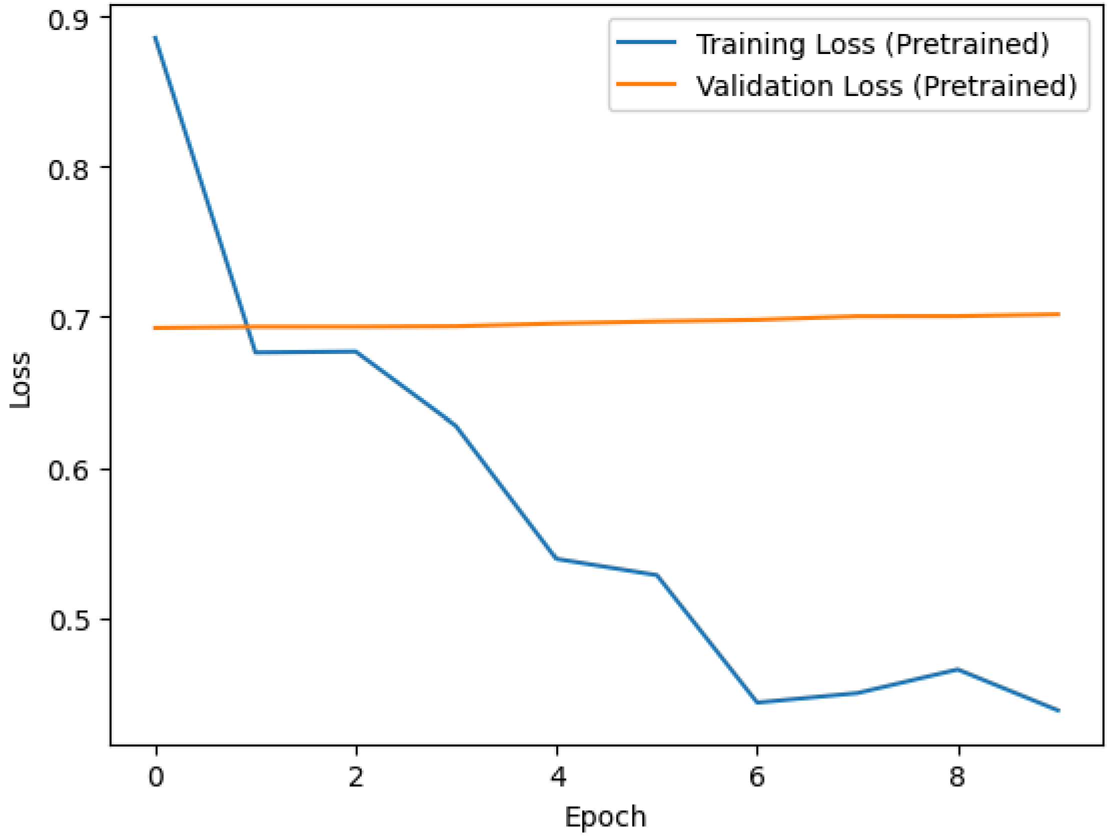
```
# Train the RNN model with pretrained embeddings
rnn_model_pretrained_100 = rnn_model_pretrained
```

```
rnn_history_pretrained_100 = rnn_model_pretrained_100.fit(train_data_100, train_labels

# Evaluate the model on the test data
test_loss_pre_trained_rnn100, test_accuracy_pre_trained_rnn100 = rnn_model_pretrained_

print("Test Loss : ", test_loss_pre_trained_rnn100)
print("Test Accuracy : ", test_accuracy_pre_trained_rnn100)

# Plot training and validation accuracy
print("Perfomance of Pre Trained RNN Model for 100 Training Samples : ")
print(" ")
print("Accuracy : ")
print(" ")
plt.plot(rnn_history_pretrained_100.history['accuracy'], label='Training Accuracy (Pre
plt.plot(rnn_history_pretrained_100.history['val_accuracy'], label='Validation Accurac
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()
plt.show()

print(" ")
print("Loss : ")
print(" ")
# Plot training and validation loss
plt.plot(rnn_history_pretrained_100.history['loss'], label='Training Loss (Pretrained)
plt.plot(rnn_history_pretrained_100.history['val_loss'], label='Validation Loss (Pretr
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.show()
```

```
Epoch 1/10
4/4 [==============================] - 14s 1s/step - loss: 0.8859 - accuracy: 0.5000
- val_loss: 0.6927 - val_accuracy: 0.5142
Epoch 2/10
4/4 [==============================] - 2s 520ms/step - loss: 0.6763 - accuracy: 0.600
0 - val_loss: 0.6934 - val_accuracy: 0.5142
Epoch 3/10
4/4 [==============================] - 3s 878ms/step - loss: 0.6769 - accuracy: 0.590
0 - val_loss: 0.6935 - val_accuracy: 0.5142
Epoch 4/10
4/4 [==============================] - 2s 766ms/step - loss: 0.6276 - accuracy: 0.660
0 - val_loss: 0.6938 - val_accuracy: 0.5142
Epoch 5/10
4/4 [==============================] - 2s 776ms/step - loss: 0.5391 - accuracy: 0.740
0 - val_loss: 0.6956 - val_accuracy: 0.5142
Epoch 6/10
4/4 [==============================] - 2s 807ms/step - loss: 0.5283 - accuracy: 0.710
0 - val_loss: 0.6970 - val_accuracy: 0.5142
Epoch 7/10
4/4 [==============================] - 3s 1s/step - loss: 0.4434 - accuracy: 0.7900 -
val_loss: 0.6981 - val_accuracy: 0.5142
Epoch 8/10
4/4 [==============================] - 5s 2s/step - loss: 0.4497 - accuracy: 0.7500 -
val_loss: 0.7004 - val_accuracy: 0.5142
Epoch 9/10
4/4 [==============================] - 3s 953ms/step - loss: 0.4655 - accuracy: 0.810
0 - val_loss: 0.7005 - val_accuracy: 0.5142
Epoch 10/10
4/4 [==============================] - 5s 2s/step - loss: 0.4382 - accuracy: 0.8000 -
val_loss: 0.7017 - val_accuracy: 0.5142
157/157 [==============================] - 2s 16ms/step - loss: 0.7017 - accuracy: 0.
5142
Test Loss :  0.7017306685447693
Test Accuracy :  0.51419997215271
Perfomance of Pre Trained RNN Model for 100 Training Samples :

Accuracy :
```



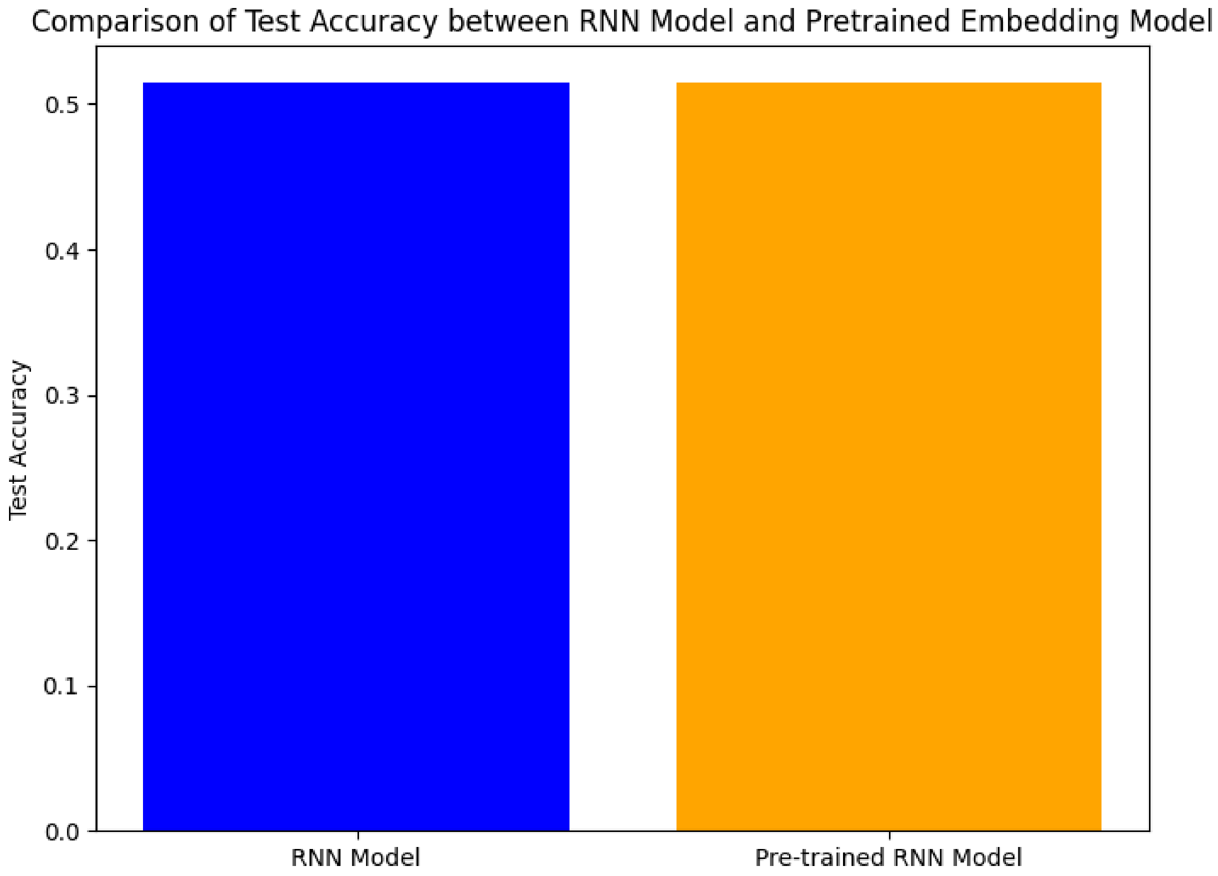
```
Loss :
```



In [8]:

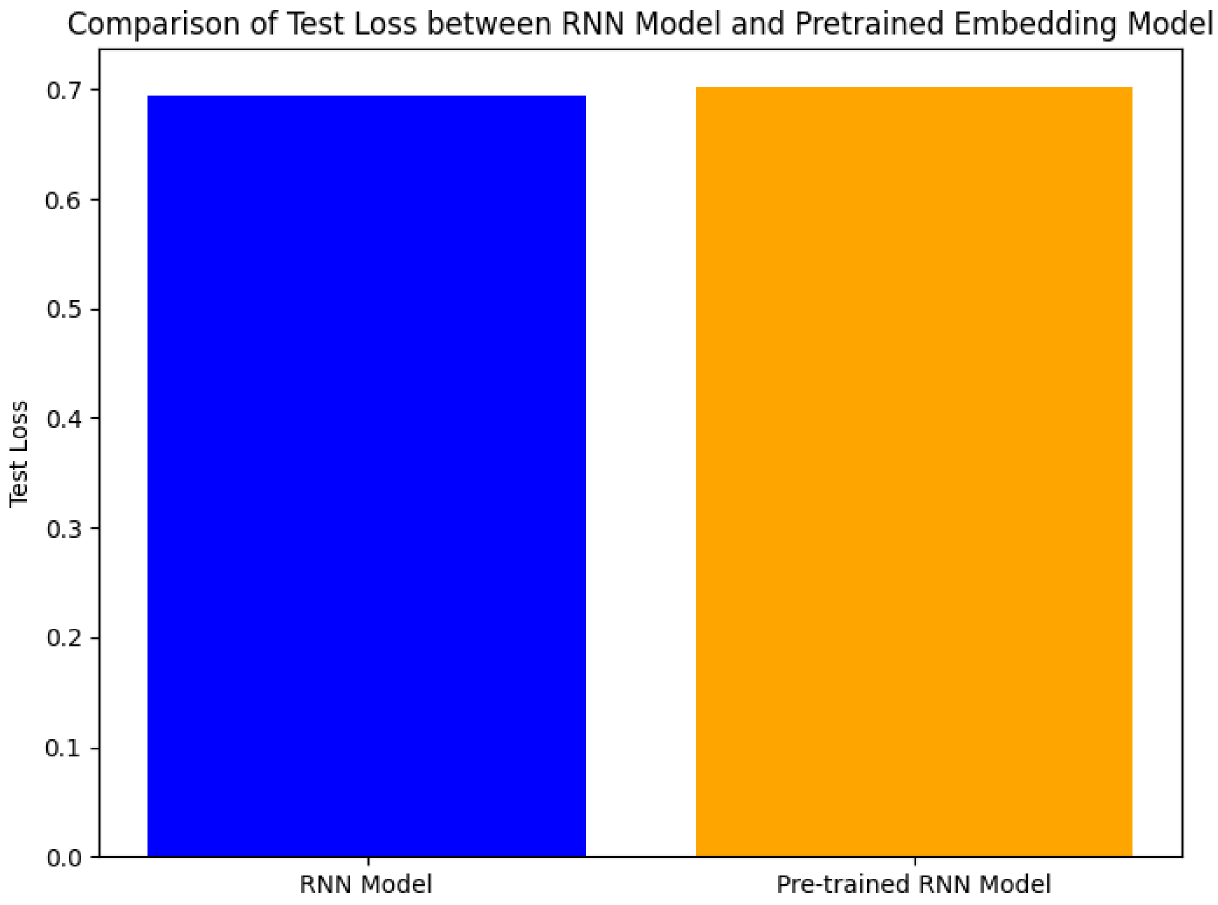
```
# Model names for labeling
model_names = ['RNN Model', 'Pre-trained RNN Model']
```

```
# Plot comparison graph
plt.figure(figsize=(8, 6))
plt.bar(model_names, [test_accuracy_rnn100, test_accuracy_pre_trained_rnn100], color=[
plt.title('Comparison of Test Accuracy between RNN Model and Pretrained Embedding Mode
plt.ylabel('Test Accuracy')
plt.show()
```



In [9]:

```
# Model names for labeling
model_names = ['RNN Model', 'Pre-trained RNN Model']

# Plot comparison graph
plt.figure(figsize=(8, 6))
plt.bar(model_names, [test_loss_rnn100, test_loss_pre_trained_rnn100], color=['blue',
plt.title('Comparison of Test Loss between RNN Model and Pretrained Embedding Model')
plt.ylabel('Test Loss')
plt.show()
```



For Training Samples 500

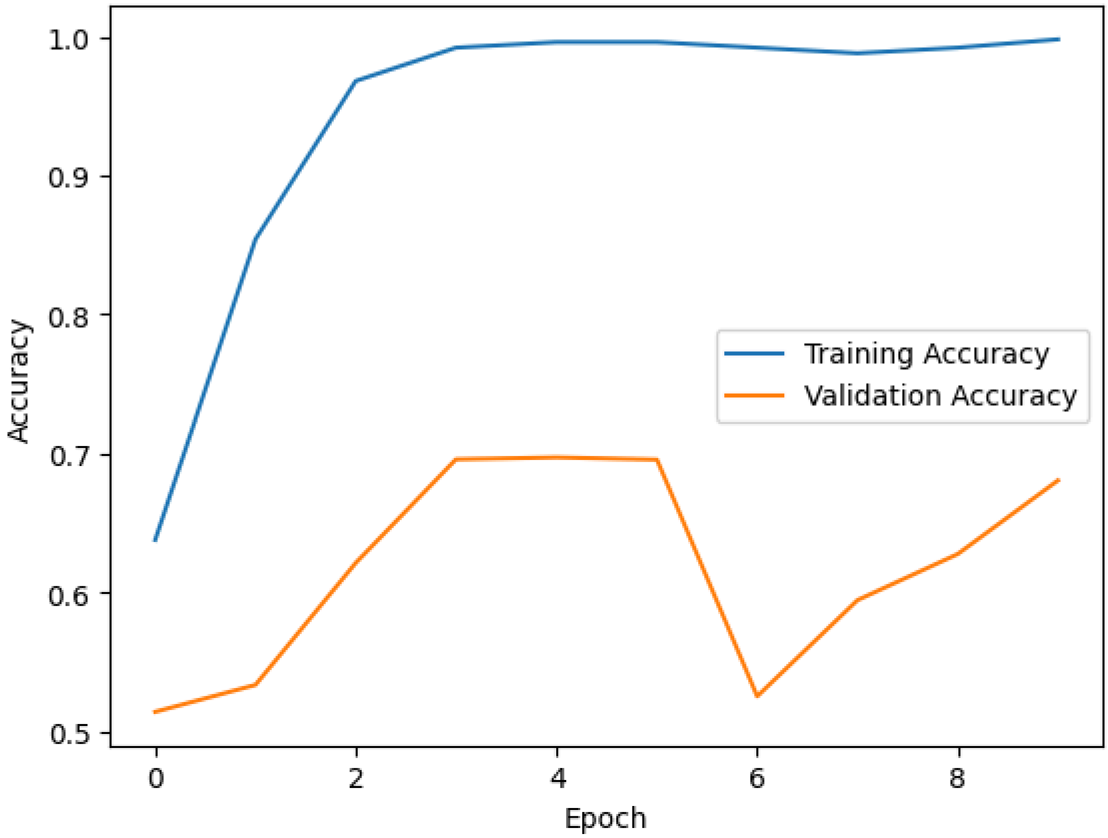
In [10]:

```
# Select the first 500 samples for training
train_data_500 = train_data[:500]
train_labels_500 = train_labels[:500]
```

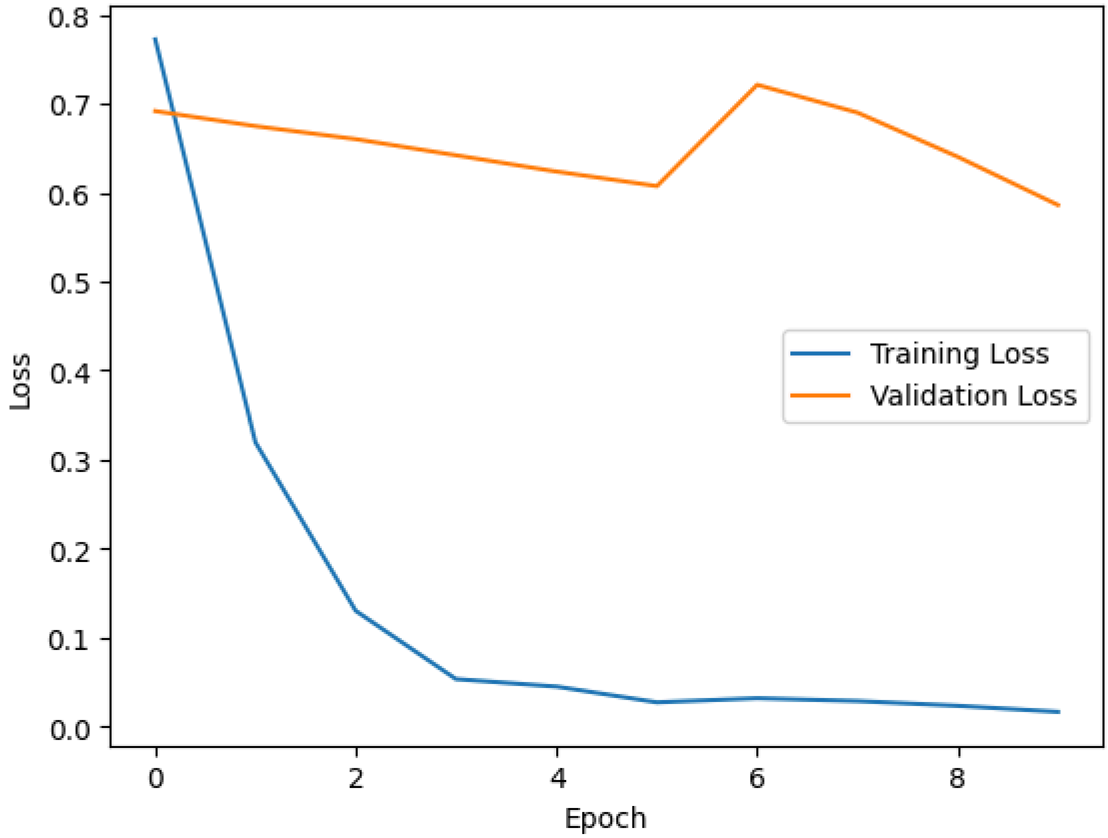
In [11]:

```
# Train the RNN model
rnn_model_500 = rnn_model
rnn_history_500 = rnn_model_500.fit(train_data_500, train_labels_500, epochs=10, batch

# Evaluate the model
test_loss_rnn500, test_accuracy_rnn500 = rnn_model_500.evaluate(test_data, test_labels

print("Test Loss : ", test_loss_rnn500)
print("Test Accuracy : ", test_accuracy_rnn500)


#Model Perfomance Evaluation
print(" ")
print("Perfomance of RNN Model for 500 Training Samples : ")
print(" ")
# Plot training and validation accuracy
print("Accuracy : ")
print(" ")
plt.plot(rnn_history_500.history['accuracy'], label='Training Accuracy')
plt.plot(rnn_history_500.history['val_accuracy'], label='Validation Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()
plt.show()

# Plot training and validation loss
print(" ")
print("Loss : ")
print(" ")
plt.plot(rnn_history_500.history['loss'], label='Training Loss')
plt.plot(rnn_history_500.history['val_loss'], label='Validation Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.show()
```

```
Epoch 1/10
16/16 [==============================] - 4s 284ms/step - loss: 0.7726 - accuracy: 0.6
380 - val_loss: 0.6918 - val_accuracy: 0.5142
Epoch 2/10
16/16 [==============================] - 5s 302ms/step - loss: 0.3197 - accuracy: 0.8
540 - val_loss: 0.6749 - val_accuracy: 0.5336
Epoch 3/10
16/16 [==============================] - 5s 310ms/step - loss: 0.1302 - accuracy: 0.9
680 - val_loss: 0.6603 - val_accuracy: 0.6214
Epoch 4/10
16/16 [==============================] - 5s 346ms/step - loss: 0.0534 - accuracy: 0.9
920 - val_loss: 0.6421 - val_accuracy: 0.6960
Epoch 5/10
16/16 [==============================] - 3s 192ms/step - loss: 0.0449 - accuracy: 0.9
960 - val_loss: 0.6238 - val_accuracy: 0.6974
Epoch 6/10
16/16 [==============================] - 4s 245ms/step - loss: 0.0272 - accuracy: 0.9
960 - val_loss: 0.6075 - val_accuracy: 0.6958
Epoch 7/10
16/16 [==============================] - 4s 235ms/step - loss: 0.0318 - accuracy: 0.9
920 - val_loss: 0.7214 - val_accuracy: 0.5254
Epoch 8/10
16/16 [==============================] - 4s 242ms/step - loss: 0.0286 - accuracy: 0.9
880 - val_loss: 0.6901 - val_accuracy: 0.5946
Epoch 9/10
16/16 [==============================] - 4s 278ms/step - loss: 0.0233 - accuracy: 0.9
920 - val_loss: 0.6404 - val_accuracy: 0.6278
Epoch 10/10
16/16 [==============================] - 4s 281ms/step - loss: 0.0165 - accuracy: 0.9
980 - val_loss: 0.5862 - val_accuracy: 0.6808
157/157 [==============================] - 3s 16ms/step - loss: 0.5862 - accuracy: 0.
6808
Test Loss :  0.5861781239509583
Test Accuracy :  0.6808000206947327

Perfomance of RNN Model for 500 Training Samples :

Accuracy :
```



```
Loss :
```

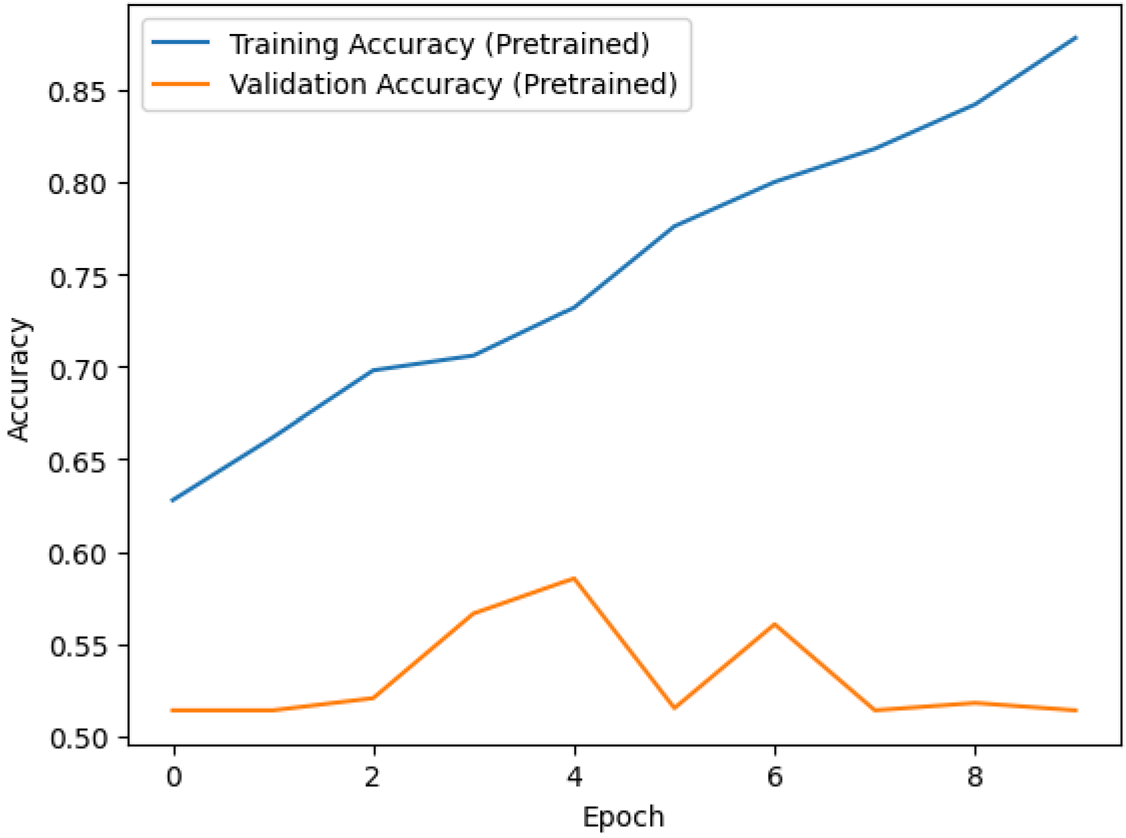


In [12]:

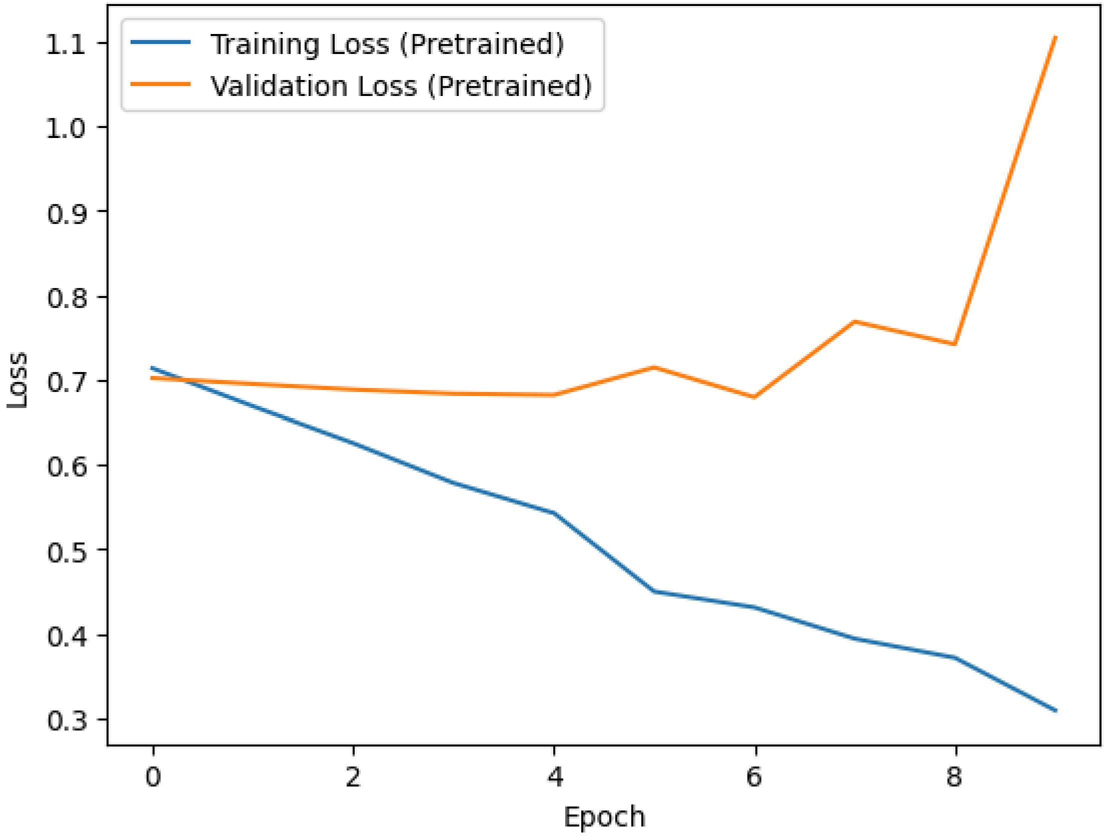
```
# Train the RNN model with pretrained embeddings
rnn_model_pretrained_500 = rnn_model_pretrained
```

```
rnn_history_pretrained_500 = rnn_model_pretrained_500.fit(train_data_500, train_labels

# Evaluate the model on the test data
test_loss_pre_trained_rnn500, test_accuracy_pre_trained_rnn500 = rnn_model_pretrained_

print("Test Loss : ", test_loss_pre_trained_rnn500)
print("Test Accuracy : ", test_accuracy_pre_trained_rnn500)

# Plot training and validation accuracy
print("Perfomance of Pre Trained RNN Model for 500 Training Samples : ")
print(" ")
print("Accuracy : ")
print(" ")
plt.plot(rnn_history_pretrained_500.history['accuracy'], label='Training Accuracy (Pre
plt.plot(rnn_history_pretrained_500.history['val_accuracy'], label='Validation Accurac
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()
plt.show()

print(" ")
print("Loss : ")
print(" ")
# Plot training and validation loss
plt.plot(rnn_history_pretrained_500.history['loss'], label='Training Loss (Pretrained)
plt.plot(rnn_history_pretrained_500.history['val_loss'], label='Validation Loss (Pretr
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.show()
```

```
Epoch 1/10
16/16 [==============================] - 2s 130ms/step - loss: 0.7135 - accuracy: 0.6
280 - val_loss: 0.7019 - val_accuracy: 0.5142
Epoch 2/10
16/16 [==============================] - 2s 123ms/step - loss: 0.6688 - accuracy: 0.6
620 - val_loss: 0.6950 - val_accuracy: 0.5142
Epoch 3/10
16/16 [==============================] - 3s 195ms/step - loss: 0.6255 - accuracy: 0.6
980 - val_loss: 0.6883 - val_accuracy: 0.5208
Epoch 4/10
16/16 [==============================] - 3s 170ms/step - loss: 0.5785 - accuracy: 0.7
060 - val_loss: 0.6835 - val_accuracy: 0.5666
Epoch 5/10
16/16 [==============================] - 3s 193ms/step - loss: 0.5428 - accuracy: 0.7
320 - val_loss: 0.6819 - val_accuracy: 0.5856
Epoch 6/10
16/16 [==============================] - 3s 207ms/step - loss: 0.4500 - accuracy: 0.7
760 - val_loss: 0.7145 - val_accuracy: 0.5154
Epoch 7/10
16/16 [==============================] - 3s 208ms/step - loss: 0.4312 - accuracy: 0.8
000 - val_loss: 0.6793 - val_accuracy: 0.5608
Epoch 8/10
16/16 [==============================] - 3s 208ms/step - loss: 0.3942 - accuracy: 0.8
180 - val_loss: 0.7686 - val_accuracy: 0.5142
Epoch 9/10
16/16 [==============================] - 3s 193ms/step - loss: 0.3716 - accuracy: 0.8
420 - val_loss: 0.7419 - val_accuracy: 0.5182
Epoch 10/10
16/16 [==============================] - 2s 123ms/step - loss: 0.3094 - accuracy: 0.8
780 - val_loss: 1.1044 - val_accuracy: 0.5142
157/157 [==============================] - 3s 16ms/step - loss: 1.1044 - accuracy: 0.
5142
Test Loss :  1.104356288909912
Test Accuracy :  0.51419997215271
Perfomance of Pre Trained RNN Model for 500 Training Samples :

Accuracy :
```



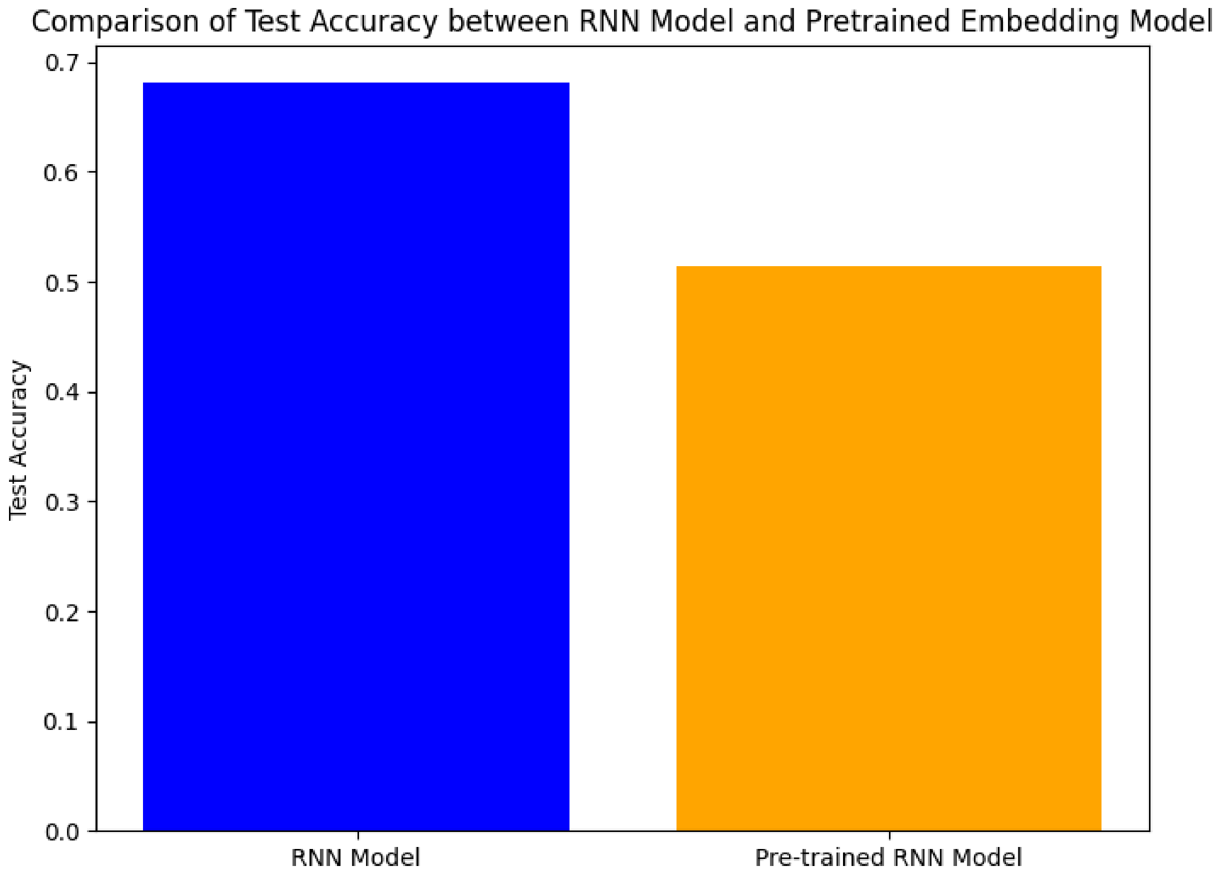
```
Loss :
```



In [13]:

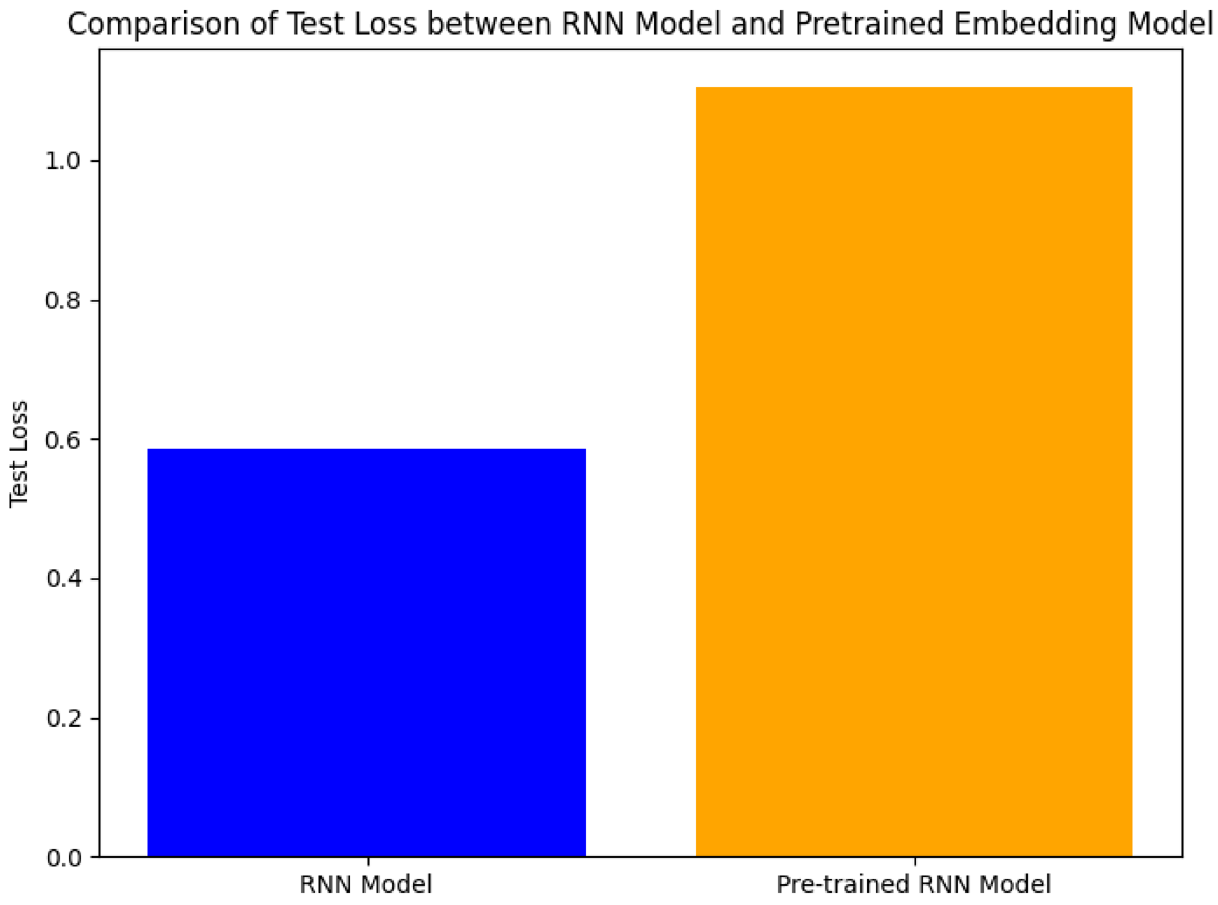
```
# Model names for labeling
model_names = ['RNN Model', 'Pre-trained RNN Model']
```

```
# Plot comparison graph
plt.figure(figsize=(8, 6))
plt.bar(model_names, [test_accuracy_rnn500, test_accuracy_pre_trained_rnn500], color=[
plt.title('Comparison of Test Accuracy between RNN Model and Pretrained Embedding Mode
plt.ylabel('Test Accuracy')
plt.show()
```



In [14]:

```
# Model names for labeling
model_names = ['RNN Model', 'Pre-trained RNN Model']

# Plot comparison graph
plt.figure(figsize=(8, 6))
plt.bar(model_names, [test_loss_rnn500, test_loss_pre_trained_rnn500], color=['blue',
plt.title('Comparison of Test Loss between RNN Model and Pretrained Embedding Model')
plt.ylabel('Test Loss')
plt.show()
```



For 1000 Training Samples

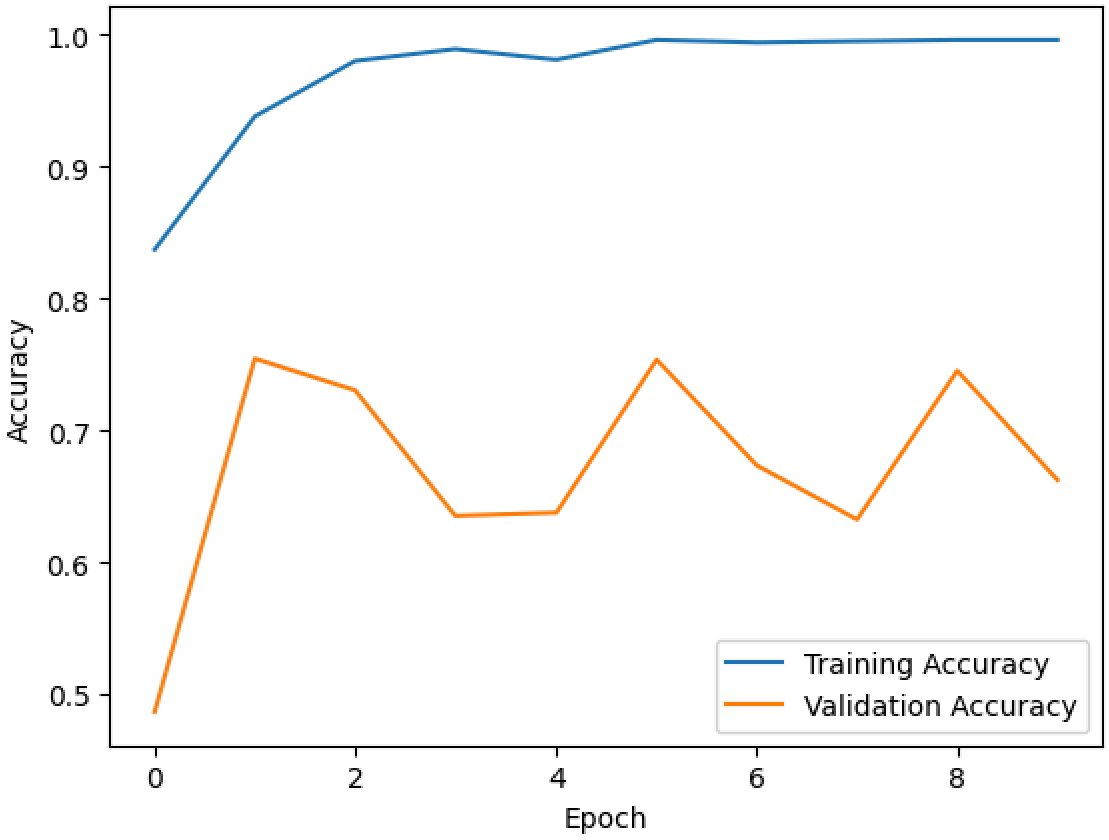
In [15]:

```
# Select the first 1000 samples for training
train_data_1000 = train_data[:1000]
train_labels_1000 = train_labels[:1000]
```

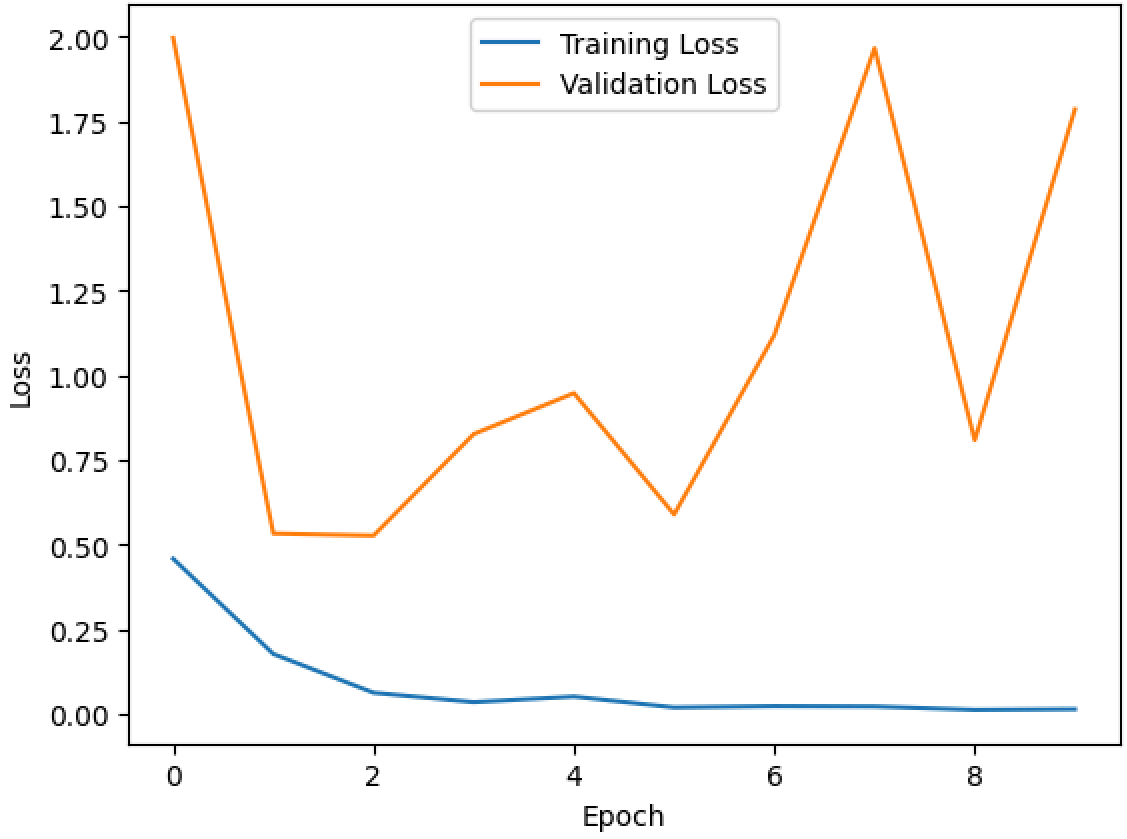
In [16]:

```
# Train the RNN model
rnn_model_1000 = rnn_model
rnn_history_1000 = rnn_model_1000.fit(train_data_1000, train_labels_1000, epochs=10, b

# Evaluate the model
test_loss_rnn1000, test_accuracy_rnn1000 = rnn_model_1000.evaluate(test_data, test_lab

print("Test Loss : ", test_loss_rnn1000)
print("Test Accuracy : ", test_accuracy_rnn1000)


#Model Perfomance Evaluation
print(" ")
print("Perfomance of RNN Model for 1000 Training Samples : ")
print(" ")
# Plot training and validation accuracy
print("Accuracy : ")
print(" ")
plt.plot(rnn_history_1000.history['accuracy'], label='Training Accuracy')
plt.plot(rnn_history_1000.history['val_accuracy'], label='Validation Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()
plt.show()

# Plot training and validation loss
print(" ")
print("Loss : ")
print(" ")
plt.plot(rnn_history_1000.history['loss'], label='Training Loss')
plt.plot(rnn_history_1000.history['val_loss'], label='Validation Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.show()
```

```
Epoch 1/10
32/32 [==============================] - 4s 119ms/step - loss: 0.4581 - accuracy: 0.8
370 - val_loss: 1.9968 - val_accuracy: 0.4866
Epoch 2/10
32/32 [==============================] - 3s 105ms/step - loss: 0.1766 - accuracy: 0.9
380 - val_loss: 0.5325 - val_accuracy: 0.7544
Epoch 3/10
32/32 [==============================] - 5s 156ms/step - loss: 0.0621 - accuracy: 0.9
800 - val_loss: 0.5263 - val_accuracy: 0.7304
Epoch 4/10
32/32 [==============================] - 5s 172ms/step - loss: 0.0343 - accuracy: 0.9
890 - val_loss: 0.8264 - val_accuracy: 0.6352
Epoch 5/10
32/32 [==============================] - 6s 181ms/step - loss: 0.0508 - accuracy: 0.9
810 - val_loss: 0.9472 - val_accuracy: 0.6376
Epoch 6/10
32/32 [==============================] - 4s 137ms/step - loss: 0.0186 - accuracy: 0.9
960 - val_loss: 0.5887 - val_accuracy: 0.7536
Epoch 7/10
32/32 [==============================] - 3s 92ms/step - loss: 0.0224 - accuracy: 0.99
40 - val_loss: 1.1188 - val_accuracy: 0.6734
Epoch 8/10
32/32 [==============================] - 4s 139ms/step - loss: 0.0215 - accuracy: 0.9
950 - val_loss: 1.9663 - val_accuracy: 0.6324
Epoch 9/10
32/32 [==============================] - 4s 142ms/step - loss: 0.0115 - accuracy: 0.9
960 - val_loss: 0.8082 - val_accuracy: 0.7452
Epoch 10/10
32/32 [==============================] - 5s 144ms/step - loss: 0.0135 - accuracy: 0.9
960 - val_loss: 1.7857 - val_accuracy: 0.6624
157/157 [==============================] - 3s 16ms/step - loss: 1.7857 - accuracy: 0.
6624
Test Loss :  1.7857351303100586
Test Accuracy :  0.6624000072479248

Perfomance of RNN Model for 1000 Training Samples :

Accuracy :
```



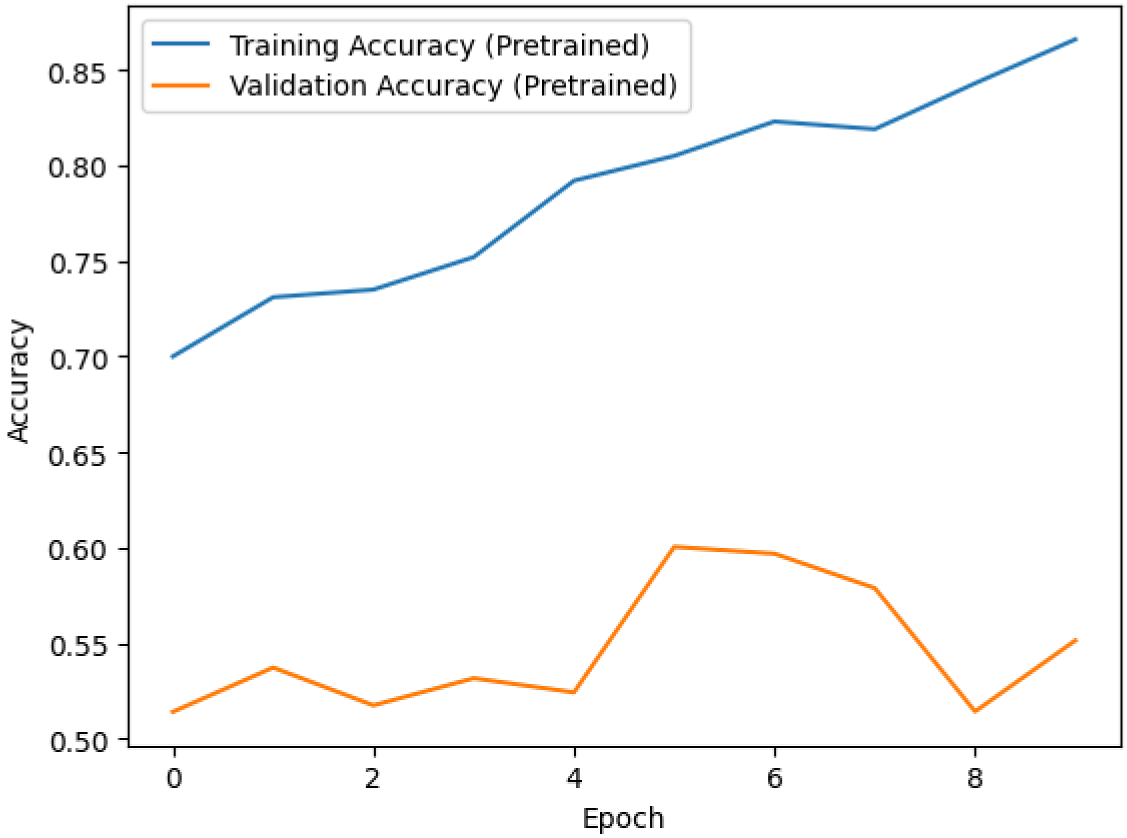
```
Loss :
```



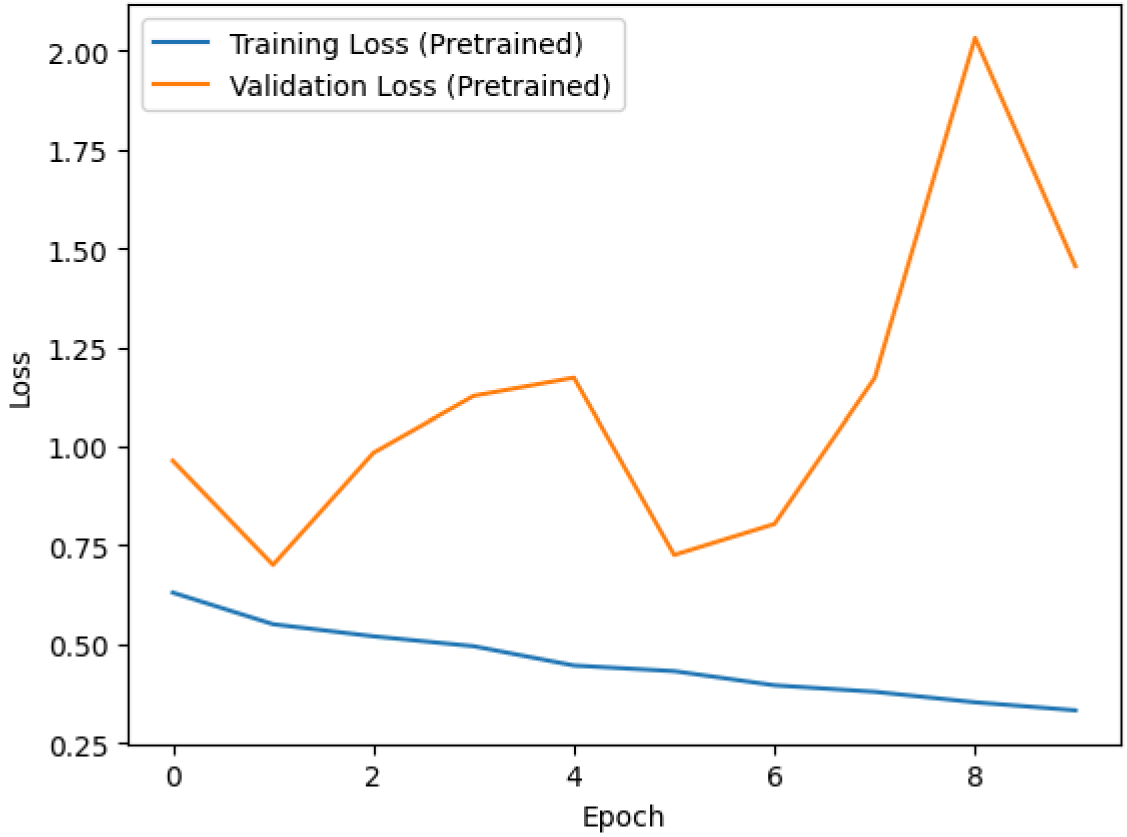
In [17]:
```python
# Train the RNN model with pretrained embeddings
rnn_model_pretrained_1000 = rnn_model_pretrained
```

```
rnn_history_pretrained_1000 = rnn_model_pretrained_1000.fit(train_data_1000, train_lab

# Evaluate the model on the test data
test_loss_pre_trained_rnn1000, test_accuracy_pre_trained_rnn1000 = rnn_model_pretraine

print("Test Loss : ", test_loss_pre_trained_rnn1000)
print("Test Accuracy : ", test_accuracy_pre_trained_rnn1000)

# Plot training and validation accuracy
print("Perfomance of Pre Trained RNN Model for 1000 Training Samples : ")
print(" ")
print("Accuracy : ")
print(" ")
plt.plot(rnn_history_pretrained_1000.history['accuracy'], label='Training Accuracy (Pr
plt.plot(rnn_history_pretrained_1000.history['val_accuracy'], label='Validation Accura
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()
plt.show()

print(" ")
print("Loss : ")
print(" ")
# Plot training and validation loss
plt.plot(rnn_history_pretrained_1000.history['loss'], label='Training Loss (Pretrained
plt.plot(rnn_history_pretrained_1000.history['val_loss'], label='Validation Loss (Pret
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.show()
```

```
Epoch 1/10
32/32 [==============================] - 4s 122ms/step - loss: 0.6300 - accuracy: 0.7
000 - val_loss: 0.9638 - val_accuracy: 0.5142
Epoch 2/10
32/32 [==============================] - 3s 106ms/step - loss: 0.5501 - accuracy: 0.7
310 - val_loss: 0.7002 - val_accuracy: 0.5374
Epoch 3/10
32/32 [==============================] - 3s 107ms/step - loss: 0.5194 - accuracy: 0.7
350 - val_loss: 0.9834 - val_accuracy: 0.5176
Epoch 4/10
32/32 [==============================] - 3s 106ms/step - loss: 0.4944 - accuracy: 0.7
520 - val_loss: 1.1269 - val_accuracy: 0.5318
Epoch 5/10
32/32 [==============================] - 4s 120ms/step - loss: 0.4456 - accuracy: 0.7
920 - val_loss: 1.1728 - val_accuracy: 0.5244
Epoch 6/10
32/32 [==============================] - 4s 113ms/step - loss: 0.4313 - accuracy: 0.8
050 - val_loss: 0.7253 - val_accuracy: 0.6006
Epoch 7/10
32/32 [==============================] - 6s 202ms/step - loss: 0.3955 - accuracy: 0.8
230 - val_loss: 0.8037 - val_accuracy: 0.5970
Epoch 8/10
32/32 [==============================] - 4s 124ms/step - loss: 0.3790 - accuracy: 0.8
190 - val_loss: 1.1724 - val_accuracy: 0.5790
Epoch 9/10
32/32 [==============================] - 4s 133ms/step - loss: 0.3525 - accuracy: 0.8
430 - val_loss: 2.0326 - val_accuracy: 0.5144
Epoch 10/10
32/32 [==============================] - 3s 107ms/step - loss: 0.3321 - accuracy: 0.8
660 - val_loss: 1.4546 - val_accuracy: 0.5516
157/157 [==============================] - 3s 16ms/step - loss: 1.4546 - accuracy: 0.
5516
Test Loss :  1.4546138048171997
Test Accuracy :  0.5515999794006348
Perfomance of Pre Trained RNN Model for 1000 Training Samples :

Accuracy :
```



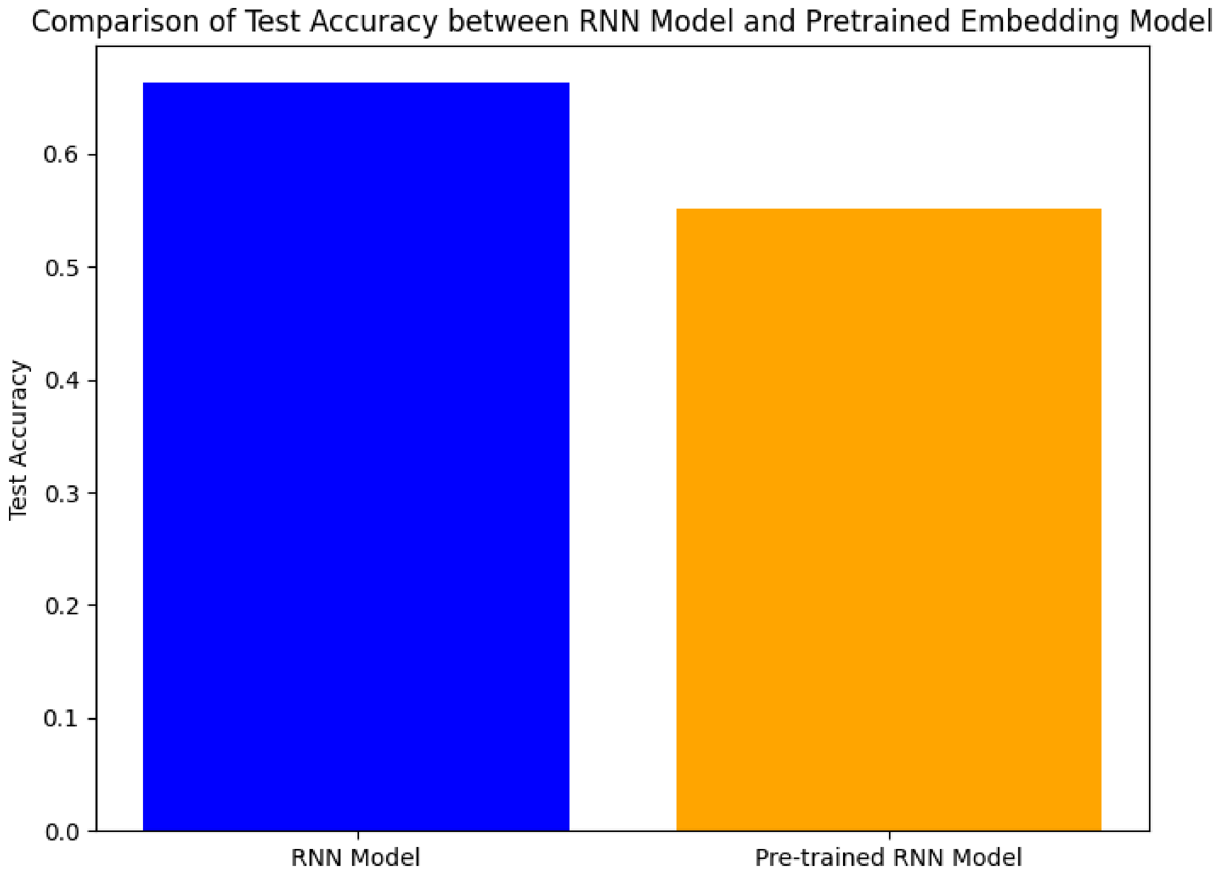
```
Loss :
```



In [18]:

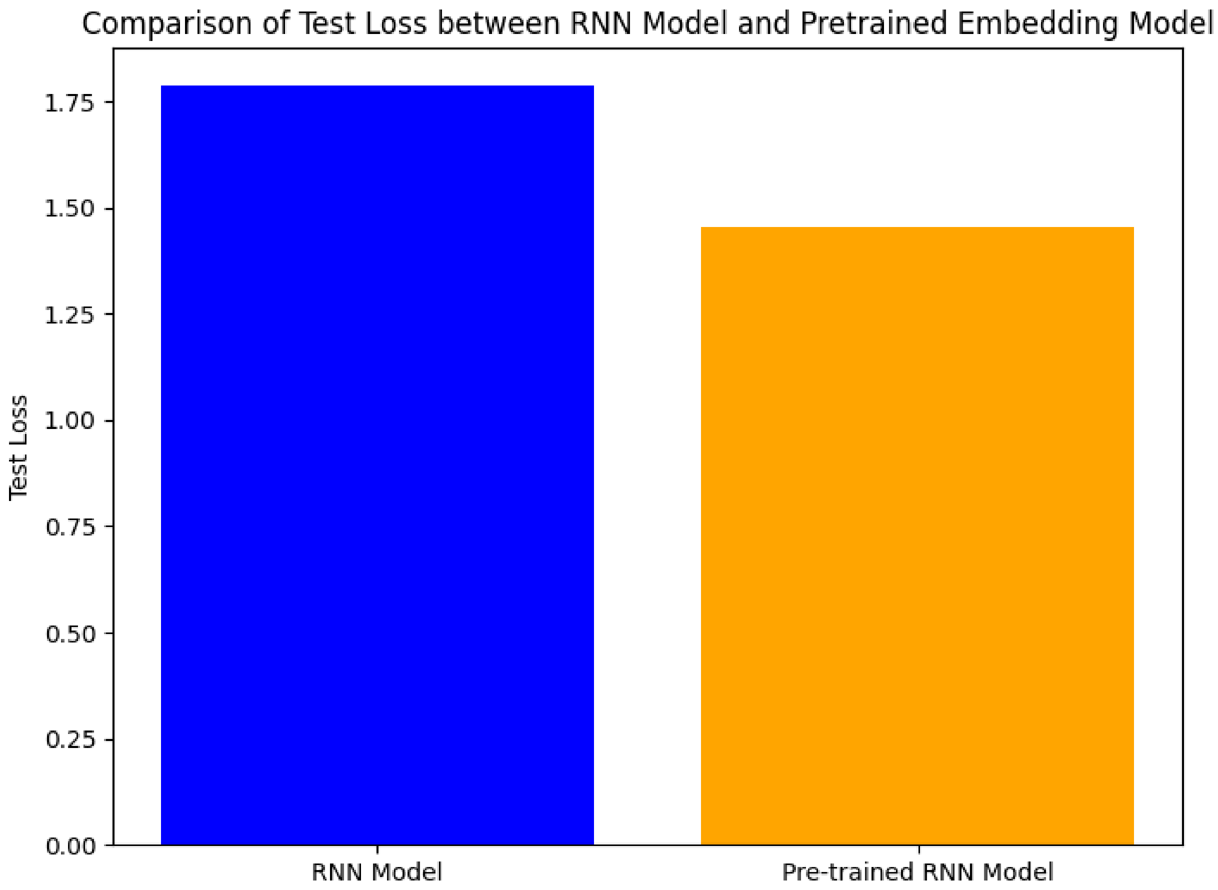
```
# Model names for labeling
model_names = ['RNN Model', 'Pre-trained RNN Model']
```

```
# Plot comparison graph
plt.figure(figsize=(8, 6))
plt.bar(model_names, [test_accuracy_rnn1000, test_accuracy_pre_trained_rnn1000], color
plt.title('Comparison of Test Accuracy between RNN Model and Pretrained Embedding Mode
plt.ylabel('Test Accuracy')
plt.show()
```



In [19]:

```
# Model names for labeling
model_names = ['RNN Model', 'Pre-trained RNN Model']

# Plot comparison graph
plt.figure(figsize=(8, 6))
plt.bar(model_names, [test_loss_rnn1000, test_loss_pre_trained_rnn1000], color=['blue'
plt.title('Comparison of Test Loss between RNN Model and Pretrained Embedding Model')
plt.ylabel('Test Loss')
plt.show()
```

Comparison of Test Loss between RNN Model and Pretrained Embedding Model
Test Loss
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
RNN Model
Pre-trained RNN Model