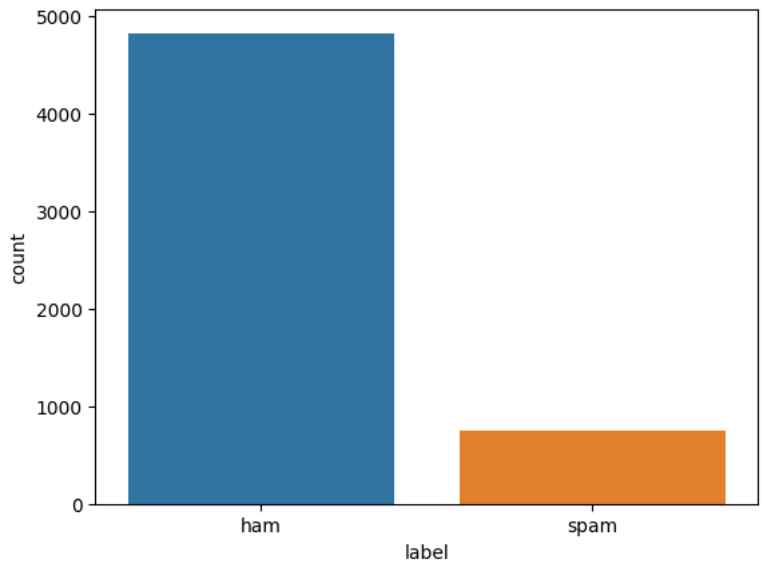
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers


# Reading the data
df = pd.read_csv("/content/spam.csv",encoding='latin-1')
df.head()
```

	v1	v2	Unnamed: 2	Unnamed: 3	Unnamed: 4
0	ham	Go until jurong point, crazy.. Available only ...	NaN	NaN	NaN
1	ham	Ok lar... Joking wif u oni...	NaN	NaN	NaN
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...	NaN	NaN	NaN
3	ham	U dun say so early hor... U c already then say...	NaN	NaN	NaN
4	ham	Nah I don't think he goes to usf, he lives aro...	NaN	NaN	NaN

```
df = df.drop(['Unnamed: 2','Unnamed: 3','Unnamed: 4'],axis=1)
df = df.rename(columns={'v1':'label','v2':'Text'})
df['label_enc'] = df['label'].map({'ham':0,'spam':1})
df.head()
```

	label	Text	label_enc
0	ham	Go until jurong point, crazy.. Available only ...	0
1	ham	Ok lar... Joking wif u oni...	0
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...	1
3	ham	U dun say so early hor... U c already then say...	0
4	ham	Nah I don't think he goes to usf, he lives aro...	0

```
sns.countplot(x=df['label'])
plt.show()
```




```
# Find average number of tokens in all sentences
avg_words_len=round(sum([len(i.split()) for i in df['Text']])/len(df['Text']))
print(avg_words_len)
```

```
15
```

```
# Finding Total no of unique words in corpus
s = set()
```

```
for sent in df['Text']:
  for word in sent.split():
      s.add(word)
total_words_length=len(s)
print(total_words_length)
```

```
15585
```

```
# Splitting data for Training and testing
from sklearn.model_selection import train_test_split

X, y = np.asanyarray(df['Text']), np.asanyarray(df['label_enc'])
new_df = pd.DataFrame({'Text': X, 'label': y})
X_train, X_test, y_train, y_test = train_test_split(
    new_df['Text'], new_df['label'], test_size=0.2, random_state=42)
X_train.shape, y_train.shape, X_test.shape, y_test.shape
```

```
((4457,), (4457,), (1115,), (1115,))
```

```
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import classification_report,accuracy_score

tfidf_vec = TfidfVectorizer().fit(X_train)
X_train_vec,X_test_vec = tfidf_vec.transform(X_train),tfidf_vec.transform(X_test)

baseline_model = MultinomialNB()
baseline_model.fit(X_train_vec,y_train)
```

```
▾ MultinomialNB
MultinomialNB()
```

```
from tensorflow.keras.layers import TextVectorization

MAXTOKENS=total_words_length
OUTPUTLEN=avg_words_len

text_vec = TextVectorization(
    max_tokens=MAXTOKENS,
    standardize='lower_and_strip_punctuation',
    output_mode='int',
    output_sequence_length=OUTPUTLEN
)
text_vec.adapt(X_train)
```

```
embedding_layer = layers.Embedding(
    input_dim=MAXTOKENS,
    output_dim=128,
    embeddings_initializer='uniform',
    input_length=OUTPUTLEN
)
```

```
input_layer = layers.Input(shape=(1,), dtype=tf.string)
vec_layer = text_vec(input_layer)
embedding_layer_model = embedding_layer(vec_layer)
x = layers.GlobalAveragePooling1D()(embedding_layer_model)
x = layers.Flatten()(x)
x = layers.Dense(32, activation='relu')(x)
output_layer = layers.Dense(1, activation='sigmoid')(x)
model_1 = keras.Model(input_layer, output_layer)

model_1.compile(optimizer='adam', loss=keras.losses.BinaryCrossentropy(
    label_smoothing=0.5), metrics=['accuracy'])
```

```
from sklearn.metrics import precision_score, recall_score, f1_score

def compile_model(model):
    '''
    simply compile the model with adam optimzer
    '''
    model.compile(optimizer=keras.optimizers.Adam(),
                loss=keras.losses.BinaryCrossentropy(),
```

```
                metrics=['accuracy'])

def fit_model(model, epochs, X_train=X_train, y_train=y_train,
              X_test=X_test, y_test=y_test):
    '''
    fit the model with given epochs, train
    and test data
    '''
    history = model.fit(X_train,
                        y_train,
                        epochs=epochs,
                        validation_data=(X_test, y_test),
                        validation_steps=int(0.2*len(X_test)))
    return history

def evaluate_model(model, X, y):
    '''
    evaluate the model and returns accuracy,
    precision, recall and f1-score
    '''
    y_preds = np.round(model.predict(X))
    accuracy = accuracy_score(y, y_preds)
    precision = precision_score(y, y_preds)
    recall = recall_score(y, y_preds)
    f1 = f1_score(y, y_preds)

    model_results_dict = {'accuracy': accuracy,
                          'precision': precision,
                          'recall': recall,
                          'f1-score': f1}

    return model_results_dict



input_layer = layers.Input(shape=(1,), dtype=tf.string)
vec_layer = text_vec(input_layer)
embedding_layer_model = embedding_layer(vec_layer)
bi_lstm = layers.Bidirectional(layers.LSTM(
    64, activation='tanh', return_sequences=True))(embedding_layer_model)
lstm = layers.Bidirectional(layers.LSTM(64))(bi_lstm)
flatten = layers.Flatten()(lstm)
dropout = layers.Dropout(.1)(flatten)
x = layers.Dense(32, activation='relu')(dropout)
output_layer = layers.Dense(1, activation='sigmoid')(x)
model_2 = keras.Model(input_layer, output_layer)

compile_model(model_2) # compile the model
history_2 = fit_model(model_2, epochs=5) # fit the model
```

```
Epoch 1/5
140/140 [==============================] - 22s 97ms/step - loss: 0.1741 - accuracy: 0.9437 - val_loss: 0.0872 - val_accuracy: 0.975
Epoch 2/5
140/140 [==============================] - 12s 85ms/step - loss: 0.0285 - accuracy: 0.9926 - val_loss: 0.0852 - val_accuracy: 0.974
Epoch 3/5
140/140 [==============================] - 13s 94ms/step - loss: 0.0087 - accuracy: 0.9975 - val_loss: 0.1083 - val_accuracy: 0.978
Epoch 4/5
140/140 [==============================] - 13s 93ms/step - loss: 0.0044 - accuracy: 0.9989 - val_loss: 0.1070 - val_accuracy: 0.976
Epoch 5/5
140/140 [==============================] - 12s 88ms/step - loss: 2.7848e-04 - accuracy: 1.0000 - val_loss: 0.1272 - val_accuracy: 0
```

```
import tensorflow_hub as hub

# model with Sequential api
model_3 = keras.Sequential()

# universal-sentence-encoder layer
# directly from tfhub
use_layer = hub.KerasLayer("https://tfhub.dev/google/universal-sentence-encoder/4",
                           trainable=False,
                           input_shape=[],
                           dtype=tf.string,
                           name='USE')
model_3.add(use_layer)
model_3.add(layers.Dropout(0.2))
model_3.add(layers.Dense(64, activation=keras.activations.relu))
model_3.add(layers.Dense(1, activation=keras.activations.sigmoid))

compile_model(model_3)
```

```
history_3 = fit_model(model_3, epochs=5)
```

```
Epoch 1/5
140/140 [==============================] - 8s 36ms/step - loss: 0.2747 - accuracy: 0.9188 - val_loss: 0.1089 - val_accuracy: 0.9713
Epoch 2/5
140/140 [==============================] - 3s 20ms/step - loss: 0.0785 - accuracy: 0.9805 - val_loss: 0.0732 - val_accuracy: 0.9758
Epoch 3/5
140/140 [==============================] - 3s 19ms/step - loss: 0.0558 - accuracy: 0.9845 - val_loss: 0.0592 - val_accuracy: 0.9794
Epoch 4/5
140/140 [==============================] - 3s 19ms/step - loss: 0.0455 - accuracy: 0.9870 - val_loss: 0.0530 - val_accuracy: 0.9839
Epoch 5/5
140/140 [==============================] - 3s 24ms/step - loss: 0.0396 - accuracy: 0.9877 - val_loss: 0.0520 - val_accuracy: 0.9839
```

```
baseline_model_results = evaluate_model(baseline_model, X_test_vec, y_test)
model_1_results = evaluate_model(model_1, X_test, y_test)
model_2_results = evaluate_model(model_2, X_test, y_test)
model_3_results = evaluate_model(model_3, X_test, y_test)

total_results = pd.DataFrame({'MultinomialNB Model':baseline_model_results,
                              'Custom-Vec-Embedding Model':model_1_results,
                              'Bidirectional-LSTM Model':model_2_results,
                              'USE-Transfer learning Model':model_3_results}).transpose()

total_results
```

```
35/35 [==============================] - 0s 2ms/step
35/35 [==============================] - 2s 12ms/step
35/35 [==============================] - 1s 10ms/step
```

	accuracy	precision	recall	f1-score
MultinomialNB Model	0.962332	1.000000	0.720000	0.837209
Custom-Vec-Embedding Model	0.801794	0.284848	0.313333	0.298413
Bidirectional-LSTM Model	0.975785	0.930070	0.886667	0.907850
USE-Transfer learning Model	0.983857	0.971429	0.906667	0.937931