```
# Importing necessary libraries for EDA
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

import string
import nltk
from nltk.corpus import stopwords
from wordcloud import WordCloud
nltk.download('stopwords')

# Importing libraries necessary for Model Building and Training
import tensorflow as tf
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
from sklearn.model_selection import train_test_split
from keras.callbacks import EarlyStopping, ReduceLROnPlateau

import warnings
warnings.filterwarnings('ignore')
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
```

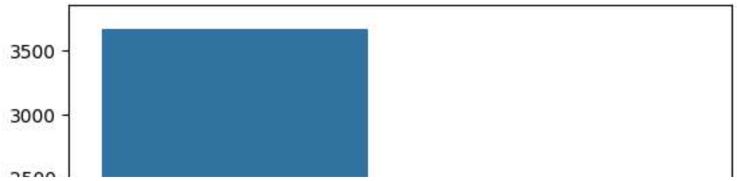
```
data = pd.read_csv('/content/spam_ham_dataset.csv')
data.head(10)
```

	Unnamed: 0	label	text	label_num
0	605	ham	Subject: enron methanol ; meter # : 988291\r\n...	0
1	2349	ham	Subject: hpl nom for january 9 , 2001\r\n(see...	0
2	3624	ham	Subject: neon retreat\r\nho ho ho , we ' re ar...	0
3	4685	spam	Subject: photoshop , windows , office . cheap ...	1
4	2030	ham	Subject: re : indian springs\r\nthis deal is t...	0
5	2949	ham	Subject: ehronline web address change\r\nthis ...	0
6	2793	ham	Subject: spring savings certificate - take 30 ...	0
7	4185	spam	Subject: looking for medication ? we ` re the ...	1
8	2641	ham	Subject: noms / actual flow for 2 / 26\r\nwe a...	0
9	1870	ham	Subject: nominations for oct . 21 - 23 , 2000\...	0

```
data.shape
```

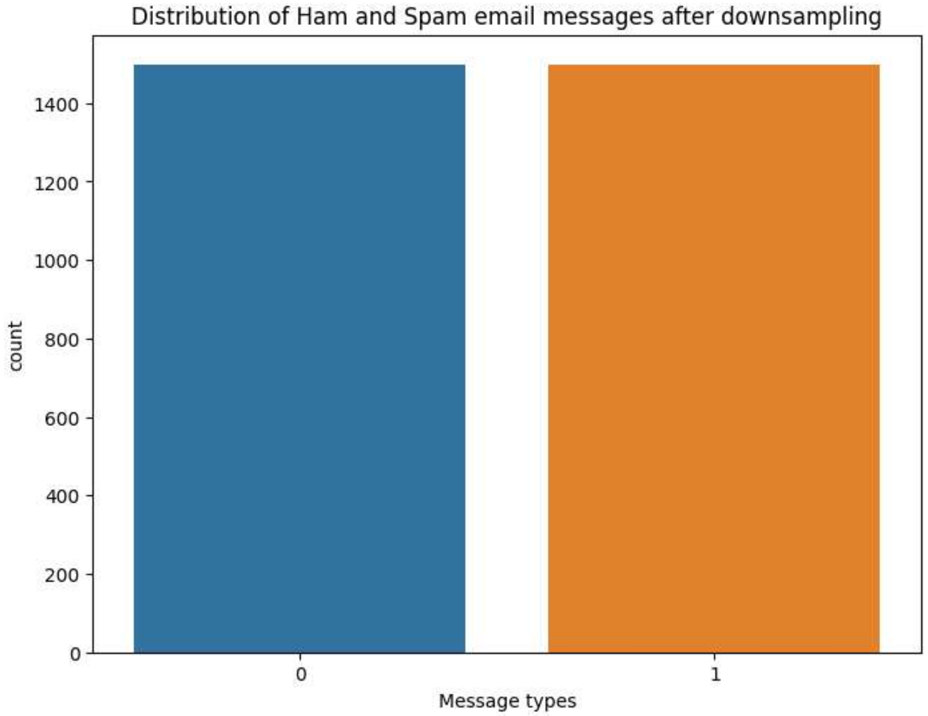
```
(5171, 4)
```

```
sns.countplot(x='label_num', data=data)
plt.show()
```



```
# Downsampling to balance the dataset
ham_msg = data[data.label_num == 0]
spam_msg = data[data.label_num == 1]
ham_msg = ham_msg.sample(n=len(spam_msg),
                        random_state=42)

# Plotting the counts of down sampled dataset
balanced_data = ham_msg.append(spam_msg)\
    .reset_index(drop=True)
plt.figure(figsize=(8, 6))
sns.countplot(data = balanced_data, x='label_num')
plt.title('Distribution of Ham and Spam email messages after downsampling')
plt.xlabel('Message types')
```

```
Text(0.5, 0, 'Message types')
```



```
balanced_data['text'] = balanced_data['text'].str.replace('Subject', '')
balanced_data.head()
```

	Unnamed: 0	label	text	label_num
0	3444	ham	: conoco - big cowboy\r\ndarren :\r\ni ' m not...	0
1	2982	ham	: feb 01 prod : sale to teco gas processing\r\...	0
2	2711	ham	: california energy crisis\r\ncalifornia □ , s...	0
3	3116	ham	: re : nom / actual volume for april 23 rd\r\n...	0
4	1314	ham	: eastrans nomination changes effective 8 / 2 ...	0

```
punctuations_list = string.punctuation
def remove_punctuations(text):
  temp = str.maketrans('', '', punctuations_list)
  return text.translate(temp)

balanced_data['text']= balanced_data['text'].apply(lambda x: remove_punctuations(x))
balanced_data.head()
```

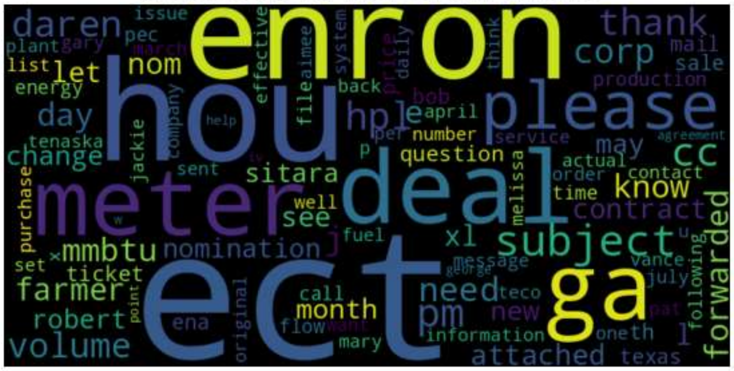
```
   Unnamed: 0  label                                          text  label_num
0        3444    ham      conoco big cowboy\r\ndarren \r\ni m not sur...          0
1        2982    ham   feb 01 prod sale to teco gas processing\r\ns...          0
2        2711    ham       california energy crisis\r\ncalifornia □ s p...          0
3        3116    ham     re nom actual volume for april 23 rd\r\nwe ...          0
4        1314    ham   eastrans nomination changes effective 8 2 0...          0
```

```
def remove_stopwords(text):
  stop_words = stopwords.words('english')

  imp_words = []

  # Storing the important words
  for word in str(text).split():
    word = word.lower()

    if word not in stop_words:
      imp_words.append(word)

  output = " ".join(imp_words)

  return output


balanced_data['text'] = balanced_data['text'].apply(lambda text: remove_stopwords(text))
balanced_data.head()
```

```
   Unnamed: 0  label                                          text  label_num
0        3444    ham   conoco big cowboy darren sure help know else a...          0
1        2982    ham     feb 01 prod sale teco gas processing sale deal...          0
2        2711    ham        california energy crisis california □ power cr...          0
3        3116    ham     nom actual volume april 23 rd agree eileen pon...          0
4        1314    ham    eastrans nomination changes effective 8 2 00 p...          0
```

```
def plot_word_cloud(data, typ):
    email_corpus = " ".join(data['text'])

    plt.figure(figsize=(7, 7))

    wc = WordCloud(background_color='black',
                max_words=100,
                width=800,
                height=400,
                collocations=False).generate(email_corpus)

    plt.imshow(wc, interpolation='bilinear')
    plt.title(f'WordCloud for {typ} emails', fontsize=15)
    plt.axis('off')
    plt.show()

plot_word_cloud(balanced_data[balanced_data['label_num'] == 0], typ='Non-Spam')
plot_word_cloud(balanced_data[balanced_data['label_num'] == 1], typ='Spam')
```

WordCloud for Non-Spam emails



WordCloud for Spam emails

order
without
email
c
stock
link
size
free
time
work
face
result
office
e
pill
height
price
one
looking
mail
many
see
high
available
account
system
may
p
number
line
inc
day
product

```
#train test split
train_X, test_X, train_Y, test_Y = train_test_split(balanced_data['text'],
                                                    balanced_data['label_num'],
                                                    test_size = 0.2,
                                                    random_state = 42)
```

```
# Tokenize the text data
tokenizer = Tokenizer()
tokenizer.fit_on_texts(train_X)

# Convert text to sequences
train_sequences = tokenizer.texts_to_sequences(train_X)
test_sequences = tokenizer.texts_to_sequences(test_X)

# Pad sequences to have the same length
max_len = 100 # maximum sequence length
train_sequences = pad_sequences(train_sequences,
                                maxlen=max_len,
                                padding='post',
                                truncating='post')
test_sequences = pad_sequences(test_sequences,
                            maxlen=max_len,
                            padding='post',
                            truncating='post')
```

```
# Build the model
model = tf.keras.models.Sequential()
model.add(tf.keras.layers.Embedding(input_dim=len(tokenizer.word_index) + 1,
                  output_dim=32,
                  input_length=max_len))
model.add(tf.keras.layers.LSTM(16))
model.add(tf.keras.layers.Dense(32, activation='relu'))
model.add(tf.keras.layers.Dense(1, activation='sigmoid'))

# Print the model summary
model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 embedding (Embedding)       (None, 100, 32)           1274912

 lstm (LSTM)                 (None, 16)                3136

 dense (Dense)               (None, 32)                544

 dense_1 (Dense)             (None, 1)                 33

=================================================================
Total params: 1278625 (4.88 MB)
```

```
Trainable params: 1278625 (4.88 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

```
model.compile(loss = tf.keras.losses.BinaryCrossentropy(from_logits = True),
            metrics = ['accuracy'],
            optimizer = 'adam')
```

```
es = EarlyStopping(patience=3,
                monitor = 'val_accuracy',
                restore_best_weights = True)

lr = ReduceLROnPlateau(patience = 2,
                    monitor = 'val_loss',
                    factor = 0.5,
                    verbose = 0)
```

```
# Train the model
history = model.fit(train_sequences, train_Y,
                    validation_data=(test_sequences, test_Y),
                    epochs=20,
                    batch_size=32,
                    callbacks = [lr, es]
                )
```

```
Epoch 1/20
75/75 [==============================] - 12s 65ms/step - loss: 0.6895 - accuracy: 0.5580 - val_loss: 0.6536 - val_accuracy: 0.6017 - lr:
Epoch 2/20
75/75 [==============================] - 4s 59ms/step - loss: 0.2831 - accuracy: 0.9099 - val_loss: 0.1362 - val_accuracy: 0.9700 - lr:
Epoch 3/20
75/75 [==============================] - 6s 75ms/step - loss: 0.1268 - accuracy: 0.9696 - val_loss: 0.1074 - val_accuracy: 0.9733 - lr:
Epoch 4/20
75/75 [==============================] - 4s 58ms/step - loss: 0.0763 - accuracy: 0.9842 - val_loss: 0.1153 - val_accuracy: 0.9767 - lr:
Epoch 5/20
75/75 [==============================] - 5s 69ms/step - loss: 0.0562 - accuracy: 0.9896 - val_loss: 0.1187 - val_accuracy: 0.9767 - lr:
Epoch 6/20
75/75 [==============================] - 5s 63ms/step - loss: 0.0443 - accuracy: 0.9921 - val_loss: 0.1276 - val_accuracy: 0.9750 - lr:
Epoch 7/20
75/75 [==============================] - 4s 57ms/step - loss: 0.0422 - accuracy: 0.9925 - val_loss: 0.1299 - val_accuracy: 0.9750 - lr:
```

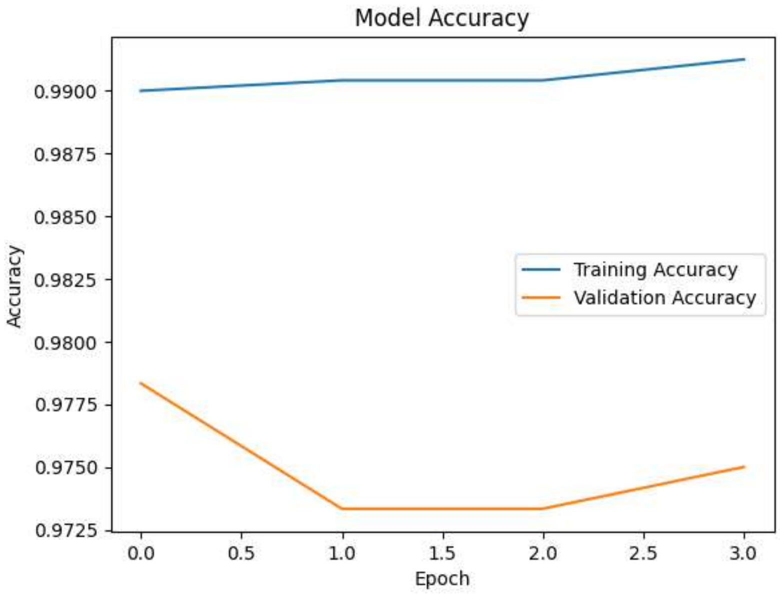
```
# Train the model
history = model.fit(train_sequences, train_Y,
                    validation_data=(test_sequences, test_Y),
                    epochs=20,
                    batch_size=32,
                    callbacks = [lr, es]
                )
```

```
Epoch 1/20
75/75 [==============================] - 5s 73ms/step - loss: 0.0538 - accuracy: 0.9900 - val_loss: 0.1090 - val_accuracy: 0.9783 - lr:
Epoch 2/20
75/75 [==============================] - 4s 60ms/step - loss: 0.0516 - accuracy: 0.9904 - val_loss: 0.1373 - val_accuracy: 0.9733 - lr:
Epoch 3/20
75/75 [==============================] - 5s 62ms/step - loss: 0.0536 - accuracy: 0.9904 - val_loss: 0.1379 - val_accuracy: 0.9733 - lr:
Epoch 4/20
75/75 [==============================] - 5s 69ms/step - loss: 0.0497 - accuracy: 0.9912 - val_loss: 0.1228 - val_accuracy: 0.9750 - lr:
```

```
# Evaluate the model
test_loss, test_accuracy = model.evaluate(test_sequences, test_Y)
print('Test Loss :',test_loss)
print('Test Accuracy :',test_accuracy)
```

```
19/19 [==============================] - 0s 10ms/step - loss: 0.1090 - accuracy: 0.9783
Test Loss : 0.1089741513133049
Test Accuracy : 0.9783333539962769
```

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


Model Accuracy
Accuracy
Epoch
Training Accuracy
Validation Accuracy