Data_Preprocessing

November 30, 2019

0.1 Notebook Imports

In [1]:
```
from os import walk
from os.path import join

import pandas as pd
import matplotlib.pyplot as plt
import numpy as np

import nltk
from nltk.stem import PorterStemmer
from nltk.stem import SnowballStemmer
from nltk.corpus import stopwords
from nltk.tokenize import word_tokenize

from bs4 import BeautifulSoup
from wordcloud import WordCloud
from PIL import Image

from sklearn.model_selection import train_test_split

%matplotlib inline
```

0.2 Constants

In [2]:
```
EXAMPLE_FILE = 'SpamData/01_Processing/practice_email.txt'

SPAM_1_PATH = 'SpamData/01_Processing/spam_assassin_corpus/spam_1'
SPAM_2_PATH = 'SpamData/01_Processing/spam_assassin_corpus/spam_2'
EASY_NONSPAM_1_PATH = 'SpamData/01_Processing/spam_assassin_corpus/easy_ham_1'
EASY_NONSPAM_2_PATH = 'SpamData/01_Processing/spam_assassin_corpus/easy_ham_2'

SPAM_CAT = 1
HAM_CAT = 0
VOCAB_SIZE = 2500

DATA_JSON_FILE = 'SpamData/01_Processing/email-text-data.json'
```

```
WORD_ID_FILE = 'SpamData/01_Processing/word-by-id.csv'

TRAINING_DATA_FILE = 'SpamData/02_Training/train-data.txt'
TEST_DATA_FILE = 'SpamData/02_Training/test-data.txt'

THUMBS_UP_FILE = 'SpamData/01_Processing/wordcloud_resources/thumbs-up.png'
THUMBS_DOWN_FILE = 'SpamData/01_Processing/wordcloud_resources/thumbs-down.png'
CUSTOM_FONT_FILE = 'SpamData/01_Processing/wordcloud_resources/OpenSansCondensed-Bold.t
```

0.3 Reading Files

```
In [3]: stream = open(EXAMPLE_FILE, encoding='latin-1')
        message = stream.read()
        stream.close()

        print(type(message))
        print(message)
```

```
<class 'str'>
From exmh-workers-admin@redhat.com  Thu Aug 22 12:36:23 2002
Return-Path: <exmh-workers-admin@spamassassin.taint.org>
Delivered-To: zzzz@localhost.netnoteinc.com
Received: from localhost (localhost [127.0.0.1])
        by phobos.labs.netnoteinc.com (Postfix) with ESMTP id D03E543C36
        for <zzzz@localhost>; Thu, 22 Aug 2002 07:36:16 -0400 (EDT)
Received: from phobos [127.0.0.1]
        by localhost with IMAP (fetchmail-5.9.0)
        for zzzz@localhost (single-drop); Thu, 22 Aug 2002 12:36:16 +0100 (IST)
Received: from listman.spamassassin.taint.org (listman.spamassassin.taint.org [66.187.233.211])
    dogma.slashnull.org (8.11.6/8.11.6) with ESMTP id g7MBYrZ04811 for
    <zzzz-exmh@spamassassin.taint.org>; Thu, 22 Aug 2002 12:34:53 +0100
Received: from listman.spamassassin.taint.org (localhost.localdomain [127.0.0.1]) by
    listman.redhat.com (Postfix) with ESMTP id 8386540858; Thu, 22 Aug 2002
    07:35:02 -0400 (EDT)
Delivered-To: exmh-workers@listman.spamassassin.taint.org
Received: from int-mx1.corp.spamassassin.taint.org (int-mx1.corp.spamassassin.taint.org
    [172.16.52.254]) by listman.redhat.com (Postfix) with ESMTP id 10CF8406D7
    for <exmh-workers@listman.redhat.com>; Thu, 22 Aug 2002 07:34:10 -0400
    (EDT)
Received: (from mail@localhost) by int-mx1.corp.spamassassin.taint.org (8.11.6/8.11.6)
    id g7MBY7g11259 for exmh-workers@listman.redhat.com; Thu, 22 Aug 2002
    07:34:07 -0400
Received: from mx1.spamassassin.taint.org (mx1.spamassassin.taint.org [172.16.48.31]) by
    int-mx1.corp.redhat.com (8.11.6/8.11.6) with SMTP id g7MBY7Y11255 for
    <exmh-workers@redhat.com>; Thu, 22 Aug 2002 07:34:07 -0400
Received: from ratree.psu.ac.th ([202.28.97.6]) by mx1.spamassassin.taint.org
    (8.11.6/8.11.6) with SMTP id g7MBIhl25223 for <exmh-workers@redhat.com>;
    Thu, 22 Aug 2002 07:18:55 -0400
```

```
Received: from delta.cs.mu.OZ.AU (delta.coe.psu.ac.th [172.30.0.98]) by
    ratree.psu.ac.th (8.11.6/8.11.6) with ESMTP id g7MBWel29762;
    Thu, 22 Aug 2002 18:32:40 +0700 (ICT)
Received: from munnari.OZ.AU (localhost [127.0.0.1]) by delta.cs.mu.OZ.AU
    (8.11.6/8.11.6) with ESMTP id g7MBQPW13260; Thu, 22 Aug 2002 18:26:25
    +0700 (ICT)
From: Robert Elz <kre@munnari.OZ.AU>
To: Chris Garrigues <cwg-dated-1030377287.06fa6d@DeepEddy.Com>
Cc: exmh-workers@spamassassin.taint.org
Subject: Re: New Sequences Window
In-Reply-To: <1029945287.4797.TMDA@deepeddy.vircio.com>
References: <1029945287.4797.TMDA@deepeddy.vircio.com>
    <1029882468.3116.TMDA@deepeddy.vircio.com> <9627.1029933001@munnari.OZ.AU>
    <1029943066.26919.TMDA@deepeddy.vircio.com>
    <1029944441.398.TMDA@deepeddy.vircio.com>
MIME-Version: 1.0
Content-Type: text/plain; charset=us-ascii
Message-Id: <13258.1030015585@munnari.OZ.AU>
X-Loop: exmh-workers@spamassassin.taint.org
Sender: exmh-workers-admin@spamassassin.taint.org
Errors-To: exmh-workers-admin@spamassassin.taint.org
X-Beenthere: exmh-workers@spamassassin.taint.org
X-Mailman-Version: 2.0.1
Precedence: bulk
List-Help: <mailto:exmh-workers-request@spamassassin.taint.org?subject=help>
List-Post: <mailto:exmh-workers@spamassassin.taint.org>
List-Subscribe: <https://listman.spamassassin.taint.org/mailman/listinfo/exmh-workers>,
    <mailto:exmh-workers-request@redhat.com?subject=subscribe>
List-Id: Discussion list for EXMH developers <exmh-workers.spamassassin.taint.org>
List-Unsubscribe: <https://listman.spamassassin.taint.org/mailman/listinfo/exmh-workers>,
    <mailto:exmh-workers-request@redhat.com?subject=unsubscribe>
List-Archive: <https://listman.spamassassin.taint.org/mailman/private/exmh-workers/>
Date: Thu, 22 Aug 2002 18:26:25 +0700


Dear Mr Still

Good tidings to you and all your staff for the festive season ahead (Christmas).
Now to the crux of the matter-in-hand: I am a fully qualified Santa Claus and am wondering whet
But WAIT! You're probably thinking: "What makes him so special?"
Well, first of all, I have made several changes to the characterisation of Father Christmas. Ra
You will note also, from the enclosed sketch, that I have radically redesigned Santa's outfit a
I look forward to hearing from you.

Best wishes
Robin Cooper
[Excerpt from the book: The Timewaster Letters by Robin Cooper]
```

```
In [4]: stream = open(EXAMPLE_FILE, encoding='latin-1')

        is_body = False
        lines = []

        for line in stream:
            if is_body:
                lines.append(line)
            elif line == '\n':
                is_body = True

        stream.close()
        email_body = '\n'.join(lines)
        print(email_body)
```

```
Dear Mr Still


Good tidings to you and all your staff for the festive season ahead (Christmas).

Now to the crux of the matter-in-hand: I am a fully qualified Santa Claus and am wondering whet

But WAIT! You're probably thinking: "What makes him so special?"

Well, first of all, I have made several changes to the characterisation of Father Christmas. Ra

You will note also, from the enclosed sketch, that I have radically redesigned Santa's outfit a

I look forward to hearing from you.


Best wishes

Robin Cooper

[Excerpt from the book: The Timewaster Letters by Robin Cooper]
```

0.4 Email body extraction

```
In [5]: def email_body_generator(path):
```

```
            for root,dirnames, filenames in walk(path):
                for file_name in filenames:

                    filepath = join(root,file_name)
                    stream = open(filepath, encoding='latin-1')

                    is_body = False
                    lines = []

                    for line in stream:
                        if is_body:
                            lines.append(line)
                        elif line =='\n':
                            is_body = True

                    stream.close()
                    email_body = '\n'.join(lines)
                    yield file_name, email_body
```

In [6]:
```
def df_from_directory(path, classification):
    rows = []
    row_names = []

    for file_name, email_body in email_body_generator(path):
        rows.append({'MESSAGE' : email_body, 'CATEGORY': classification})
        row_names.append(file_name)

    return pd.DataFrame(rows, index=row_names)
```

In [7]:
```
spam_emails = df_from_directory(SPAM_1_PATH,SPAM_CAT)
spam_emails = spam_emails.append(df_from_directory(SPAM_2_PATH,SPAM_CAT))
spam_emails.head()
```

Out[7]:

	CATEGORY	\
00234.6b386bd178f4ae52c67b6c6d15ece489	1	
00150.f97c73fa56460a6afc6d9418ad76b5b5	1	
00282.0e230e05877f40a522bfb93aa3e314f3	1	
00457.f8db516c753eff2c82cfb89b33bd2620	1	
00368.2c1ab4bc7f408e0fcb22dca9b2d5a113	1	

	MESSA
00234.6b386bd178f4ae52c67b6c6d15ece489	REQUEST FOR URGENT BUSINESS ASSISTANCE\n\n---
00150.f97c73fa56460a6afc6d9418ad76b5b5	This is a multi-part message in MIME format.\n
00282.0e230e05877f40a522bfb93aa3e314f3	<html>\n\n<head>\n\n</head>\n\n \n\n<h1
00457.f8db516c753eff2c82cfb89b33bd2620	<HTML>\n\n<HEAD>\n\n</HEAD>\n\n<BODY>\n\nVIAGR
00368.2c1ab4bc7f408e0fcb22dca9b2d5a113	<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 3.2//E

In [8]:
```
spam_emails.shape
```

```
Out[8]: (1898, 2)
```

```
In [9]: ham_emails = df_from_directory(EASY_NONSPAM_1_PATH, HAM_CAT)
        ham_emails = ham_emails.append(df_from_directory(EASY_NONSPAM_2_PATH,HAM_CAT))
        ham_emails.shape
```

```
Out[9]: (3901, 2)
```

```
In [10]: data = pd.concat([spam_emails, ham_emails])
         print('Shape of entire dataframe is ', data.shape)
         data.head()
```

```
Shape of entire dataframe is  (5799, 2)
```

```
Out[10]:                                          CATEGORY  \
         00234.6b386bd178f4ae52c67b6c6d15ece489         1
         00150.f97c73fa56460a6afc6d9418ad76b5b5         1
         00282.0e230e05877f40a522bfb93aa3e314f3         1
         00457.f8db516c753eff2c82cfb89b33bd2620         1
         00368.2c1ab4bc7f408e0fcb22dca9b2d5a113         1

                                                                                MESS
         00234.6b386bd178f4ae52c67b6c6d15ece489   REQUEST FOR URGENT BUSINESS ASSISTANCE\n\n---
         00150.f97c73fa56460a6afc6d9418ad76b5b5  This is a multi-part message in MIME format.\
         00282.0e230e05877f40a522bfb93aa3e314f3  <html>\n\n<head>\n\n</head>\n\n<center>\n\n<h
         00457.f8db516c753eff2c82cfb89b33bd2620  <HTML>\n\n<HEAD>\n\n</HEAD>\n\n<BODY>\n\nVIAG
         00368.2c1ab4bc7f408e0fcb22dca9b2d5a113  <!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 3.2//
```

```
In [11]: data.tail()
```

```
Out[11]:                                          CATEGORY  \
         00154.7bda4738681c601e0fd93f3c6d1ae4a1         0
         00363.2c66a99268facef9c5dab8c1f7b81190         0
         00449.9272eb34ed6d02f46e34bd7300d9e7d8         0
         00062.43847c613a539ca9c47b4593ee34bd6d         0
         00912.74b435accaf4e65a948c7769b6380f01         0

                                                                                MESS
         00154.7bda4738681c601e0fd93f3c6d1ae4a1  On Tue, Jul 30, 2002 at 11:28:11AM +0200, Dav
         00363.2c66a99268facef9c5dab8c1f7b81190  Paul, my apologies for being irritable on the
         00449.9272eb34ed6d02f46e34bd7300d9e7d8  Yes indeed - there should be an agents direct
         00062.43847c613a539ca9c47b4593ee34bd6d  There's been some discussion just now on the
         00912.74b435accaf4e65a948c7769b6380f01  On Fri, 2002-07-26 at 12:49, Ian Andrew Bell
```

0.5 Data Cleaning: Checking for Missing Values

```
In [12]: data['MESSAGE'].isnull().values.any()
```

```
Out[12]: False
```

```
In [13]: (data.MESSAGE.str.len()==0).sum()
```

```
Out[13]: 3
```

0.6 Locate empty emails

```
In [14]: data[data.MESSAGE.str.len()==0].index
```

```
Out[14]: Index(['cmds', 'cmds', 'cmds'], dtype='object')
```

```
In [15]: data.drop(['cmds'], inplace=True)
```

```
In [16]: data.shape
```

```
Out[16]: (5796, 2)
```

0.7 Add Document IDs to Track Emails in Dataset

```
In [17]: document_ids = range(0, len(data.index))
         data['DOC_ID'] = document_ids
```

```
In [18]: data['FILE_NAME'] = data.index
         data.set_index('DOC_ID', inplace=True)
         data.head()
```

```
Out[18]:         CATEGORY                                            MESSAGE  \
         DOC_ID
         0               1   REQUEST FOR URGENT BUSINESS ASSISTANCE\n\n---...
         1               1  This is a multi-part message in MIME format.\n...
         2               1  <html>\n\n<head>\n\n</head>\n\n<center>\n\n<h1...
         3               1  <HTML>\n\n<HEAD>\n\n</HEAD>\n\n<BODY>\n\nVIAGR...
         4               1  <!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 3.2//E...

                                              FILE_NAME
         DOC_ID
         0       00234.6b386bd178f4ae52c67b6c6d15ece489
         1       00150.f97c73fa56460a6afc6d9418ad76b5b5
         2       00282.0e230e05877f40a522bfb93aa3e314f3
         3       00457.f8db516c753eff2c82cfb89b33bd2620
         4       00368.2c1ab4bc7f408e0fcb22dca9b2d5a113
```

```
In [19]: data.to_json(DATA_JSON_FILE)
```

0.8 Number of Spam and Ham messages Visualised

```
In [20]: data.CATEGORY.value_counts()
```

```
Out[20]: 0    3900
         1    1896
         Name: CATEGORY, dtype: int64
```

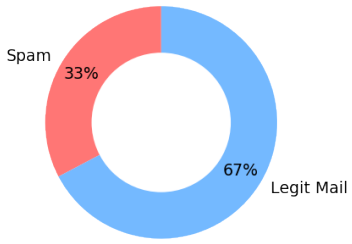
```
In [21]: amount_of_spam = data.CATEGORY.value_counts()[1]
         amount_of_ham = data.CATEGORY.value_counts()[0]

In [22]: category_names = ['Spam', 'Legit Mail']
         sizes = [amount_of_spam, amount_of_ham]
         custom_colours = ['#ff7675','#74b9ff']

         plt.figure(figsize=(2,2), dpi=227)
         plt.pie(sizes, labels=category_names, textprops={'fontsize':6}, startangle=90,
                autopct='%1.0f%%', colors=custom_colours, pctdistance=0.8)

         centre_circle = plt.Circle((0,0), radius=0.6, fc='white')
         plt.gca().add_artist(centre_circle)

         plt.show()
```



0.9 Download NLP Packages

```
In [23]: nltk.download('punkt')

[nltk_data] Downloading package punkt to /home/anish/nltk_data...
[nltk_data]   Package punkt is already up-to-date!


Out[23]: True

In [24]: nltk.download('stopwords')

[nltk_data] Downloading package stopwords to /home/anish/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!


Out[24]: True
```

0.10 Functions for Email Processing

```
In [25]: def clean_message(message, stemmer=PorterStemmer(), stop_words=set(stopwords.words('e
             words = word_tokenize(message.lower())

             filtered_words = []

             for word in words:
                 if word not in stop_words and word.isalpha():
                     filtered_words.append(stemmer.stem(word))

             return filtered_words
```

```
In [26]: clean_message(email_body)
```

```
Out[26]: ['dear',
          'mr',
          'still',
          'good',
          'tide',
          'staff',
          'festiv',
          'season',
          'ahead',
          'christma',
          'crux',
          'fulli',
          'qualifi',
          'santa',
          'clau',
          'wonder',
          'whether',
          'might',
          'consid',
          'run',
          'santa',
          'grotto',
          'store',
          'wait',
          'probabl',
          'think',
          'make',
          'special',
          'well',
          'first',
          'made',
          'sever',
          'chang',
          'characteris',
```

```
'father',
'christma',
'rather',
'greet',
'children',
'shout',
'ho',
'ho',
'ho',
'prefer',
'whisper',
'phrase',
'depend',
'unfathom',
'cruel',
'world',
'live',
'addit',
'gift',
'rang',
'felt',
'hoop',
'holder',
'note',
'also',
'enclos',
'sketch',
'radic',
'redesign',
'santa',
'outfit',
'renam',
'charact',
'lord',
'buckl',
'would',
'interest',
'employ',
'promis',
'never',
'let',
'look',
'forward',
'hear',
'best',
'wish',
'robin',
'cooper',
```

```
          'excerpt',
          'book',
          'timewast',
          'letter',
          'robin',
          'cooper']

In [27]: def clean_msg_no_html(message, stemmer = PorterStemmer(), stop_words=set(stopwords.wo
             soup = BeautifulSoup(message, 'html.parser')
             cleaned_text = soup.get_text()

             words = word_tokenize(cleaned_text.lower())

             filtered_words = []

             for word in words:
                 if word not in stop_words and word.isalpha():
                     filtered_words.append(stemmer.stem(word))

             return filtered_words

In [28]: clean_msg_no_html(data.at[2,'MESSAGE'])

Out[28]: ['free',
          'person',
          'busi',
          'grant',
          'qualifi',
          'least',
          'free',
          'grant',
          'money',
          'guarante',
          'day',
          'one',
          'million',
          'dollar',
          'free',
          'govern',
          'grant',
          'given',
          'away',
          'peopl',
          'like',
          'wide',
          'varieti',
          'busi',
          'person',
```

```
'need',
'dear',
'grant',
'seeker',
'moment',
'tell',
'exactli',
'get',
'grant',
'money',
'given',
'away',
'may',
'think',
'get',
'free',
'grant',
'money',
'mayb',
'think',
'imposs',
'get',
'free',
'money',
'let',
'tell',
'imposs',
'fact',
'ordinari',
'peopl',
'busi',
'across',
'unit',
'state',
'receiv',
'million',
'dollar',
'govern',
'privat',
'foundat',
'everyday',
'appli',
'anyon',
'appli',
'grant',
'year',
'old',
'grant',
```

```
'possibl',
'grant',
'paid',
'back',
'ever',
'claim',
'slice',
'free',
'american',
'pie',
'money',
'loan',
'tri',
'get',
'money',
'convent',
'bank',
'time',
'consum',
'requir',
'lot',
'paperwork',
'find',
'deni',
'govern',
'agenc',
'oper',
'stringent',
'requir',
'bank',
'decid',
'much',
'money',
'need',
'long',
'law',
'amount',
'meet',
'govern',
'agenc',
'criteria',
'money',
'keep',
'never',
'repaid',
'money',
'non',
'taxabl',
```

```
'interest',
'free',
'none',
'program',
'requir',
'credit',
'check',
'collater',
'secur',
'deposit',
'appli',
'even',
'bankruptci',
'bad',
'credit',
'matter',
'tax',
'payer',
'citizen',
'entitl',
'money',
'current',
'feder',
'program',
'state',
'program',
'privat',
'foundat',
'scholarship',
'program',
'avail',
'year',
'billion',
'dollar',
'free',
'person',
'busi',
'govern',
'grant',
'money',
'given',
'away',
'govern',
'grant',
'agenc',
'govern',
'person',
'busi',
```

```
'grant',
'fact',
'million',
'peopl',
'get',
'govern',
'money',
'everi',
'year',
'entrepreneur',
'get',
'money',
'start',
'expand',
'busi',
'peopl',
'get',
'money',
'invest',
'real',
'estat',
'peopl',
'get',
'money',
'go',
'colleg',
'peopl',
'get',
'free',
'help',
'train',
'better',
'job',
'get',
'busi',
'grant',
'anyon',
'think',
'go',
'busi',
'want',
'expand',
'exist',
'busi',
'rush',
'world',
'largest',
'free',
```

```
'busi',
'grant',
'start',
'expand',
'busi',
'held',
'feder',
'govern',
'sound',
'absolut',
'incred',
'peopl',
'live',
'right',
'unit',
'state',
'america',
'would',
'know',
'year',
'world',
'largest',
'sourc',
'free',
'busi',
'help',
'deliv',
'billion',
'dollar',
'free',
'busi',
'grant',
'loan',
'trillion',
'dollar',
'procur',
'contract',
'billion',
'dollar',
'free',
'consult',
'research',
'grant',
'economi',
'remain',
'unpredict',
'need',
'even',
```

```
'greater',
'econom',
'develop',
'front',
'feder',
'govern',
'will',
'ever',
'give',
'money',
'need',
'busi',
'becom',
'boss',
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'peopl',
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'help',
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'know',
'fact',
'howev',
```

```
'peopl',
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'govern',
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'grant',
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'home',
'low',
'incom',
'famili',
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'home',
'rent',
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'util',
'bill',
'purchas',
'new',
'car',
'groceri',
'childcar',
'fuel',
'gener',
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'cloth',
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'hous',
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```

```
'debt',
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'art',
'lesson',
'extracurricular',
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'bill',
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'grant',
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'children',
'nurseri',
'school',
'educ',
'privat',
'primari',
'secondari',
'school',
'men',
'women',
'educ',
'scholarship',
'athlet',
'busi',
```

```
'manag',
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'comput',
'scienc',
'medic',
'school',
'undergradu',
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'profession',
'foreign',
'studi',
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'grant',
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'appli',
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'free',
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'requir',
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'present',
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'complet',
'guid',
'govern',
```

```
'grant',
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'heard',
'govern',
'grant',
'done',
'put',
'togeth',
'complet',
'blueprint',
'research',
'locat',
'obtain',
'govern',
'grant',
'complet',
'guid',
'govern',
'grant',
'comprehens',
'tool',
'obtain',
'free',
'grant',
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'come',
'electron',
'book',
'format',
'mean',
'download',
'start',
'use',
'minut',
'order',
'complet',
'guid',
'govern',
'grant',
'provid',
'access',
'thousand',
'grant',
'loan',
'sourc',
'step',
```

```
'step',
'instruct',
'propos',
'write',
'contact',
'procedur',
'complet',
'guid',
'govern',
'grant',
'find',
'step',
'step',
'guidelin',
'appli',
'govern',
'grant',
'direct',
'access',
'grant',
'loan',
'assist',
'program',
'offer',
'feder',
'govern',
'need',
'click',
'find',
'program',
'detail',
'categor',
'list',
'direct',
'access',
'thousand',
'resourc',
'state',
'specif',
'grant',
'program',
'name',
'phone',
'number',
'address',
'expert',
'state',
'answer',
```

```
'grant',
'relat',
'question',
'help',
'grant',
'applic',
'free',
'charg',
'onlin',
'directori',
'govern',
'support',
'ventur',
'capit',
'firm',
'uniqu',
'search',
'tool',
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'gener',
'custom',
'list',
'recent',
'announc',
'grant',
'program',
'govern',
'fund',
'program',
'small',
'busi',
'top',
'govern',
'program',
'base',
'number',
'inquiri',
'discov',
'sought',
'govern',
'grant',
'assist',
'program',
'claim',
'slice',
'free',
'american',
'pie',
```

```
'onlin',
'directori',
'feder',
'state',
'resourc',
'govern',
'scholarship',
'grant',
'educ',
'step',
'step',
'guidelin',
'locat',
'grant',
'loan',
'assist',
'program',
'start',
'new',
'busi',
'expand',
'exist',
'one',
'get',
'free',
'small',
'busi',
'counsel',
'expert',
'advic',
'courtesi',
'us',
'govern',
'govern',
'grant',
'applic',
'form',
'direct',
'access',
'thousand',
'govern',
'grant',
'program',
'cover',
'small',
'busi',
'home',
'improv',
```

```
'home',
'buy',
'homeownership',
'land',
'acquisit',
'site',
'prepar',
'hous',
'health',
'assist',
'servic',
'unemploy',
'job',
'train',
'feder',
'employ',
'educ',
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'develop',
'write',
'grant',
'propos',
'get',
'result',
'plu',
'much',
'complet',
'guid',
'govern',
'grant',
'comprehens',
'provid',
'direct',
'access',
'practic',
'everi',
'sourc',
'free',
'govern',
'grant',
'money',
'current',
'avail',
'american',
'citizen',
'resid',
'entitl',
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'free',
'grant',
'money',
'rang',
'black',
'alreadi',
'qualifi',
'program',
'hispan',
'qualifi',
'mani',
'program',
'christian',
'get',
'program',
'also',
'mani',
'program',
'avail',
'differ',
'faith',
'jewish',
'cathol',
'money',
'get',
'program',
'program',
'unemploy',
'underemploy',
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'sourc',
'endless',
'elig',
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'absolut',
'free',
'use',
'worthwhil',
'purpos',
'know',
'appli',
'mani',
'grant',
'want',
'true',
'instanc',
'could',
'get',
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```
'grant',
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'weight',
'loss',
'busi',
'get',
'tuition',
'becom',
'nurs',
'open',
'center',
'alway',
'dream',
'own',
'go',
'appli',
'grant',
'buy',
'home',
'famili',
'new',
'busi',
'start',
'well',
'could',
'go',
'get',
'anoth',
'grant',
'expans',
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'qualifi',
'least',
'free',
'grant',
'money',
'money',
'back',
'confid',
'grant',
'guid',
'receiv',
'least',
'free',
'grant',
```

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'money',
'unhappi',
'reason',
'within',
'next',
'month',
'send',
'back',
'refund',
'entir',
'payment',
'question',
'ask',
'want',
'order',
'insist',
'entir',
'risk',
'come',
'risk',
'full',
'year',
'guarante',
'absolut',
'risk',
'part',
'day',
'guarante',
'mean',
'want',
'order',
'without',
'feel',
'might',
'get',
'taken',
'therefor',
'want',
'order',
'materi',
'today',
'read',
'use',
'reason',
'complet',
'satisfi',
'cancel',
'immedi',
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'refund',
'purchas',
'price',
'simpli',
'ca',
'lose',
'free',
'bonus',
'sweeten',
'deal',
'includ',
'follow',
'four',
'valuabl',
'bonus',
'keep',
'gift',
'even',
'later',
'decid',
'keep',
'grant',
'guid',
'free',
'bonu',
'fulli',
'featur',
'grant',
'write',
'tutori',
'softwar',
'packag',
'info',
'alon',
'worth',
'thousand',
'dollar',
'guarante',
'purchas',
'grant',
'cd',
'info',
'anywher',
'receiv',
'download',
'softwar',
'actual',
'show',
```

```
'appli',
'say',
'accept',
'grant',
'interact',
'softwar',
'tool',
'walk',
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'teach',
'everyth',
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'competit',
'grant',
'propos',
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'includ',
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'write',
'grant',
'propos',
'complet',
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'packag',
'exampl',
'good',
'complet',
'grant',
'packag',
'glossari',
'grant',
'term',
'resourc',
'contact',
'mock',
'activ',
'abl',
'compar',
'result',
'success',
'grant',
'applic',
'plu',
```

```
'much',
'much',
'free',
'bonu',
'insid',
'inform',
'report',
'way',
'save',
'money',
'valuabl',
'special',
'report',
'contain',
'insid',
'expert',
'tip',
'techniqu',
'help',
'save',
'thousand',
'dollar',
'discov',
'littl',
'known',
'secret',
'trick',
'save',
'money',
'airlin',
'fare',
'car',
'rental',
'new',
'use',
'car',
'buy',
'auto',
'leas',
'gasolin',
'car',
'repair',
'auto',
'insur',
'life',
'insur',
'save',
'invest',
```

```
          'credit',
          'card',
          'home',
          'equiti',
          'loan',
          'home',
          'purchas',
          'major',
          'applianc',
          'home',
          'heat',
          'telephon',
          'servic',
          'food',
          'purchas',
          ...]
```

```
In [29]: %%time

         nested_list = data.MESSAGE.apply(clean_msg_no_html)
```

```
/home/anish/anaconda3/lib/python3.7/site-packages/bs4/__init__.py:336: UserWarning: "http://ww
" looks like a URL. Beautiful Soup is not an HTTP client. You should probably use an HTTP clie
  ' that document to Beautiful Soup.' % decoded_markup


CPU times: user 35.7 s, sys: 33.6 ms, total: 35.7 s
Wall time: 35.7 s
```

```
In [30]: nested_list.tail()
```

```
Out[30]: DOC_ID
         5791    [tue, jul, david, neari, mention, exampl, say,...
         5792    [paul, apolog, irrit, subject, tone, rhetor, q...
         5793    [ye, inde, agent, directori, verita, cd, unix,...
         5794    [discuss, ilug, irc, channel, osi, protocol, l...
         5795    [fri, ian, andrew, bell, wrote, particularli, ...
         Name: MESSAGE, dtype: object
```

```
In [31]: doc_ids_spam = data[data.CATEGORY == 1].index
         doc_ids_ham = data[data.CATEGORY == 0].index
```

```
In [32]: doc_ids_ham
```

```
Out[32]: Int64Index([1896, 1897, 1898, 1899, 1900, 1901, 1902, 1903, 1904, 1905,
                      ...
                      5786, 5787, 5788, 5789, 5790, 5791, 5792, 5793, 5794, 5795],
                     dtype='int64', name='DOC_ID', length=3900)
```

```
In [33]: nested_list_ham = nested_list.loc[doc_ids_ham]

In [34]: nested_list_ham.shape

Out[34]: (3900,)

In [35]: nested_list_ham.tail()

Out[35]: DOC_ID
         5791    [tue, jul, david, neari, mention, exampl, say,...
         5792    [paul, apolog, irrit, subject, tone, rhetor, q...
         5793    [ye, inde, agent, directori, verita, cd, unix,...
         5794    [discuss, ilug, irc, channel, osi, protocol, l...
         5795    [fri, ian, andrew, bell, wrote, particularli, ...
         Name: MESSAGE, dtype: object

In [36]: nested_list_spam = nested_list.loc[doc_ids_spam]

In [37]: flat_list_ham = [item for sublist in nested_list_ham for item in sublist]
         normal_words = pd.Series(flat_list_ham).value_counts()
         normal_words.shape[0]

Out[37]: 20755

In [38]: normal_words[:10]

Out[38]: http      7561
         use       3630
         list      2878
         one       2371
         get       2284
         mail      2255
         would     2003
         like      1928
         messag    1847
         work      1798
         dtype: int64

In [39]: flat_list_spam = [item for sublist in nested_list_spam for item in sublist]
         spammy_words = pd.Series(flat_list_spam).value_counts()
         spammy_words.shape[0]

Out[39]: 13284

In [40]: spammy_words[:10]

Out[40]: http      3101
         email     3094
         free      2555
         click     2058
```

```
receiv    1987
list      1974
get       1903
pleas     1842
busi      1792
order     1743
dtype: int64
```

0.11 Word Cloud

```
In [41]: icon = Image.open(THUMBS_UP_FILE)
         image_mask = Image.new(mode='RGB', size=icon.size, color=(255, 255, 255))
         image_mask.paste(icon, box=icon)

         rgb_array = np.array(image_mask)

         ham_str = ' '.join(flat_list_ham)

         word_cloud = WordCloud(mask=rgb_array, background_color='white',
                                max_words=500, colormap='winter')

         word_cloud.generate(ham_str)

         plt.figure(figsize=[16, 8])
         plt.imshow(word_cloud, interpolation='bilinear')
         plt.axis('off')
         plt.show()
```


```
In [42]: icon = Image.open(THUMBS_DOWN_FILE)
         image_mask = Image.new(mode='RGB', size=icon.size, color=(255, 255, 255))
         image_mask.paste(icon, box=icon)

         rgb_array = np.array(image_mask)

         spam_str = ' '.join(flat_list_spam)

         word_cloud = WordCloud(mask=rgb_array, background_color='white',
                                max_words=2000, colormap='gist_heat', font_path=CUSTOM_FONT_FIL
         spam_str = spam_str.upper()
         word_cloud.generate(spam_str)
```

```
plt.figure(figsize=[16, 8])
plt.imshow(word_cloud, interpolation='bilinear')
plt.axis('off')
plt.show()
```

0.12 Generating Vocabulary & Dictionary

```
In [43]: stemmed_nested_list = data.MESSAGE.apply(clean_msg_no_html)
         flat_stemmed_list = [item for sublist in stemmed_nested_list for item in sublist]

In [44]: unique_words = pd.Series(flat_stemmed_list).value_counts()
         print('Number of unique words', unique_words.shape[0])
         unique_words.head()
```

```
Number of unique words 27305
```

```
Out[44]: http     10662
         use       5017
         list      4852
         email     4370
         get       4187
         dtype: int64
```

```
In [45]: frequent_words = unique_words[0:VOCAB_SIZE]
         print('Most common words: \n', frequent_words[:10])
```

```
Most common words:
 http     10662
use       5017
list      4852
email     4370
get       4187
mail      3985
one       3905
free      3171
time      3090
work      2880
dtype: int64
```

0.13 Create vocabulary DataFrame with a WORD_ID

```
In [46]: word_ids = list(range(0, VOCAB_SIZE))
         vocab = pd.DataFrame({'VOCAB_WORD' : frequent_words.index.values}, index=word_ids)
         vocab.index.name = 'WORD_ID'
         vocab.head()
```

Out[46]:

WORD_ID	VOCAB_WORD
0	http
1	use
2	list
3	email
4	get

```
In [47]: vocab.to_csv(WORD_ID_FILE, index_label=vocab.index.name, header=vocab.VOCAB_WORD.name)
```

0.14 Email with most number of words

```
In [48]: clean_email_lengths = [len(sublist) for sublist in stemmed_nested_list]
         print('Number of words in the longest email:', max(clean_email_lengths))
```

```
Number of words in the longest email: 7671
```

0.15 Generate Features and a Sparse Matrix

```
In [49]: type(stemmed_nested_list)
```

```
Out[49]: pandas.core.series.Series
```

```
In [50]: word_columns_df = pd.DataFrame.from_records(stemmed_nested_list.tolist())
         word_columns_df.head()
```

Out[50]:

	0	1	2	3	4	5	6	7	\
0	request	urgent	busi	assist	contact	avail	chamber	commerc	
1	messag	mime	format	maxim	select	want	pay	less	
2	free	person	busi	grant	qualifi	least	free	grant	
3	viagra	xenic	vioxx	zyban	propecia	offer	real	viagra	
4	untitl	attent	must	comput	user	packag	deal	norton	

	8	9	...	7661	7662	7663	7664	7665	7666	7667	7668	\
0	given	diplomat	...	None	None	None	None	None	None	None	None	
1	term	insur	...	None	None	None	None	None	None	None	None	
2	money	guarante	...	None	None	None	None	None	None	None	None	
3	xenic	vioxx	...	None	None	None	None	None	None	None	None	
4	systemwork	oftwar	...	None	None	None	None	None	None	None	None	

	7669	7670
0	None	None
1	None	None
2	None	None
3	None	None
4	None	None

[5 rows x 7671 columns]

In [51]:
```
word_columns_df.shape
```

Out[51]: (5796, 7671)

0.16 Spilitting the Data into a Training and Testing Dataset

In [52]:
```
X_train, X_test, y_train,y_test = train_test_split(word_columns_df, data.CATEGORY, tes
```

In [53]:
```
X_train.index.name = X_test.index.name = 'DOC_ID'
X_train.head()
```

Out[53]:

DOC_ID	0	1	2	3	4	5	6	\
4844	hi	look	get	hand	either	doom	ii	
4727	get	hope	career	move	next	stop	hollywood	
5022	server	bug	backup	discoveri	server	fix	cheer	
3504	permiss	issu	razor	log	file	spamassassin	run	
3921	pgp	sign	messag	vincent	cunniff	wrote	justin	

DOC_ID	7	8	9	...	7661	7662	7663	7664	7665	\
4844	pc	unfortun	access	...	None	None	None	None	None	
4727	rememb	madonna	actress	...	None	None	None	None	None	
5022	chad	scott	augustu	...	None	None	None	None	None	
3504	setuid	user	mail	...	None	None	None	None	None	
3921	maccarthi	wrote	think	...	None	None	None	None	None	

```
        7666  7667  7668  7669  7670
DOC_ID
4844    None  None  None  None  None
4727    None  None  None  None  None
5022    None  None  None  None  None
3504    None  None  None  None  None
3921    None  None  None  None  None

[5 rows x 7671 columns]
```

```
In [54]: y_train.head()
```

```
Out[54]: DOC_ID
         4844    0
         4727    0
         5022    0
         3504    0
         3921    0
         Name: CATEGORY, dtype: int64
```

0.17 Create a Sparse Matrix for the training data

```
In [55]: word_index = pd.Index(vocab.VOCAB_WORD)
         word_index
```

```
Out[55]: Index(['http', 'use', 'list', 'email', 'get', 'mail', 'one', 'free', 'time',
                'work',
                ...
                'milter', 'trader', 'council', 'advisor', 'mutual', 'burner', 'maxaman',
                'bullet', 'subsequ', 'decreas'],
               dtype='object', name='VOCAB_WORD', length=2500)
```

```
In [56]: def make_sparse_matrix(df, indexed_words, labels):
             """
             Returns sparse matrix as dataframe.

             df: A dataframe with words in the columns with a document id as an index (X_train
             indexed_words: index of words ordered by word_id
             labels: category as a series (y_train or y_test)
             """

             nr_rows = df.shape[0]
             nr_cols = df.shape[1]
             word_set = set(indexed_words)
             dict_list = []

             for i in range(nr_rows):
                 for j in range(nr_cols):
```

```
                    word = df.iat[i,j]
                    if word in word_set:
                        doc_id = df.index[i]
                        word_id = indexed_words.get_loc(word)
                        category = labels.at[doc_id]

                        item = {'LABEL': category, 'DOC_ID': doc_id,
                               'OCCURENCE' : 1, 'WORD_ID' : word_id}

                        dict_list.append(item)

            return pd.DataFrame(dict_list)
```

```
In [57]: %%time
         sparse_train_df = make_sparse_matrix(X_train, word_index, y_train)
```

```
CPU times: user 3min 24s, sys: 212 ms, total: 3min 24s
Wall time: 3min 24s
```

```
In [58]: sparse_train_df[:5]
```

Out[58]:

	DOC_ID	LABEL	OCCURENCE	WORD_ID
0	4844	0	1	531
1	4844	0	1	40
2	4844	0	1	4
3	4844	0	1	443
4	4844	0	1	431

```
In [59]: sparse_train_df.shape
```

```
Out[59]: (426844, 4)
```

0.17.1 Combining Occurences with the Pandas groupby() Method

```
In [60]: train_grouped = sparse_train_df.groupby(['DOC_ID', 'WORD_ID', 'LABEL']).sum()
         train_grouped.head()
```

Out[60]:

			OCCURENCE
DOC_ID	WORD_ID	LABEL	
0	0	1	1
	1	1	1
	2	1	1
	6	1	1
	9	1	1

```
In [61]: train_grouped = train_grouped.reset_index()
         train_grouped.head()
```

Out[61]:

	DOC_ID	WORD_ID	LABEL	OCCURENCE
0	0	0	1	1
1	0	1	1	1
2	0	2	1	1
3	0	6	1	1
4	0	9	1	1

0.18 Creating Sparse matrix for Test Data

```
In [62]: %%time
         sparse_test_df = make_sparse_matrix(X_test, word_index, y_test)
```

```
CPU times: user 1min 27s, sys: 208 ms, total: 1min 27s
Wall time: 1min 27s
```

```
In [63]: test_grouped = sparse_test_df.groupby(['DOC_ID', 'WORD_ID','LABEL']).sum().reset_index
         test_grouped.head()
```

Out[63]:

	DOC_ID	WORD_ID	LABEL	OCCURENCE
0	8	0	1	4
1	8	2	1	1
2	8	3	1	1
3	8	5	1	1
4	8	6	1	1

```
In [64]: test_grouped.shape
```

```
Out[64]: (115650, 4)
```

```
In [65]: np.savetxt(TRAINING_DATA_FILE, train_grouped, fmt='%d')
         np.savetxt(TEST_DATA_FILE, test_grouped, fmt='%d')
```