

1. Read the following instructions and try to answer questions.
2. I strongly recommend to use Google Colab interface to implement and run your Python code.
 - A. <https://colab.google/> (Colab website, Use your Google account to join and sign in.)
 - B. Get started with Google Colaboratory
<https://youtu.be/inN8seMm7UI?si=KUdMKhWLjDqzzhh8>
 - C. You may find many useful information about Colab on the internet. (Maybe you need to get used to use the Jupyter Notebook interface.)
3. Our goal is to make a spam message filter according to specific words.
4. Data preparation

```
import pandas as pd
import urllib.request

urllib.request.urlretrieve("https://raw.githubusercontent.com/ukairia777/tensorflow-nlp-tutorial/main/10.%20RNN%20Text%20Classification/dataset/spam.csv",
filename="spam.csv")
df = pd.read_csv('spam.csv', encoding='latin1', usecols=[0, 1])

df.columns = ['Label', 'Message']

print(df.head())
```

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

- A. You can download the dataset directly in you Python code like above.
- B. Use `print(df.head())` function to see the first few lines of the data.

5. Function to split messages into words

```
import re

# Function to split messages into words
def tokenize(message):
    message = message.lower() # Convert to lowercase
    words = re.findall(r'\b\w+\b', message) # Extract words
    return words
```

6. Separate spam and non-spam messages

```
# Separate spam and non-spam messages
spam_messages = df[df['Label'] == 'spam']['Message']
non_spam_messages = df[df['Label'] == 'ham']['Message']
```

7. Count the number of spam messages

```
# Count the number of spam messages
spam_count = spam_messages.shape[0]

# Print the result
print(f"Total number of spam messages: {spam_count}")
```

Total number of spam messages: 747

8. **Question 1:** How to get the number of non-spam(ham) messages?

Your answer here

```
non_spam_count = non_spam_messages.shape[0]
print(f"Total number of non_spam messages: {non_spam_count}")
```

9. Calculate word frequency

```
from collections import Counter

# Calculate word frequency
spam_words = Counter()
non_spam_words = Counter()

for message in spam_messages:
    spam_words.update(tokenize(message))

for message in non_spam_messages:
    non_spam_words.update(tokenize(message))
```

10. Print the most common words

```
# Print the most common words
print("Most common words in spam messages:")
print(spam_words.most_common(30))

print("\nMost common words in non-spam messages:")
print(non_spam_words.most_common(30))
```

Most common words in spam messages:
[('to', 688), ('a', 377), ('call', 355), ('â', 299), ('you', 297), ('your', 264), ('free', 224), ('2', 206), ('the', 206),

Most common words in non-spam messages:
[('i', 2940), ('you', 1943), ('to', 1554), ('the', 1122), ('a', 1056), ('u', 1018), ('and', 857), ('in', 818), ('me', 772),

11. **Question 2:** Do you think is it meaningful to use the most common words in each message category to make a spam filter? Explain why.

Your answer here

No, it's meaningless. Because a comparison of the 30 most common words in spam and the 30 most common words in non-spam messages resulted in 12 identical words. Then, if a sentence is made up of those 12 words, it is impossible to distinguish whether it is a spam message or a

non-spam message. Therefore, this method has limitations in the way it tries to make a sample filter.

12. Identify words that are more frequent in spam than in non-spam

```
# Identify words that are more frequent in spam than in non-spam
# Compare the frequency of each word in spam and non-spam
unique_words = set(list(spam_words.keys()) +
list(non_spam_words.keys()))
spam_dominant_words = {}

for word in unique_words:
    spam_freq = spam_words[word]
    non_spam_freq = non_spam_words[word]
    # Select the word if it is significantly more frequent in spam
    if spam_freq > non_spam_freq * 2: # This ratio can be adjusted.
        spam_dominant_words[word] = spam_freq

# Print the results
print("Words more frequent in spam than in non-spam:")
for word, freq in sorted(spam_dominant_words.items(), key=lambda x:
x[1], reverse=True):
    print(f"{word}: {freq}")
```

```
Words more frequent in spam than in non-spam:
a: 299
free: 224
txt: 163
mobile: 127
stop: 121
claim: 113
reply: 104
www: 98
```

13. **Question 3:** If you want to Identify words that are a way more frequent in spam than in non-spam, how are you going to modify the previous code?

Your answer here

First of all, the probabilities of the word appearing in spam messages and non-spam messages were calculated as 'p_w' and 'q_w'.

If the non-spam messages do not contain a word, then the value of 'q_w' is 0, then the probability that the incoming message based on BAYES' Theorem is spam is 1. I don't think it's meaningless if the probability is 1. So I use the condition "q_w!=0" to exclude the condition that the probability is 1.

```
unique_words = set(list(spam_words.keys()) +
list(non_spam_words.keys()))

spam_dominant_words = {}
for word in unique_words:
    spam_freq = spam_words[word]#the frequency of word in spam message
    non_spam_freq = non_spam_words[word]#the frequency of word in non-
spam message
```

```

    p_w = spam_freq / spam_count #the probability that the spam message
contains the word
    q_w = non_spam_freq / non_spam_count #the probability that the non-
spam message contains the word

    if p_w > q_w * 2 and q_w !=0 : # This ratio can be adjusted.

        spam_dominant_words[word] = spam_freq
for word, freq in sorted(spam_dominant_words.items(), key=lambda x:
x[1], reverse=True):
    print(f"{word}: {freq}")

```

14. **Question 4:** How many words do you want to pick to make your spam filter? What are the words?

Your answer here

Use the BAYES' theorem and then pick words through the code. Combine words just before the probability becomes 1 to create a new filter of your own. .

The number of words in my spam filter varies depending on how I adjust the ratio of the condition in question 3.

If $p_w > q_w * 1$ and $q_w \neq 0$. -> the number of words : 20

{to, a, call, å, your, free, 2, the, for, now, or, u, txt, is, ur, on, 4, have, from , mobile}

If $p_w > q_w * 2$ and $q_w \neq 0$. -> the number of words : 17

{to, a, call, å, your, free, 2, for, now, or, txt, ur, on, 4, from , mobile, text}

If $p_w > q_w * 10$ and $q_w \neq 0$. -> the number of words : 9

{å, free, txt, mobile, text, stop, 1, reply, www}

```

p_num = 0
q_num = 0
p_w = 1.0
q_w = 1.0
p_total = 1.0
q_total = 1.0
r_w = 0.0
spam_my_words={}
for word, freq in sorted(spam_dominant_words.items(), key=lambda x:
x[1], reverse=True):
    p_num = spam_words[word] #the frequency of word in spam message
    q_num = non_spam_words[word]#the frequency of word in non-spam message

```

```

if q_num !=0:
    p_w = p_num / spam_count
    q_w = q_num / non_spam_count
    p_total *= p_w
    q_total *= q_w
    r_w = p_total / (p_total + q_total) #Generalized BAYES' Theorem
    if(r_w<1.0):
        spam_my_words[word] = freq
    else :
        break
else:
    continue
print(len(spam_my_words))
print(spam_my_words)

```

15. Refer to the following codes if you think you need.

```

# Function to check if a word is in a message
def is_word_in_message(word, message):
    message = message.lower() # Convert to lowercase
    words = set(re.findall(r'\b\w+\b', message)) # Extract words and
convert to a set
    return word in words

```

```

# Specify the word to search for
search_word = 'free'.lower() # Replace with your specific word

# Filter spam messages
spam_messages = df[df['Label'] == 'spam']['Message']

# Count how many spam messages contain the word
count = sum(is_word_in_message(search_word, message) for message in
spam_messages)

# Print the result
print(f"The word '{search_word}' appears in {count} spam messages.")

```

16. **Question 5:** Using the multi-words filtering method covered in the class, implement a function that determines if a given input message is a spam or not. (Suppose the decision threshold is set to 90%.)

Your answer here

```

def create_word_frequency_dict(words): #Remove the duplicated words and
calculate the number of words
    word_frequency_dict = {}

```

```

    for word in words:
        if word in word_frequency_dict:
            word_frequency_dict[word] += 1
        else:
            word_frequency_dict[word] = 1

    return word_frequency_dict

def make_filter():
    p_num = 0
    q_num = 0
    p_w = 0.0
    q_w = 0.0
    p_total = 1.0
    q_total = 1.0
    r_w = 0.0
    spam_my_words={}
    for word, freq in sorted(spam_dominant_words.items(), key=lambda x:
x[1], reverse=True):
        p_num = spam_words[word] #the frequency of word in spam message
        q_num = non_spam_words[word] #the frequency of word in non-spam
message
        if q_num !=0:
            p_w = p_num / spam_count
            q_w = q_num / non_spam_count
            p_total *= p_w
            q_total *= q_w
            r_w = p_total / (p_total + q_total) #Generalized BAYES' Theorem
            if(r_w<1.0):
                spam_my_words[word] = freq
            else :
                break

        else:
            continue

    return spam_my_words

def is_spam(input_message):
    spam_my_words = make_filter() #make your spam-filter based on BAYES'
Theorem

    p_num = 0

```

```

q_num = 0
p_w = 0.0
q_w = 0.0
p_total = 1.0
q_total = 1.0
r_w = 0.0

for word in word_frequency_dict.keys():
    if word in spam_my_words:
        p_num = sum(is_word_in_message(word, message) for message in
spam_messages)
        q_num = sum(is_word_in_message(word, message) for message in
non_spam_messages)
        p_w = p_num / spam_count
        q_w = q_num / non_spam_count
        p_total *= p_w
        q_total *= q_w
    else:
        continue

    r_w = p_total / (p_total + q_total) #Generalized BAYES' Theorem
    print(word, p_total, q_total, r_w)
return r_w > 0.9

input_message = input() #enter your specific message

# Tokenize the input message
tokenized_words = tokenize(input_message)

# Create a dictionary of word frequencies
word_frequency_dict = create_word_frequency_dict(tokenized_words)

if(is_spam(input_message)):
    print(input_message+" is spam message.")
else:
    print(input_message+" is not spam message.")

-----
The result :
Input message : "I'm at work. Please call"
word = "call"
p_total = 0.4390896921017403

```

```
q_total = 0.04580310880829015
r_w = 0.9055397219296133
```

```
I'm at work. Please call
call 0.4390896921017403 0.04580310880829015 0.9055397219296133
I'm at work. Please call is spam message.
```

17. **Question 6**: Change the number of words you used and test the performance.

Your answer here

I tested through two scenarios in three situations with different word counts.

Spam messages and non-spam messages given as the first data were tested to see if they were recognized correctly again.

As the number of words decreased, the number of messages misidentified as non-spam increased, but the number of messages misidentified as spam decreased.

Scenario 1: Check the number of messages that are spam messages based on the number of words but are output as non-spam messages

Using the next code

```
count=1
for input_message in spam_messages:
    # Tokenize the input message
    tokenized_words = tokenize(input_message)
    # Create a dictionary of word frequencies
    word_frequency_dict = create_word_frequency_dict(tokenized_words)

    if(is_spam(input_message)==False):
        print(count, input_message+" is non-spam message.")
        count+=1
```

If $p_m > q_m * 1$ and $p_m > 0.1$: -> The number of spam_mywords: 20

The number of messages incorrectly identified as non-spam messages when doing this: 47

1 SMS. ac Sptv: The New Jersey Devils and the Detroit Red Wings play Ice Hockey. Correct or Incorrect? End? Reply END SPTV is non-spam message.
2 Did you hear about the new 'Divorce Barbie'? It comes with all of Ken's stuff! is non-spam message.
3 Are you unique enough? Find out from 30th August. www.areyouunique.co.uk is non-spam message.
4 100 dating service call: 1 09064012103 box314x38ch is non-spam message.
5 SMS. ac sun819 posts: HILLO! You seem cool. is non-spam message.
6 08714712388 between 10am-7pm Cost 10p is non-spam message.
7 Do you realize that in about 40 years, we'll have thousands of old ladies running around with tattoos? is non-spam message.
8 SMS SERVICES. for your inclusive text credits, pls goto www.comuk.net login= 3qxj9 unsubscribe with STOP, no extra charge. help 08702840625.COMUK. 220-CH2 9AR is non-spam message.
9 18 days to Euro2004 kickoff! U will be kept informed of all the latest news and results daily. Unsubscribe send GET EURO STOP to 83222. is non-spam message.
10 Thank you, winner notified by sms. Good Luck! No future marketing reply STOP to 84122 customer services 08450542832 is non-spam message.
11 Win the newest J.K. Rowling's Harry Potter and the Order of the Phoenix (Book 5) reply HARRY, answer 5 questions - chance to be the first among readers! is non-spam message.
12 Bought one ringtone and now getting texts costing 3 pound offering more tones etc is non-spam message.
13 Hi its LUCY Bubby at meetins all day Fri & I will B alone at hotel U fancy cumin over? Pls leave msg 2day 09099726395 Lucy x Calls&1/minMobsmoreLKP080X117HP51FL is non-spam message.
14 SMS. ac JSc0: Energy is high, but u may not know where 2channel it. 2day ur leadership skills r strong. Psychic? Reply AMS w/question. End? Reply END JSC0 is non-spam message.
15 Eerie Nokia tones 4u, rply TONE TITLE to 8007 eg TONE DRACULA to 8007 Titles: GHOST, ADDAMSFA, MUNSTERS, EXORCIST, TWILIGHT www.getzed.co.uk POBox36504W45WQ 150p is non-spam message.
16 OASNETWORKS allow companies to bill for SMS, so they are responsible for their 'suppliers' is non-spam message.
17 Would you like to see my XXX pics they are so hot they were nearly banned in the uk! is non-spam message.
18 Eerie Nokia tones 4u, rply TONE TITLE to 8007 eg TONE DRACULA to 8007 Titles: GHOST, ADDAMSFA, MUNSTERS, EXORCIST, TWILIGHT www.getzed.co.uk POBox36504W45WQ 150p is non-spam message.
19 Hi ya babe x u 4goten bout me? scammers getting smart...Though this is a regular vodafone no, if you respond you get further prem rate msg/subscription. Other nos used also. Beware! is non-spam message
20 88066 FROM 88066 LOST 3POUND HELP is non-spam message.
21 Text82228>> Get more ringtones, logos and games from www.txt82228.com. Questions: info@txt82228.co.uk is non-spam message.
22 This message is brought to you by GWM Ltd. and is not connected to the is non-spam message.
23 18 days to Euro2004 kickoff! U will be kept informed of all the latest news and results daily. Unsubscribe send GET EURO STOP to 83222. is non-spam message.
24 FreeMsg>FAV XMAS TONES!Reply REAL is non-spam message.
25 Adult 18 Content Your video will be with you shortly is non-spam message.
26 Do you ever notice that when you're driving, anyone going slower than you is an idiot and everyone driving faster than you is a maniac? is non-spam message.
27 Good Luck! Draw takes place 28th Feb 06. Good Luck! For removal send STOP to 87239 customer services 08708034412 is non-spam message.
28 Dear Voucher Holder, To claim this weeks offer, at you PC please go to <http://www.e-tip.co.uk/reward>. T&Cs apply. is non-spam message.
29 RCT' TENG Adrian for U text. Rgds Vatian is non-spam message.
30 LIFE has never been this much fun and great until you came in. You made it truly special for me. I won't forget you! enjoy 8 one gbp/sms is non-spam message.
31 norothykiefex.com (Bank of Granite issues Strong-Buy) EXPLOSIVE PICK FOR OUR MEMBERS *****UP OVER 300% ***** Nasdaq Symbol CDGT That is a \$5.00 per.. is non-spam message.
32 Text BANANAS to 946 to see! cost 15p textoperator g696gs 18 XXX is non-spam message.
33 You can stop further club tones by replying LSTOP MIX\ See my-tone.com/enjoy. html for terms. Club tones cost GBP4.50/week. MPL is non-spam message.
34 2/2 146tf150p is non-spam message.
35 Win the newest J.K. Rowling's Harry Potter and the Order of the Phoenix (Book 5) reply HARRY, answer 5 questions - chance to be the first among readers! is non-spam message.
36 RingtonesKing 84484 is non-spam message.
37 (Bank of Granite issues Strong-Buy) EXPLOSIVE PICK FOR OUR MEMBERS *****UP OVER 300% ***** Nasdaq Symbol CDGT That is a \$5.00 per.. is non-spam message.
38 You will be receiving this week's Triple Echo ringtone shortly. Enjoy it! is non-spam message.
39 Kit Strip - you have been billed 150p. Netcollex Ltd. PO Box 1013 IG11 0JA is non-spam message.
40 Want explicit SEX in 30 sec? Ring 02073162414 now! Costs 20p/min is non-spam message.
41 Money I have won winning number 946 wot do i do next is non-spam message.
42 Sunshine Quiz! Win a super Sony DVD recorder if you canname the capital of Australia! to Text MQUIZ to 82277. B is non-spam message.
43 [Cashbin.co.uk](http://cashbin.co.uk) (Get lots of cash this weekend!) www.cashbin.co.uk Dear Welcome to the weekend We have got our biggest and best EVER cash give away!! These.. is non-spam message.
44 Check Out Choose Your Babe Videos @ sms.shsex.net/Net/fgk1p0PWfgk1p0 is non-spam message.
45 The current leading bid is 151. To pause this auction send OUT. Customer Care: 08718726270 is non-spam message.
46 <http://tms.widelive.com/index.vml?id=820554ad0a1705572711&first=true&AC=C> Ringtones4 is non-spam message.
47 Want explicit SEX in 30 sec? Ring 02073162414 now! Costs 20p/min Gsex POBOX 2667 WC1N 3XX is non-spam message.

If $p_m > q_m * 2$ and $p_m > 0.1$: -> The number of spam_dominant_words: 17
The number of messages incorrectly identified as non-spam messages when doing this: 48

1 SMS. ac Sptv: The New Jersey Devils and the Detroit Red Wings play Ice Hockey. Correct or Incorrect? End? Reply END SPTV is non-spam message.
2 Did you hear about the new 'Divorce Barbie'? It comes with all of Ken's stuff! is non-spam message.
3 Are you unique enough? Find out from 30th August. www.areyouunique.co.uk is non-spam message.
4 100 dating service call: 1 09064012103 box314x38ch is non-spam message.
5 SMS. ac sun819 posts: HILLO! You seem cool. is non-spam message.
6 08714712388 between 10am-7pm Cost 10p is non-spam message.
7 Do you realize that in about 40 years, we'll have thousands of old ladies running around with tattoos? is non-spam message.
8 You have an important customer service announcement from PREMIER. is non-spam message.
9 U were outbid by almontanid129 on the Shinoe DVD Plyr. 2 bid again, visit ms.ac/twarcrows 2 and bid notifications, reply END OUT is non-spam message.
10 18 days to Euro2004 kickoff! U will be kept informed of all the latest news and results daily. Unsubscribe send GET EURO STOP to 83222. is non-spam message.
11 Thank you, winner notified by sms. Good Luck! No future marketing reply STOP to 84122 customer services 08450542832 is non-spam message.
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15 SMS. ac JSc0: Energy is high, but u may not know where 2channel it. 2day ur leadership skills r strong. Psychic? Reply AMS w/question. End? Reply END JSC0 is non-spam message.
16 Eerie Nokia tones 4u, rply TONE TITLE to 8007 eg TONE DRACULA to 8007 Titles: GHOST, ADDAMSFA, MUNSTERS, EXORCIST, TWILIGHT www.getzed.co.uk POBox36504W45WQ 150p is non-spam message.
17 OASNETWORKS allow companies to bill for SMS, so they are responsible for their 'suppliers' is non-spam message.
18 Would you like to see my XXX pics they are so hot they were nearly banned in the uk! is non-spam message.
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21 88066 FROM 88066 LOST 3POUND HELP is non-spam message.
22 Text82228>> Get more ringtones, logos and games from www.txt82228.com. Questions: info@txt82228.co.uk is non-spam message.
23 This message is brought to you by GWM Ltd. and is not connected to the is non-spam message.
24 Hello darling how are you today? I would love to have a chat, why dont you tell me what you look like and what you are in to sexy? is non-spam message.
25 18 days to Euro2004 kickoff! U will be kept informed of all the latest news and results daily. Unsubscribe send GET EURO STOP to 83222. is non-spam message.
26 FreeMsg>FAV XMAS TONES!Reply REAL is non-spam message.
27 Adult 18 Content Your video will be with you shortly is non-spam message.
28 Do you ever notice that when you're driving, anyone going slower than you is an idiot and everyone driving faster than you is a maniac? is non-spam message.
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30 Dear Voucher Holder, To claim this weeks offer, at you PC please go to <http://www.e-tip.co.uk/reward>. T&Cs apply. is non-spam message.
31 LIFE has never been this much fun and great until you came in. You made it truly special for me. I won't forget you! enjoy 8 one gbp/sms is non-spam message.
32 norothykiefex.com (Bank of Granite issues Strong-Buy) EXPLOSIVE PICK FOR OUR MEMBERS *****UP OVER 300% ***** Nasdaq Symbol CDGT That is a \$5.00 per.. is non-spam message.
33 You can stop further club tones by replying LSTOP MIX\ See my-tone.com/enjoy. html for terms. Club tones cost GBP4.50/week. MPL is non-spam message.
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39 Kit Strip - you have been billed 150p. Netcollex Ltd. PO Box 1013 IG11 0JA is non-spam message.
40 RCTPT 1/3. You have ordered a Ringtone. Your order is being processed... is non-spam message.
41 Money I have won winning number 946 wot do i do next is non-spam message.
42 Sunshine Quiz! Win a super Sony DVD recorder if you canname the capital of Australia! to Text MQUIZ to 82277. B is non-spam message.
43 [Cashbin.co.uk](http://cashbin.co.uk) (Get lots of cash this weekend!) www.cashbin.co.uk Dear Welcome to the weekend We have got our biggest and best EVER cash give away!! These.. is non-spam message.
44 Check Out Choose Your Babe Videos @ sms.shsex.net/Net/fgk1p0PWfgk1p0 is non-spam message.
45 The current leading bid is 151. To pause this auction send OUT. Customer Care: 08718726270 is non-spam message.
46 Latest News! Police station toilet stolen, cops have nothing to go on! is non-spam message.
47 <http://tms.widelive.com/index.vml?id=820554ad0a1705572711&first=true&AC=C> Ringtones4 is non-spam message.
48 Want explicit SEX in 30 sec? Ring 02073162414 now! Costs 20p/min Gsex POBOX 2667 WC1N 3XX is non-spam message.

If $p_m > q_m * 10$ and $p_m > 0.1$: -> The number of spam_dominant_words: 9
The number of messages incorrectly identified as non-spam messages when doing this: 165

```
156 Camera - You are awarded a SiPix Digital Camera! call 09061221066 from landline. Delivery within 28 days. is non-spam message.
157 IMPORTANT MESSAGE. This is a final contact attempt. You have important messages waiting out our customer claims dept. Expires 13/4/04. Call 08717507382 NOW! is non-spam messa
158 The current leading bid is 151. To pause this auction send OUT. Customer Care: 08718726270 is non-spam message.
159 Santa Calling! Would your little ones like a call from Santa Xmas eve? Call 09058094583 to book your time. is non-spam message.
160 Latest News! Police station toilet stolen, cops have nothing to go on! is non-spam message.
161 http://ms.widelive.com/index.wml?id=828554&cd=0&1705572711&first=true&MC C Ringtone&A is non-spam message.
162 PRIVATE! Your 2003 Account Statement for 07808247860 shows 800 un-redeemed S. I. M. points. Call 08719899229 Identifier Code: 40411 Expires 06/11/04 is non-spam message.
163 You are awarded a SiPix Digital Camera! call 09061221066 from landline. Delivery within 28days. 7 Cs Box177, M221BP. 2yr warranty. 150ppm. 16 . p páf3.99 is non-spam message.
164 PRIVATE! Your 2003 Account Statement for shows 800 un-redeemed S.I.M. points. Call 08718738001 Identifier Code: 49557 Expires 26/11/04 is non-spam message.
165 Want explicit SEX in 30 secs? Ring 02073162414 now! Costs 20p/min Gsex POBOX 2667 WC1N 3XX is non-spam message.
```

Scenario 2: Check the number of messages that are non-spam messages based on the number of words but are output as spam messages

Using the next code

```
count=1
for input_message in non_spam_messages:
    # Tokenize the input message
    tokenized_words = tokenize(input_message)
    # Create a dictionary of word frequencies
    word_frequency_dict = create_word_frequency_dict(tokenized_words)

    if(is_spam(input_message)==True):
        print(count, input_message+" is spam message.")
        count+=1
```

If $p_m > q_m * 1$ and $p_m > 0.1$: -> The number of spam_dominant_words: 20
The number of messages incorrectly identified as spam messages when doing this: 1164

```
1154 Compliments to you. Was away from the system. How your side. is spam message.
1155 Hey chief, can you give me a bell when you get this. Need to talk to you about this royal visit on the 1st june. is spam message.
1156 I know you are thinkin malaria. But relax, children cant handle malaria. She would have been worse and its gastroenteritis. If she takes enough t
1157 I can't believe how attached I am to seeing you every day. I know you will do the best you can to get to me babe. I will go to teach my class at
1158 Armand says get your ass over to epsilon is spam message.
1159 Have a safe trip to Nigeria. Wish you happiness and very soon company to share moments with is spam message.
1160 Yeh. Indians was nice. Tho it did kane me off a bit he he. We shud go out 4 a drink sometime soon. Mite hav 2 go 2 da works 4 a laugh soon. Love
1161 No. I meant the calculation is the same. That &lt;#> units at &lt;#>. This school is really expensive. Have you started practicing your
1162 Sorry, I'll call later is spam message.
1163 Why don't you wait 'til at least wednesday to see if you get your . is spam message.
1164 The guy did some bitching but I acted like i'd be interested in buying something else next week and he gave it to us for free is spam message.
```

If $p_m > q_m * 2$ and $p_m > 0.1$: -> The number of spam_dominant_words: 17
The number of messages incorrectly identified as spam messages when doing this: 1068

```
1062 Armand says get your ass over to epsilon is spam message.
1063 I'm taking derek &amp; taylor to walmart, if I'm not back by the time you're done just leave the mouse on my desk and I'll text you when priscilla's ready is spam message.
1064 Yeh. Indians was nice. Tho it did kane me off a bit he he. We shud go out 4 a drink sometime soon. Mite hav 2 go 2 da works 4 a laugh soon. Love Pete x x is spam message.
1065 No. I meant the calculation is the same. That &lt;#> units at &lt;#>. This school is really expensive. Have you started practicing your accent. Because its important.
1066 Sorry, I'll call later is spam message.
1067 Why don't you wait 'til at least wednesday to see if you get your . is spam message.
1068 The guy did some bitching but I acted like i'd be interested in buying something else next week and he gave it to us for free is spam message.
```

If $p_m > q_m * 10$ and $p_m > 0.1$: -> The number of spam_dominant_words: 9
The number of messages incorrectly identified as spam messages when doing this: 268

```

259 Guai... If shd haf seen him when he's naughty... If so free today? Can go jogging... is spam message.
260 Aiyo cos i sms i then i neva reply so i wait 4 i to reply lar. I tot i havent finish ur lab wat. is spam message.
261 This is ur face test ( 1 2 3 4 5 6 7 8 9 &lt;#> ) select any number i will tell ur face astrology.... am waiting. quick reply... is spam message.
262 Dunno lei shd b driving lor cos i go sch 1 hr oni. is spam message.
263 So gd got free ice cream... I oso wan... is spam message.
264 If you can make it any time tonight or whenever you can it's cool, just text me whenever you're around is spam message.
265 I want to tell you how bad I feel that basically the only times I text you lately are when I need drugs is spam message.
266 I know you are thinkin malaria. But relax, children cant handle malaria. She would have been worse and its gastroenteritis. If she takes enough to replace her los
267 I'm taking derek & taylor to walmart, if I'm not back by the time you're done just leave the mouse on my desk and I'll text you when priscilla's ready is spam
268 The guy did some bitching but I acted like i'd be interested in buying something else next week and he gave it to us for free is spam message.

```

18. **Question 7:** Analyze(discuss) the advantages and disadvantages of the spam filter method implemented through this assignment.

Your answer here

[Advantages]

1. Identification of Spam-Dominant Words: Your approach identifies words that significantly appear more frequently in spam messages. This can be effective in capturing distinctive characteristics of spam.
2. Bayesian Probability Integration: The incorporation of Bayesian probability provides a principled way to update probabilities based on evidence. This allows the filter to adapt and potentially improve over time.
3. Customization: The filter allows customization of thresholds and conditions for considering a word as spam-dominant. This flexibility allows for tuning based on the characteristics of the data.
4. Iterative Bayesian Probability Calculation: The iterative calculation of Bayesian probabilities for each word, considering both spam and non-spam messages, provides a dynamic and evolving approach to spam detection.

[Disadvantages]

1. Stopping Condition: The decision to stop updating probabilities when the Bayesian probability (r_w) becomes greater than 1.0 may lead to premature termination. It could potentially miss opportunities for refining the filter further.
2. Sensitivity to Thresholds: The effectiveness of the filter may be sensitive to the chosen thresholds and conditions for considering a word as spam-dominant. Fine-tuning these parameters could be challenging.
3. Word Frequency Calculation: The accuracy of the filter heavily depends on the accurate calculation of word frequencies. Errors in tokenization or frequency counting could lead to incorrect probabilities.
4. Limited Feature Set: The filter relies primarily on word frequencies and Bayesian probabilities. Incorporating additional features or more sophisticated machine learning techniques could enhance the filter's performance.
5. Assumption of Independence: The assumption of independence among words may not always hold true in natural language. This can limit the effectiveness of the filter, especially in capturing context or relationships between words.

6. Limited Generalization: Depending on the training data, the filter may have limitations in generalizing to diverse and unseen messages. Overfitting to the training set could be a concern.