13장. 나이브 베이즈 (NaiveBayes) 과제

1. 데이터 읽기

1.1 SpamAssassin 데이터셋 다운 로드

In [1]:

```
from io import BytesIO
import requests
import tarfile
import os
from scratch.machine_learning import split_data

BASE_URL = "https://spamassassin.apache.org/old/publiccorpus/"
FILES = ["20021010_easy_ham.tar.bz2",
         "20021010_hard_ham.tar.bz2",
         "20021010_spam.tar.bz2"]
OUTPUT_DIR = 'spam_data'

if os.path.exists(OUTPUT_DIR) is False:
    for filename in FILES:
        content = requests.get(f"{BASE_URL}/{filename}").content

        fin = BytesIO(content)

        with tarfile.open(fileobj=fin, mode='r:bz2') as tf:
            tf.extractall(OUTPUT_DIR)
```

1.2 메세지 클래스 정의

In [2]:

```
from typing import NamedTuple

class Message(NamedTuple):
    text: str
    is_spam: bool
```

1.3 이메일 본문 디코딩

In [3]:

```
from email.parser import Parser

def decode_email(msg_str):
    p = Parser()
    message = p.parsestr(msg_str)
    decoded_message = ''
    for part in message.walk():
        if part.get_content_type() not in ('text/plain', 'text/html'): continue

        charset = part.get_content_charset()
        part_str = part.get_payload(decode=1)
        try:
            decoded_message += part_str.decode(charset)
        except:
            decoded_message += str(part_str)

    return decoded_message
```

1.3 이메일 텍스트 읽기 (Q)

이메일의 제목과 본문 텍스트를 읽어서 Message 타입을 만들고 데이터 리스트를 생성하시오.

In [4]:

```
import glob
import email
from typing import List
import re

def read_emails(include_body : bool = False) -> List[Message]:
    # modify the path to wherever you've put the files
    path = 'spam_data/*/*'

    data: List[Message] = []
    # glob.glob returns every filename that matches the wildcarded path
    for filename in glob.glob(path):
        is_spam = "ham" not in filename
        # is_spam = "spam" in filename
        # There are some garbage characters in the emails, the errors='ignore'
        # skips them instead of raising an exception.
        with open(filename, errors='ignore') as email_file:
            raw_email = email_file.read()
            msgobj = email.message_from_string(raw_email)
            message = msgobj['Subject'] or ""
            message = message.lower()
            message = message.replace("₩n","")

            body = decode_email(raw_email)
            body1 = body.replace("₩n","")
            bdoy2 = body1.strip('₩n')
            # body = body.lower()
            result = message + body
            # data.append(Message(message, is_spam))

            # data.append(Message(body, is_spam))
            data.append(Message(result, is_spam))


    return data
```

In [5]:

```
include_body = True
data = read_emails(include_body= True)
print("읽은 email 개수 :", len(data))

# print(type(data))
# print(data[30:35])
```

읽은 email 개수 : 3302

2. NLTK 설치 및 테스트

2.1 NLTK설치 및 리소스 다운로드

In [6]:

```
! pip install nltk
```

```
Requirement already satisfied: nltk in c:₩users₩이준용₩.conda₩envs₩data_mining₩lib₩s
ite-packages (3.5)
Requirement already satisfied: click in c:₩users₩이준용₩.conda₩envs₩data_mining₩lib
₩site-packages (from nltk) (7.1.2)
Requirement already satisfied: regex in c:₩users₩이준용₩.conda₩envs₩data_mining₩lib
₩site-packages (from nltk) (2020.10.15)
Requirement already satisfied: tqdm in c:₩users₩이준용₩.conda₩envs₩data_mining₩lib₩s
ite-packages (from nltk) (4.50.2)
Requirement already satisfied: joblib in c:₩users₩이준용₩.conda₩envs₩data_mining₩lib
₩site-packages (from nltk) (0.17.0)
```

In [7]:

```
import nltk
nltk.download()
```

```
showing info https://raw.githubusercontent.com/nltk/nltk_data/gh-pages/index.xml (ht
tps://raw.githubusercontent.com/nltk/nltk_data/gh-pages/index.xml)
```

Out[7]:

```
True
```

2.1 단어 토큰화 및 어간 추출 테스트

단어 토큰화

In [8]:

```
from nltk.tokenize import TreebankWordTokenizer
text="This was not the map we found in Billy Bones's chest, but an accurate copy, complete in all th
tokenizer=TreebankWordTokenizer()
words = tokenizer.tokenize(text)
print("tokens : ", words)
```

```
tokens :  ['This', 'was', 'not', 'the', 'map', 'we', 'found', 'in', 'Billy', "Bone
s's", 'chest', ',', 'but', 'an', 'accurate', 'copy', ',', 'complete', 'in', 'all',
'things', '--', 'names', 'and', 'heights', 'and', 'soundings', '--', 'with', 'the',
'single', 'exception', 'of', 'the', 'red', 'crosses', 'and', 'the', 'written', 'note
s', '.']
```

불용어

In [9]:

```
from nltk.corpus import stopwords
stopwords_set = set(stopwords.words('english'))
print("stopwords : ", stopwords_set)
```

```
stopwords :  {'doing', 'after', 'are', "doesn't", 'was', 'most', 'being', 'i', 'by',
'out', 't', 'hasn', 'his', 'once', "you'd", 'between', 'such', 'which', 'm', "were
n't", 'in', 'for', "don't", 'ours', 'those', 'y', "she's", 'll', 'isn', 'only', 'mig
htn', 'my', 'if', 'needn', 'through', 'shan', 'you', 'whom', "aren't", 'do', "have
n't", 'each', 'too', 'nor', 'myself', 'from', 'then', 'him', 'what', 've', 'more',
"mightn't", 'haven', 'ourselves', 'that', 'these', 'up', 'me', 'as', 'further', 'no
w', "that'll", 'didn', "you're", 'does', 'couldn', 'under', 'and', 'this', 'not', 'i
ts', 'because', 'herself', 'same', 'than', 'have', 'an', 'ma', 'she', 'some', 'unti
l', 'has', 'having', 'own', "needn't", 'be', 'before', 'am', 'he', 'other', "shoul
d've", 'above', 'the', "you'll", 'again', 'both', 'a', 'there', "won't", 'o', "sha
n't", 'yours', 'our', "hadn't", 'to', 'is', 's', 'about', 'so', "wasn't", 'their',
"you've", 'but', 'wouldn', 'did', 'off', 'should', 'will', 'mustn', "wouldn't", 'whe
n', 'won', 'where', 'can', 'shouldn', 'how', 'theirs', 'it', 'over', 'we', 'itself',
'at', 'few', 'any', "didn't", 'who', 'very', 'of', 'down', "it's", 'd', 'they', 'you
rself', 'during', "hasn't", 'below', 'doesn', "mustn't", 'hers', 'with', 'just', 'ai
n', 'here', 'into', 'aren', 'her', "isn't", "shouldn't", 'yourselves', 'why', 'on',
'weren', 'against', 'don', 'were', 'themselves', 're', 'all', "couldn't", 'been', 'h
imself', 'them', 'your', 'had', 'while', 'wasn', 'no', 'hadn', 'or'}
```

어간 추출

In [10]:

```
from nltk.stem import PorterStemmer
s = PorterStemmer()
stem_words = [s.stem(w) for w in words]
print("stem tokens : ", len(stem_words), stem_words)
print("")
stem_words_wo_stopwords = [s.stem(w) for w in words if w not in stopwords_set]
print("stem tokens without stopwords: ",
      len(stem_words_wo_stopwords),
      stem_words_wo_stopwords)
```

```
stem tokens :  41 ['thi', 'wa', 'not', 'the', 'map', 'we', 'found', 'in', 'billi',
"bones'", 'chest', ',', 'but', 'an', 'accur', 'copi', ',', 'complet', 'in', 'all',
'thing', '--', 'name', 'and', 'height', 'and', 'sound', '--', 'with', 'the', 'sing
l', 'except', 'of', 'the', 'red', 'cross', 'and', 'the', 'written', 'note', '.']

stem tokens without stopwords:  24 ['thi', 'map', 'found', 'billi', "bones'", 'ches
t', ',', 'accur', 'copi', ',', 'complet', 'thing', '--', 'name', 'height', 'sound',
'--', 'singl', 'except', 'red', 'cross', 'written', 'note', '.']
```

2.3 토큰화 함수 (Q)

Treebank Tokenizer를 사용해서 어간 추출 및 불용어 제거를 해보자.

In [11]:

```
from nltk.tokenize import TreebankWordTokenizer
from nltk.stem import PorterStemmer
from nltk.corpus import stopwords
from typing import Set

def tokenize(text: str) -> Set[str]:
    tokenizer=TreebankWordTokenizer()
    text = tokenizer.tokenize(text)
    stop_words = set(stopwords.words('english'))
    result = []
    for w in text:
        w = w.lower()
        if w not in stop_words:
            if len(w) > 2:
                result.append(w)
    s = PorterStemmer()
    resultword = [s.stem(w) for w in result if w not in stopwords_set]
    words = resultword

    return set(words)                       # remove duplicates.
print(len(tokenize(str(data))))
# print(tokenize(str(data[0:5])))
```

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3. 나이브 베이즈 분류기

3.1 NaiveBayesClassifier (Q)

단어의 최소 빈도수를 설정해서 그 이하로 나오는 단어는 무시하도록 _thresholding_tokens 함수 작성하시오

In [12]:

```
from typing import List, Tuple, Dict, Iterable
import math
from collections import defaultdict
import matplotlib.pyplot as plt

class NaiveBayesClassifier:
    def __init__(self, k: float = 0.5) -> None:
        self.k = k  # smoothing factor

        self.tokens: Set[str] = set()
        self.token_spam_counts: Dict[str, int] = defaultdict(int)
        self.token_ham_counts: Dict[str, int] = defaultdict(int)
        self.spam_messages = self.ham_messages = 0

    def train(self,
              messages: Iterable[Message],
              threshold: int = 0,
              verbos : bool = True) -> None:
        self._count_tokens(messages)
        del_spam_count, del_ham_count = self._thresholding_tokens(messages, threshold)

        if verbos :
            print(del_spam_count, "tokens are deleted in spams ")
            print(del_ham_count, "tokens are deleted in hams ")
            print("spam ", self.spam_messages)
            print("ham ", self.ham_messages)
            print("token", len(self.tokens))
            print("spam token", len(self.token_spam_counts))
            print("ham token", len(self.token_ham_counts))

            print("======= token probabilities ======= ")
            self.print_token_probilities()

    def _count_tokens(self, messages: Iterable[Message]) -> None:
        for message in messages:
            # print(message)
            # Increment message counts
            if message.is_spam:
                self.spam_messages += 1
            else:
                self.ham_messages += 1

            # Increment word counts
            for token in tokenize(message.text):
                if message.is_spam:
                    self.token_spam_counts[token] += 1
                else:
                    self.token_ham_counts[token] += 1
    #    print(len(self.token_spam_counts.items()),len(self.token_ham_counts.items()))
    #    print(self.spam_messages)
      # **********************최소 빈도수 이하 토큰 삭제*****************

    def _thresholding_tokens(self,
                             messages: Iterable[Message],
                             threshold: int = 0) -> Tuple[int, int]:

        self.tokens = [w for w, c in self.token_spam_counts.items()]
        self.tokens = [w for w, c in self.token_ham_counts.items()]
        # print(self.token_spam_counts.items())
```

```
        del_spam_count = len([w for w,c in self.token_spam_counts.items() if c <= 5])
        del_ham_count = len([w for w,c in self.token_ham_counts.items() if c <= 5])


        return del_spam_count, del_ham_count

    def print_token_probilities(self, count=10):
        for token in self.tokens:
            p_token_spam, p_token_ham = self._probabilities(token)
            print(token, "(spam:", p_token_spam, "ham:", p_token_ham, ")")
            count -= 1
            if count == 0 : return

    def token_histogram(self):
        plt.figure(figsize=(15,8))
        plt.subplot(2, 1, 1)
        n, bins, patches = plt.hist(self.token_spam_counts.values(),
                                    200,
                                    facecolor="#2E495E",
                                    edgecolor=(0, 0, 0))
        plt.title("Spam words")
        plt.xlabel("")
        plt.ylabel("Word Count")

        plt.subplot(2, 1, 2)
        n, bins, patches = plt.hist(self.token_ham_counts.values(),
                                    200,
                                    facecolor="#2E495E",
                                    edgecolor=(0, 0, 0))
        plt.title("Ham words")
        plt.xlabel("")
        plt.ylabel("Word Count")

        plt.show()

    def _probabilities(self, token: str) -> Tuple[float, float]:
        """returns P(token | spam) and P(token | not spam)"""
        spam = self.token_spam_counts[token]
        ham = self.token_ham_counts[token]

        p_token_spam = (spam + self.k) / (self.spam_messages + 2 * self.k)
        p_token_ham = (ham + self.k) / (self.ham_messages + 2 * self.k)

        return p_token_spam, p_token_ham

    def token_histogram(self):
        plt.figure(figsize=(15,8))
        plt.subplot(2, 1, 1)
        n, bins, patches = plt.hist(self.token_spam_counts.values(),
                                    200,
                                    facecolor="#2E495E",
                                    edgecolor=(0, 0, 0))
        plt.title("Spam words")
        plt.xlabel("")
        plt.ylabel("Word Count")

        plt.subplot(2, 1, 2)
        n, bins, patches = plt.hist(self.token_ham_counts.values(),
                                    200,
```

```
                                    facecolor="#2E495E",
                                    edgecolor=(0, 0, 0))
        plt.title("Ham words")
        plt.xlabel("")
        plt.ylabel("Word Count")

        plt.show()

    def predict(self, text: str) -> float:
        text_tokens = tokenize(text)
        log_prob_if_spam = log_prob_if_ham = 0.0

        # Iterate through each word in our vocabulary.
        for token in self.tokens:
            prob_if_spam, prob_if_ham = self._probabilities(token)

            # If *token* appears in the message,
            # add the log probability of seeing it;
            if token in text_tokens:
                log_prob_if_spam += math.log(prob_if_spam)
                log_prob_if_ham += math.log(prob_if_ham)

            # otherwise add the log probability of _not_ seeing it
            # which is log(1 - probability of seeing it)
            else:
                log_prob_if_spam += math.log(1.0 - prob_if_spam)
                log_prob_if_ham += math.log(1.0 - prob_if_ham)

        prob_if_spam = math.exp(log_prob_if_spam)
        prob_if_ham = math.exp(log_prob_if_ham)
        try :
            posterior = prob_if_spam / (prob_if_spam + prob_if_ham)
        except ZeroDivisionError:
            posterior = 0

        return posterior
```

3.2 모델 훈련

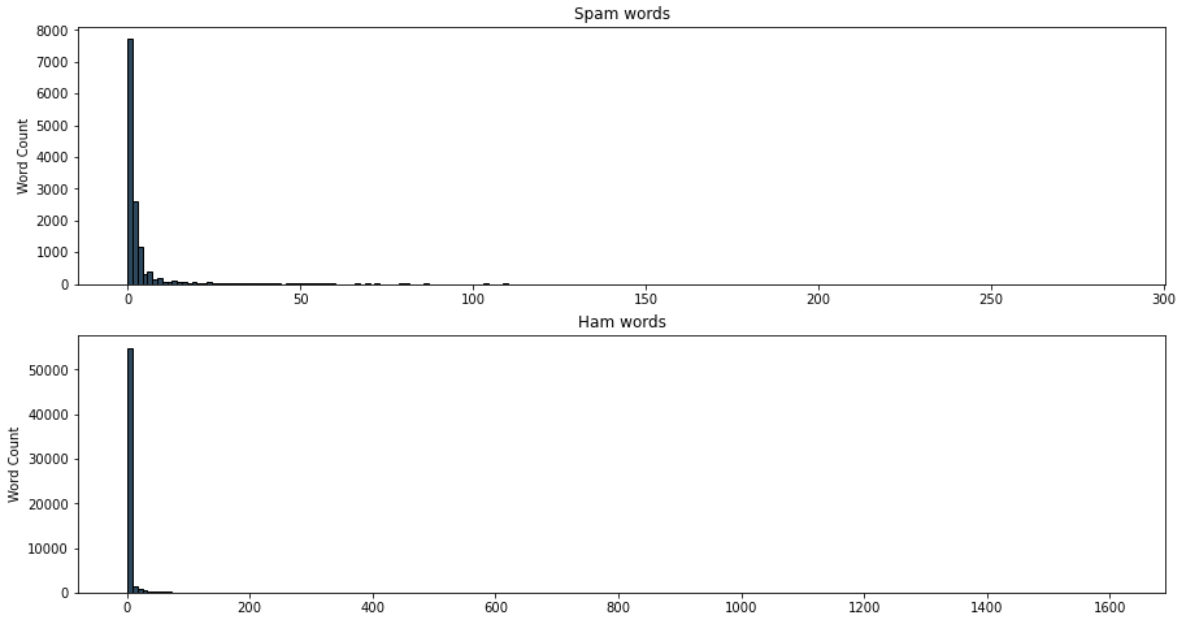
In [13]:

```
import random
from scratch.machine_learning import split_data

random.seed(0)      # just so you get the same answers as me
train_messages, test_messages = split_data(data, 0.75)
model = NaiveBayesClassifier()

model.train(train_messages,15)
model.token_histogram()
```

```
11800 tokens are deleted in spams
52719 tokens are deleted in hams
spam  371
ham  2105
token 58928
spam token 13513
ham token 58928
======= token probabilities =======
seem (spam: 0.028225806451612902 ham: 0.14506172839506173 )
sell (spam: 0.10080645161290322 ham: 0.07003798670465337 )
follow (spam: 0.18413978494623656 ham: 0.08000949667616335 )
juli (spam: 0.006720430107526882 ham: 0.04249762583095917 )
noth (spam: 0.05779569892473118 ham: 0.057692307692307696 )
said (spam: 0.04973118279569892 ham: 0.13509021842355176 )
evolv (spam: 0.0013440860215053765 ham: 0.011158594491927826 )
sinc (spam: 0.06854838709677419 ham: 0.11419753086419752 )
'thou (spam: 0.0013440860215053765 ham: 0.0011870845204178537 )
speaker (spam: 0.004032258064516129 ham: 0.0097340930674264 )
```



3.3 예측 및 성능 평가

예측

In [14]:

```
from collections import Counter

predictions = [(message, model.predict(message.text))
               for message in test_messages]
```

혼동 행렬

In [15]:

```
# Assume that spam_probability > 0.5 corresponds to spam prediction
# and count the combinations of (actual is_spam, predicted is_spam)
confusion_matrix = Counter((message.is_spam, spam_probability > 0.5)
                           for message, spam_probability in predictions)

print(confusion_matrix)
```

```
Counter({(False, False): 694, (True, True): 70, (True, False): 60, (False, True):
2})
```

정확도, 정밀도, 재현율 F1점수 (Q)

혼동 행렬 결과를 이용해서 정확도, 정밀도, 재현율 F1점수를 계산해 보시오.

In [16]:

```
from scratch.machine_learning import accuracy, precision, recall, f1_score
tp = confusion_matrix.get((True, True))
tn = confusion_matrix.get((False,False))
fp = confusion_matrix.get((True, False))
fn = confusion_matrix.get((False, True))

print("accuracy :",accuracy(tp,fp,fn,tn))
print("precision :",precision(tp,fp,fn,tn))
print("recall :", recall(tp,fp,fn,tn))
print("f1_score :", f1_score(tp,fp,fn,tn))
```

```
accuracy : 0.9249394673123487
precision : 0.5384615384615384
recall : 0.9722222222222222
f1_score : 0.693069306930693
```

3.4 스팸과 햄을 대표하는 단어 확인

In [17]:

```
def p_spam_given_token(token: str, model: NaiveBayesClassifier) -> float:
    # We probably shouldn't call private methods, but it's for a good cause.
    prob_if_spam, prob_if_ham = model._probabilities(token)

    return prob_if_spam / (prob_if_spam + prob_if_ham)

words = sorted(model.tokens, key=lambda t: p_spam_given_token(t, model))

print("spammiest_words", words[-10:])
print("hammiest_words", words[:10])
```

```
spammiest_words ['bordercolordark=', 'transaction.', '111111', 'mailings.', '00006
6', 'opt-out', '000080', "type='hidden", 'content-languag', 'border-collaps']
hammiest_words ['wrote', 'freshrpms.net', 'rpm-list', '//lists.freshrpms.net/mailma
n/listinfo/rpm-list', 'aug', 'rpm', 'satalk', 'matthia', 'spamassassin', 'spambay']
```

In [ ]:

```
```