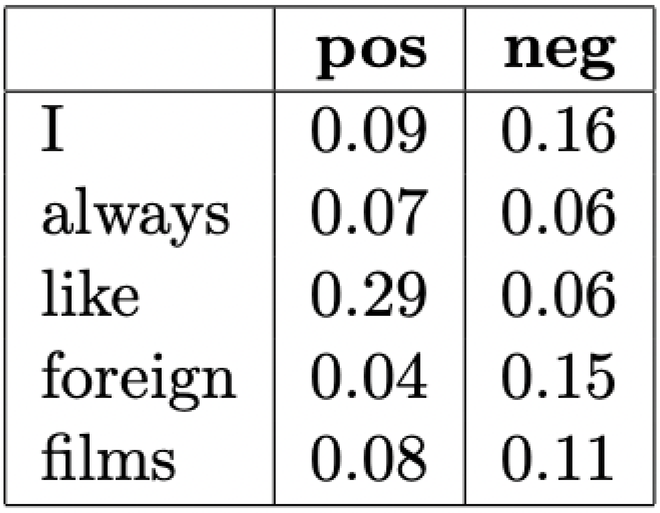
Naive Bayes Classifier

1. Question: What class will Naıve Bayes assign to the sentence “I always like foreign films”? Show your work.



	pos	neg
I	0.09	0.16
always	0.07	0.06
like	0.29	0.06
foreign	0.04	0.15
films	0.08	0.11

```
p( + | I, always, like, foreign, films) = p(+) * p(I, always, like, foreign, films | + )
                                        = p(+) * p( I | + ) * p( always | + ) * p( like | + ) * p( foreign | + ) * p( films | + )
                                        = 0.4 * 0.09 * 0.07 * 0.29 * 0.04 * 0.08
                                        = 2.33856 * 10^(-6)


p( - | I, always, like, foreign, films) = p(-) * p(I, always, like, foreign, films | - )
                                        = p(-) * p( I | - ) * p( always | - ) * p( like | - ) * p( foreign | - ) * p( films | - )
                                        = 0.6 * 0.16 * 0.06 * 0.06 * 0.15 * 0.11
                                        = 5.7024 * 10^(-6)

By comparing the result of above two expressions, we find the probability of negative is higher. Therefore, the class negative will be assigned to the sentence.
```

2a. Train Naive Bayes Classifier

Preprocessing

The file `pre_process.py` preprocess files, converting them into vectors and save them into one file.

The function below is used for preprocessing. It takes a few parameter

- `folder_path1` is the folder of files that has class `path1_class`, same applies to `folder_path2`
- `vocab_path` is the file that contains vocabulary
- `output_path` is the file to save the label and feature vector of each comment

The output file uses string `#####` as column separator since json string contains many space character.

An example of a line in output is `neg#####JSON of BOW#####1#####0`

```
preprocess(folder_path1="./data/train/pos",
               folder_path2="./data/train/neg",
               vocab_path="./data/imdb.vocab",
               path1_class="pos",
               path2_class="neg",
               output_path="./preprocessed/movie_review_BOW.txt"
               )
```

Feature Vector

Feature vector has three columns

- First is the BOW feature store as json to save space
- Second is 1 if it contains strong positive word else 0
- Third is 1 if it contains strong negative word else 0

The effect of the second and third feature in training stage is adding more weight to the words in vector if the vector is a positive class and contains strong positive words, or is a negative class and contains strong negative words, and subtracting weight to the words in a vector if it is a positive class but contains strong negative words.

These strong words are

```
positive_words = {'excellent', 'amazing', 'great', 'fantastic',
'outstanding', 'terrific', 'phenomenal', 'superb', 'brilliant',
'impressive'}

negative_words = {'disappointing', 'terrible', 'awful', 'horrible',
'dreadful', 'abysmal', 'appalling', 'atrocious', 'repulsive',
'disgusting'}
```

The function that dynamically adds weight or decrease weight is

```
def aggregate_vector_into_counter(counter: dict, vector: dict, class_type,
contains_strong_pos_word, contains_strong_neg_word):
    total_token = 0
    for word, freq in vector.items():
        counter[word] += freq
        total_token += freq

    if class_type == 'pos' and contains_strong_pos_word or class_type ==
'neg' and contains_strong_neg_word:
        for word, freq in vector.items():
            counter[word] += 10
            total_token += 10
    else:
        for word, freq in vector.items():
            if counter[word] > 10:
                counter[word] -= 10
                total_token -= 10
            else:
                total_token -= counter[word]
                counter[word] = 0
    return total_token
```

Naive Bayes

The file `naive_bayes.py` trains and evaluate comments.

The function `naive_bayes()` trains the classifier. It takes a few parameters

- `training_file_path` the file of preprocessed file
- `result_model_path` the path of model to be saved at
- `class_1` and `class_2` tells model trainer the labels or classes it have
- `vocab_path` is the file that contains vocabulary

```
naive_bayes(training_file_path="./preprocessed/movie_review_BOW.txt",
                result_model_path="./models/movie_review_BOW.NB",
                class_1="pos",
                class_2="neg",
                vocab_path="./data/imdb.vocab",
                )
```

The class `NaiveBayesClassifier`

- Parameter
    - `path_to_model` the location where the model is saved at, and `NaiveBayesClassifier` loads it by itself
- Function `classify(comment)`
    - preprocess the `comment` by lowercase and separate punctuation, then tokenize the sentence into a list
    - calculate the probability of class `neg` and `pos`
    - return a class or label that has higher probability

- also noticeable that probability is calculated using a class of `Decimal` in package `decimal` because float has a precision of 1e-300 and the probability of each comment is often lower than that

2b. Use the following small corpus of movie reviews to train your classifier. Save the parameters of your model in a file called movie-review-small.NB

```
i. fun, couple, love, love comedy
ii. fast, furious, shoot action
iii. couple, fly, fast, fun, fun comedy
iv. furious, shoot, shoot, fun action
v. fly, fast, shoot, love action
```

```
Vocabs: {fun, couple, love, fast, furious, shoot, fly}
|Vocabs| = 7    comedy_total_word = 9       action_total_word = 11
p(comedy) = 9/ (9 + 11) = 0.45
p(action) = 11 / (9 + 11) = 0.55

p(fun | comedy) = (3 + 1) / (9 + 7) = 4/16              p(fun | action) =
(1 + 1) / (11 + 7) = 2/18
p(couple | comedy) = (2 + 1) / (9 + 7) = 3/16           p(couple | comedy)
= (0 + 1) / (11 + 7) = 1/18
p(love | comedy) = (2 + 1) / (9 + 7) = 3/16             p(love | action) =
(1 + 1) / (11 + 7) = 2/18
p(fast | comedy) = (1 + 1) / (9 + 7) = 2/16             p(fast | action) =
(2 + 1) / (11 + 7) = 3/18
p(furious | comedy) = (0 + 1) / (9 + 7) = 1/16          p(furious |
action) = (2 + 1) / (11 + 7) = 3/18
p(shoot | comedy) = (0 + 1) / (9 + 7) = 1/16            p(shoot | action)
= (4 + 1) / (11 + 7) = 5/18
p(fly | comedy) = (1 + 1) / (9 + 7) = 2/16               p(fly | action) =
(1 + 1) / (11 + 7) = 2/18
```

The code that solves this problem.

preprocess() uses file at "vocab_path" as the set of vocabulary, reads all file in the folder "folder_path1" and "folder_path2", preprocess all files in the folders, and save the feature vectors to file "output_path" in format "class_type#####json_vector_representation" for each line.

naive_bayes() uses file at "vocab_path" as the set of vocabulary, train the model file at "training_file_path", and save the parameters in json format to file at "result_model_path". The structure of json is provided below.

```
def problem_2b():
    preprocess(folder_path1="./data/movie_review_small/action",
               folder_path2="./data/movie_review_small/comedy",
vocab_path="./data/movie_review_small/movie_review_small.vocab",
               path1_class="action",
               path2_class="comedy",
               output_path="./preprocessed/movie_review_small.txt"
               )


naive_bayes(training_file_path="./preprocessed/movie_review_small.txt",
                result_model_path="models/movie_review_small.NB",
                class_1="action",
                class_2="comedy",

vocab_path="./data/movie_review_small/movie_review_small.vocab",
                )
```

The parameters of the model is saved as a json, and below is the content of the json.

```
{"action":
    {"couple": 0.05555555555555555,
     "shoot": 0.2777777777777778,
     "love": 0.1111111111111111,
     "fly": 0.1111111111111111,
     "fast": 0.16666666666666666,
     "fun": 0.1111111111111111,
     "furious": 0.16666666666666666
     },
 "comedy":
     {"couple": 0.1875,
      "shoot": 0.0625,
      "love": 0.1875,
      "fly": 0.125,
      "fast": 0.125,
      "fun": 0.25,
      "furious": 0.0625
      },
 "action_prior": 0.55,
 "comedy_prior": 0.45,
 "class_1": "action",
 "class_2": "comedy"
}
```

2c. Test you classifier on the new document below: {fast, couple, shoot, fly}. Compute the most likely class. Report the probabilities for each class.

Hand-writing calculation

```
  p(comedy | fast, couple, shoot, fly)
= p(comedy) * p(fast | comedy) * p(couple | comedy) * p(shoot | comedy) *
p(fly | comedy)
```

```
= 9/20 * 2/16 * 3/16 * 1/16 * 2/16
= 0.000082397

  p(action | fast, couple, shoot, fly)
= p(action) * p(fast | action) * p(couple | action) * p(shoot | action) *
p(fly | action)
= 11/20 * 3/18 * 1/18 * 5/18 * 2/18
= 0.000157179

p(action | fast, couple, shoot, fly) > p(comedy | fast, couple, shoot,
fly)
0.000157179 > 0.000082397

The document {fast, couple, shoot, fly} will be assign the class: action
```

Code

```
class NaiveBayesClassifier:
    ...
    def classify(self, comment: str):
        comment = preprocess_comment(comment)
        word_list = comment.split()
        class_1_prob = compute_prob(word_list, self.model[self.class_1],
self.model[f"{self.class_1}_prior"])
        class_2_prob = compute_prob(word_list, self.model[self.class_2],
self.model[f"{self.class_2}_prior"])

        print(self.class_1, "probability is", class_1_prob)
        print(self.class_2, "probability is", class_2_prob)

        return self.class_1 if class_1_prob > class_2_prob else
self.class_2

def problem_2c():
    comment = "fast, couple, shoot, fly"
    naive_bayes_classifier =
NaiveBayesClassifier(path_to_model='./models/movie_review_small.NB')
    class_estimation = naive_bayes_classifier.classify(comment)

    print(f"Class of sentence {comment} is: {class_estimation}")
```

Result printed by the trained classifier

```
action probability is 0.00015717878372199936
comedy probability is 8.23974609375e-05
Class of sentence fast, couple, shoot, fly is: action
```

2d. Now use the movie review dataset provided with this homework to train a Naive Bayes classifier for the real task.

Code

```
def problem_2d():
    # preprocess training data and train model
    preprocess(folder_path1="./data/train/pos",
               folder_path2="./data/train/neg",
               vocab_path="./data/imdb.vocab",
               path1_class="pos",
               path2_class="neg",
               output_path="./preprocessed/movie_review_BOW.txt"
               )

    naive_bayes(training_file_path="./preprocessed/movie_review_BOW.txt",
                result_model_path="./models/movie_review_BOW.NB",
                class_1="pos",
                class_2="neg",
                vocab_path="./data/imdb.vocab",
                )

    naive_bayes_classifier =
NaiveBayesClassifier(path_to_model='./models/movie_review_BOW.NB')
    pos_test_folder = './data/test/pos'
    neg_test_folder = './data/test/neg'
    pos_test_files = os.listdir(pos_test_folder)
    neg_test_files = os.listdir(neg_test_folder)

    result = []  # [[estimation, comment],...]
    incorrect = []
    total_est = len(neg_test_files) + len(pos_test_files)

    for file in pos_test_files:
        comment = preprocess_file(file_path=f'{pos_test_folder}/{file}')
        class_est = naive_bayes_classifier.classify(comment)
        result.append(f'{class_est}    {comment}')
        if class_est != 'pos':
            incorrect.append(f'{class_est}    {comment}')

    for file in neg_test_files:
        comment = preprocess_file(file_path=f'{neg_test_folder}/{file}')
        class_est = naive_bayes_classifier.classify(comment)
        result.append(f'{class_est}    {comment}')
        if class_est != 'neg':
            incorrect.append(f'{class_est}    {comment}')

    accuracy = (total_est - len(incorrect)) / total_est
    result.append(f'Accuracy: {accuracy}    Total Estimations: {total_est}
Incorrect Estimations: {len(incorrect)}')
    save_file('\n'.join(result), './report.txt')
    save_file('\n'.join(incorrect), './incorrect.txt')
```

The last line of the report is `Accuracy: 0.78536 Total Estimations: 25000 Incorrect Estimations: 5366`

```
  all , was both unbelievable ( c ' mon , the entire mission gathers to see this
neg    well , this movie actually did have one redeeming quality . it made up th
Accuracy: 0.78536    Total Estimations: 25000    Incorrect Estimations: 5366
```

Note: incorrect.txt is not in the requirement, but I use it to see the incorrect estimations and find intuitions.

One reason that might cause false estimation is a positive comment might use a lot of common word in a negative comment. For example, "not", and "bad". In a sentence like "i can ' t believe people are giving bad reviews", it's obvious a positive comment but the use of words "bad", and "can't" tricked classifier to think it's a bad review.

Some examples of incorrect estimations are:

- `neg` i don ' t understand where these bad comments are coming from . the movie had you on the edge of your seat and made you somewhat afraid to go to your car at the end of the night . < br / > < br / > the part that gets you is that this could all happen . not to the extent perceived in the movie , but the whole idea is reality . this movie took that reality and twisted it into a dee snider nightmare . < br / > < br / > three thumbs up (the third one is from the dead body in my freezer) .
- `neg` i can ' t believe people are giving bad reviews about this movie ! i wonder why . . . . . . maybe because of the book . . . . . i have to admit , it really doesn ' t follow the book . . . for sure . . . the book by dean koontz is much better . . . but the movie is also good as well ! ! ! it has the suspense . . . the acting are good . . . especially michael ironside , whom have given a superb acting in this movie ! ! ! < br / > < br / > come one guyz . . . give this movie a chance . . . there are still lot more worse movie than this . . . . like sum of all fears . . . phantoms . . . the da vinci code . . . this are some of the worse movie i have seen . . . really boring if compared to watchers which really have great elements in the movie . . . this movie contains great suspense and non stop action ! ! ! i ' m looking for this movie . . . but it is really hard to be found on dvd . . . < br / > < br / > by da way . . . i really recommended this movie to everybody . . . watch it ! ! ! ! you will never regret ! ! ! < br / > < br / > 10 / 10 *
- `neg` as talk - shows go , larry king live is not bad , and since he occasionally gets good guests , it ' s a show to turn on once in awhile , but not compulsively . when bill maher , carl bernstein , a former president , or other substantive guests sit across from him , it ' s not too bad . other times , he tends to host guests involved in the latest celebrity scandal which contributes absolutely no intelligent information to the country and feeds a largely uneducated public that wants to hear the latest gossip about movie and tv stars . during the oj simpson trial , it seemed like every other guest on his show was related to the case . but is this really journalism ? or the national enquirer on the tube ? sometimes , it comes off a little bit like trash television - - jerry springer in a sit down interview with phone calls instead of a live audience . < br / > < br / > on the other side , king ' s show is definitely much better than bill o ' reilly whose show is nothing more than a rightest - political platform of the rush limbaugh variety . that said , larry king is not a bad interviewer , but alas , he is not a great one . king does not always come off like he completely comprehends when intellectual material is being presented , especially if it is by a scholar or historian with a new book on subtle aspects of politics . always seems like the minute king can ' t quite deal with the issue at hand , that ' s when he turns to the phone calls , maybe hoping someone out in the country will have a better question than he has .

he might interview someone like david gergen , but may not have read any of his books . sort of like the movie producer that never bothers to read the script . < br / > < br / > when it ' s an entertainment celebrity , no problem . he can come off like he ' s thoroughly knowledgeable since the material is not that substantive anyway . talking to elizabeth taylor about her relationship with richard burton is not exactly rocket science . and i notice he usually has seen the star ' s latest movie . watching a movie takes much less time and contemplation than reading a book . however , if it ' s the likes of john dean or bob woodward , king comes off a little like he didn ' t quite finish his homework . so off to the phones . < br / > < br / > if you are looking for real in - depth interviewing , terry gross of npr is probably the best interviewer in the united states . she reads and / or researches everything written by or about her guests beforehand and has a working knowledge of those areas . i don ' t see king quite doing that . granted , he probably has an audience 1000 times larger than terry gross , which may say more about the american audience than king . in short , larry is better than bill but not as good as terry .

- pos while it was nice to see a film about older people finding each other and falling in love and the performances by andrews and garner were not bad , this picture poured on the sapp and schmaltz at every turn . every curve in the plot was in view from a mile away !
- pos what a disaster ! normally , when one critiques a historical movie , it ' s always fun to point out the inaccuracies that slip in , usually added by the writers to create more " dramatic " situations . however , " imperium : nerone " is a whole ' nuther kind of animal . in this movie you strain to find anything at all that is confirmed by the historical record amidst the farrago of nonsense and fiction presented as the life of rome ' s bad - boy artist - emperor . < br / > < br / > and it ' s a pity , because nero is one of the most fascinating of all the roman emperors . his life was filled with enough tumultuous events and interesting people to make a really good movie . the producers of this mess chose another route , which leads only to head - scratching on the part of any informed viewer . < br / > < br / > just a few examples : < br / > < br / > 1 . nero is depicted as an 6 - 8 year old boy when caligula has his father killed for treason , exiles his mother agrippina , and sends the boy to be raised by slaves in the countryside . " ten years later , " the story resumes just before the assassination of caligula . facts : nero was born about six months after caligula began his four year reign , and was only three when he was assassinated ; nero ' s father died of natural causes ; agrippina was briefly exiled for bad behavior , not treason ; and nero was not raised among slaves , but had the typical upbringing of a young member of the imperial family . < br / > < br / > 2 . okay , according to the writers , nero is now about 16 when his great uncle claudius becomes emperor (in fact he was about to turn 4) ; agrippina engineers the downfall of the empress messalina and marries claudius , who adopts nero . then he goes off to conquer britain , and is poisoned by agrippina soon after his victorious return . nero is declared emperor , although he ' s still perhaps only 18 or 19 years old . fact : claudius conquered britain in 43 a . d . , two years after beginning his reign . he lived until 54 a . d . nero should have been 31 years old by then by any normal chronology , but in fact succeeded to the throne at age 16 . < br / > < br / > history tells us that there then followed the " five good years , " where nero ruled wisely and well under the tutelage of the philosopher seneca and the praetorian commander burrus . this is shown - - sort of - - except that portraying the roman senate as opposing nero ' s good measures is false . senatorial opposition to nero only commenced when he started to show signs of insanity and began killing senators for real or imagined treason . < br / > < br / > 3 . nero ' s mother agrippina is the controlling sort , who murdered her uncle - husband to make her son emperor . after a while , nero tires of her meddling and decides to kill her . in the movie , he sends his henchman tigellinus to stab her to death . all true enough , but the reality was so much better ! agrippina was a survivor , and didn ' t go easily . nero tried three times to poison her , but as an old

poisoner herself she was savvy to all that , and he failed . then he tried to crush her to death by collapsing the ceiling of her bedchamber , but that also failed . next , he sent her on a voyage on a ship that was deliberately constructed to fall apart and sink ; as it went down , she jumped into the sea and swam to shore . finally , he had her stabbed to death . now showing all that would have definitely improved this movie ! < br / > < br / > other errors abound : nero ' s lover acte was not a childhood slave - friend , she never repudiated him , and there is no evidence that she became a christian . nero did not commit suicide by slitting his wrists while sitting beside a lake . etc . etc . etc . < br / > < br / > the sources for nero ' s life are primarily the roman historians tacitus and suetonius , both of whom were of the senatorial class hostile to him and his memory . but the evidence indicates that he remained very popular with the common people , unlike one of the final scenes where he is pelted by the mob with vegetables as he leaves the city to commit suicide . < br / > < br / > why did the writers and producers take an inherently interesting story with plenty of good stuff for any movie , and make this piece of crap ? oh , and did i mention how cheesy the sets and costumes were ? lol . < br / > < br / > one star , because there ' s no way to rate it lower .