

# CS190I Introduction to NLP Assignment 2: Fake News Detection with Naive Bayes and Voted Perceptron

Due: 2/15, 23:59pm PT

Late submission due: 2/19, 23:59pm PT,  
via email to grader with 50% discount of credits.

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## 1 Policy on Collaboration among Students

We follow UCSB's academic integrity policy from UCSB Campus Regulations, Chapter VII: "Student Conduct and Discipline"):

*"It is expected that students attending the University of California understand and subscribe to the ideal of academic integrity, and are willing to bear individual responsibility for their work. Any work (written or otherwise) submitted to fulfill an academic requirement must represent a student's original work. Any act of academic dishonesty, such as cheating or plagiarism, will subject a person to University disciplinary action. Using or attempting to use materials, information, study aids, or commercial "research" services not authorized by the instructor of the course constitutes cheating. Representing the words, ideas, or concepts of another person without appropriate attribution is plagiarism. Whenever another person's written work is utilized, whether it be a single phrase or longer, quotation marks must be used and sources cited. Paraphrasing another's work, i.e., borrowing the ideas or concepts and putting them into one's "own" words, must also be acknowledged. Although a person's state of mind and intention will be considered in determining the University response to an act of academic dishonesty, this in no way lessens the responsibility of the student."*

More specifically, we follow Stefano Tessaro and William Cohen's policy in this class:

- You cannot copy the code or answers to homework questions or exams from your classmates or from other sources;
- You may discuss course materials and assignments with your classmate, but you cannot write anything down.
- You must write down the answers / code independently.
- The presence or absence of any form of help or collaboration, whether given or received, must be explicitly stated and disclosed in full by all involved, on the first page of their assignment.

Specifically, each assignment solution must start by answering the following questions:

1. Did you receive any help whatsoever from anyone in solving this assignment? Yes / No.  
If you answered 'yes', give full details: \_\_\_\_\_  
(e.g. "Jane explained to me what is asked in Question 3.4")
2. Did you give any help whatsoever to anyone in solving this assignment? Yes / No.  
If you answered 'yes', give full details: \_\_\_\_\_  
(e.g. "I pointed Joe to section 2.3 to help him with Question 2".)

Academic dishonesty will be reported to the highest line of command at UCSB. When you are not sure, ask the teaching staff before you do so. Students who engage in plagiarism activities will receive an F grade automatically.

## 2 Programming Assignment (80%)

### 2.1 Naive Bayes (40%)

Much of machine learning with text involves counting events. Naive Bayes fits nicely into this framework. The classifier needs just a few counters. For this assignment we will be performing document classification using Naive Bayes.

First, let  $y$  be the labels for the training documents and  $\mathcal{W} = \{w_i\}_{i=1}^L$  be the sets of words in the document. Here are the counters we need to get for predication:

- $\#(Y = y)$  for each label  $y$  the number of training instances of that class
- $\#(Y = *)$  here  $*$  means anything, so this is just the total number of training instances
- $\#(Y = y, W = w)$  number of times token  $w$  appears in the documents with label  $y$
- $\#(Y = y, W = *)$  total number of tokens for documents with label  $y$ .

One way to compute these counters is to convert all the documents into feature vectors,  $\mathbf{w} \in \mathbf{Z}^{|\mathcal{V}|}$ , i.e.  $|\mathcal{V}|$  dimension integer vectors, where  $\mathcal{V}$  is the dictionary, which provides indices for all words. Then  $w_i$  is the number of appearances of word with index  $i$  in this document. Store all of these feature vectors together as a matrix, which is saved in the format of .csv file in your case (see Section 2.3 for details).

Without smoothing, the final prediction is

$$y^* = \arg \max_y \left( \prod_{i=1}^L \frac{\#(Y = y, W = w_i)}{\#(Y = y, W = *)} \right) \frac{\#(Y = y)}{\#(Y = *)} \quad (1)$$

Also, to avoid the numerical problem, you may want to use logarithm of probability

$$y^* = \arg \max_y \left( \sum_{i=1}^L \log \frac{\#(Y = y, W = w_i)}{\#(Y = y, W = *)} \right) + \log \frac{\#(Y = y)}{\#(Y = *)} \quad (2)$$

Note that your implementation will use smoothed probabilities. For example, at classification time, you can use Laplace smoothing with  $\alpha = 1$  as described here: [https://en.wikipedia.org/wiki/Additive\\_smoothing](https://en.wikipedia.org/wiki/Additive_smoothing).

### 2.2 Voted Perceptron (40%)

Perceptron algorithm is one of the classic algorithms which has been used in machine learning from early 1960s. It is an online learning algorithm for learning a linear threshold function which works as a classifier. We will also apply the Voted Perceptron algorithm on the same document classification task in this assignment.

Let  $\mathcal{T} = \{(y_i, \mathbf{x}_i)\}_{i=1}^m$  be the training data,  $y_i$  be the labels ( $y_i \in \{-1, 1\}$  in binary classification problem) for the  $i$ th document and the corresponding feature vector is  $\mathbf{x}_i$ . The goal of the Perceptron algorithm is to find a vector  $\mathbf{w}$  which defines a linear function such that  $\forall i, y_i \langle \mathbf{w}, \mathbf{x}_i \rangle > 0$  ( $\langle \cdot, \cdot \rangle$  is the inner product operation). For the Voted Perceptron, you need a list of weighted vectors  $\{(\mathbf{w}_k, c_k)\}_{k=1}^K$ , where  $\mathbf{w}_k$  is the vector and  $c_k$  is its weight. (Please refer <https://cseweb.ucsd.edu/~yfreund/papers/LargeMarginsUsingPerceptron.pdf> for a clear descrip-

tion of Voted Perceptron)

```
Initiate  $k = 1, c_1 = 0, \mathbf{w}_1 = \mathbf{0}, t = 0$ ;  
while  $t \leq T$  (number of rounds) do  
    for each training example  $(y_i, \mathbf{x}_i)$  do  
        if  $y_i \langle \mathbf{w}_k, \mathbf{x}_i \rangle \leq 0$  then  
             $\mathbf{w}_{k+1} = \mathbf{w}_k + y_i \mathbf{x}_i$ ;  
             $c_{k+1} = 1$ ;  
             $k = k + 1$ ;  
        else  
             $c_k = c_k + 1$ ;  
        end  
    end  
     $t = t + 1$ ;  
end
```

Then you can use all these vectors and their weight to do the classification: the predicted label  $\hat{y}$  for any unlabeled document with feature vector  $\mathbf{x}$  would be

$$\hat{y} = \text{sign}\left(\sum_{k=1}^K c_k \text{sign}(\langle \mathbf{x}, \mathbf{w}_k \rangle)\right) \quad (3)$$

## 2.3 Data Set

For this assignment, you should download the training data from [https://www.dropbox.com/s/5nvdcezf85vpelj/hw2\\_data.zip?dl=0](https://www.dropbox.com/s/5nvdcezf85vpelj/hw2_data.zip?dl=0). It contains two csv files: 'Xtrain.csv' and 'Ytrain.csv'.

**Xtrain.csv** Each row is a feature vector of one document. The values in the  $i$ th columns are number of occurrences of the word with Id  $i$  in the corresponding documents. For example, assume the first row in 'Xtrain.csv' is:

0, 1, 2, 10, 0, 2, ...

which means the first word in the dictionary does not appear in this document, the second word in the dictionary appears once in this document, the third word in the dictionary appears twice in the document, and so on.

**Ytrain.csv** The csv file 'Ytrain.csv' provides the binary labels for corresponding documents in the file 'Xtrain.csv'. The corresponding label for the document in the above example has been saved at the first row of the file 'Ytrain.csv'.

There are two different kind of news documents, your task is to detect onion documents (fake news) from them:

- **onion** (fake news, labeled with 1), containing articles from the not-so-serious American magazine TheOnion.com
- **economist** (normal news, labeled with 0), containing articles from the serious European magazine Economist.com

## 2.4 Implementation & Submission

For this assignment, we publish a CodaLab competition ([https://competitions.codalab.org/competitions/16211?secret\\_key=571ba8f3-2869-42d0-8063-10384e661190](https://competitions.codalab.org/competitions/16211?secret_key=571ba8f3-2869-42d0-8063-10384e661190)), where you can submit your code and get evaluation scores that will be listed on a leader-board. If you are not familiar with CodaLab Competitions, check out here: [participating in a competition](#).

**Remember to register a CodaLab Competitions account using your uemail account, so that the username will be your UCSBNetID.** After that, log into CodaLab Competitions and set up your team name (whatever nickname you like). To protect your privacy, only the team names will be shown on the leader-board and your usernames will be anonymous. After your submission finishes running, please choose to submit it to the leader-board. Note that here team name is equivalent to your nickname, and it is still an independent homework assignment. You

must implement the two algorithms according to the instructions above. You must avoid calling APIs from existing machine learning toolkits such as scikit-learn. Using numpy is allowed.

There are two phases, *Naive Bayes* and *Voted Perceptron*, representing the two parts of the assignment. You must submit one zip file per phase via the corresponding submission page. Your code must be written in Python.

**Submission format** The final submission format should be:

naive\_bayers.zip

- run.py
- other python scripts you wrote

voted\_perceptron.zip

- run.py
- report.pdf (see Sec. 3 for more details)
- other python scripts you wrote

Note that to create a valid submission, zip all the file with 'zip -r zipfilename \*' starting from this directory. **DO NOT zip the directory itself, just its contents. (THIS IS VERY IMPORTANT!)**

Here is a sample 'run.py' file: <https://www.dropbox.com/s/a2ahv2qh7solhbn/run.py?dl=0>. You must submit the 'run.py' file with the exactly same format. For each phase, you have a total of 30 possible submissions.

**Computational restrictions** For both phases, the prescribed "time budget" is 300 seconds, including both the running time of your code and the evaluation time of the predicted results. In other words, the running time of your program must be less than 300 seconds.

| Count      |   | predicted class |   |
|------------|---|-----------------|---|
|            |   | 0               | 1 |
| true class | 0 | a               | b |
|            | 1 | c               | d |

Figure 1: Precision, Recall and Accuracy

## 2.5 Evaluation Criteria

As illustrated in Section 2.4, the prediction file generated by your code should be in the exactly same format of the file 'Ytrain.csv'. We will then compare your predictions with the ground truth labels and use a weighted combination of accuracy and F-measure to evaluate your results. So your final score for each submission

$$final\_score = 50 \times accuracy + 50 \times F\_measure.$$

For someone who is not familiar with the definitions of precision and F-measure, here is a simple explanation (see Figure. 1,  $a, b, c, d$  are the number of documents with different true and predicted labels ):

$$precision = \frac{d}{b + d}, \quad recall = \frac{d}{c + d},$$

$$F\_measure = 2 \times \frac{precision \times recall}{precision + recall}, \quad accuracy = \frac{a + d}{a + b + c + d}.$$

Even though your code is automatically evaluated on CodaLab Competitions, we will download your latest submissions and run a Plagiarism detection program on them. So please be honest.

### 3 Report (20%)

In addition to the code submission on CodaLab Competitions, you are also supposed to write a report and include it in the submission zip file for the second phase. The report should solve the following question:

First, use the last 10% of the training data as your test data. Compare Naive Bayes and Voted Perceptron on several fractions of your remaining training data. For this purpose, pick 1%, 2%, 5%, 10%, 20% and 100% of the first 90% training data to train and compare the performance of Naive Bayes and Voted Perceptron on the test data respectively. Plot the accuracy as a function of the size of the fraction you picked (x-axis should be “percent of the remaining training data” and y-axis should be “accuracy”).