HW3-Week 5-Emotion Classification Using Naïve Bayes

(100 points) **Discussion Week 5**
Due Sunday May 7th, 11:59 pm PST

Objective: In this assignment, you will investigate the core principles of the Naïve Bayes algorithm, utilize it for an emotion detection task, and assess its effectiveness in identifying six emotion categories based on the dataset you and your peers created last week.

Instructions: The assignment is divided into four sections. Complete all sections and submit the following:

1. A PDF or word doc answering the below questions.
2. Source code files **(e.g., Colab)** containing your implementation of the Naïve Bayes classifier and data preprocessing steps.

Hint: You only need to construct your data with categories and sentences corresponding to the specific category, not the emotion lexicon. In the assignment, you have six classes rather than two. Sentences in combination categories should be included in each category. For example, a sentence in Sadness + Joy is a sentence in Sadness and also a sentence in Joy.

6 categories **`{Fear, Anger, Surprise, Disgust, Sadness, Joy}.`**

Quiz: example with add-1 smoothing

	Cat	Documents
Training	-	just plain boring
	-	entirely predictable and lacks energy
	-	no surprises and very few laughs
	+	very powerful
	+	the most fun film of the summer
Test	?	predictable ~~with~~ no fun

1. Prior from training:

$$\hat{P}(c_j) = \frac{N_{c_j}}{N_{total}}$$

P(-) = 3/5
P(+) = 2/5

2. Drop "with"

3. Likelihoods from training:

$$p(w_i|c) = \frac{count(w_i, c) + 1}{(\sum_{w \in V} count(w, c)) + |V|}$$

$$P(\text{“predictable”}|-) = \frac{1+1}{14+20} \quad P(\text{“predictable”}|+) = \frac{0+1}{9+20}$$

$$P(\text{“no”}|-) = \frac{1+1}{14+20} \quad P(\text{“no”}|+) = \frac{0+1}{9+20}$$

$$P(\text{“fun”}|-) = \frac{0+1}{14+20} \quad P(\text{“fun”}|+) = \frac{1+1}{9+20}$$

4. Scoring the test set:

$$P(-)P(S|-) = \frac{3}{5} \times \frac{2 \times 2 \times 1}{34^3} = 6.1 \times 10^{-5}$$

$$P(+)P(S|+) = \frac{2}{5} \times \frac{1 \times 1 \times 2}{29^3} = 3.2 \times 10^{-5}$$

Section 1: Understanding Naïve Bayes (10 points)

1.1: Research the Naïve Bayes algorithm and write a brief summary of the algorithm's principles, assumptions, and applications. I.e.. map a list of words to some class

Answer:

Naive Bayes is a popular machine learning algorithm used for classification tasks that assumes features are independent and treats words as unordered. It calculates the probability of a new instance belonging to each class based on the features of the instance, and assigns the class with the highest probability. Laplace smoothing can be applied to address the issue of zero probabilities. Naive Bayes has many applications in natural language processing, including text classification, sentiment analysis, and spam filtering.

1.2: Explain the role of conditional probability and independence in Naïve Bayes classification.

Answer:

Conditional probability refers to the probability of a word occurring given a class, while independence means that the occurrence of one word does not affect the occurrence of any other words. This simplifies the calculation of probabilities, allowing the joint probability of all words to be expressed as the product of individual probabilities.

Section 2: Preprocessing the Data (10 points)

2.1: Download the dataset you created last week **[https://docs.google.com/spreadsheets/d/1FO779z232nz8pVEk2-lfA7pRX0BW1Nqlk1x-oPoxRmc/edit?usp=sharing]** . Please use the first 30 rows as training, the next 10 rows (30-40) as validation, and the next 10 rows (40-50) as testing set.

Answer:

Done! Downloaded it as Microsoft xlsx

2.2: Preprocess the data by tokenizing the text (make sure the end of sentence tokens, such as .!? are properly tokenized). Copy and paste one tokenized sentence for each emotion here.

Answer:

Sadness: **['The', 'devastating', 'news', 'of', 'the', 'child', "'s", 'abduction', 'left', 'a', 'solemn', 'shadow', 'over', 'the', 'family', 'for', 'the', 'next', 'month', '.']**

Joy: **['It', 'was', 'a', 'sunny', 'summer', 'morning', 'and', 'the', 'laughter', 'of', 'children', 'could', 'be', 'heard', 'from', 'the', 'pool', 'as', 'they', 'splashed', 'water', 'onto', 'each', 'other', '.']**

Fear: **['As', 'he', 'walked', 'in', 'the', 'dead', 'of', 'night', 'he', 'could', 'hear', 'sudden', 'footsteps', 'echoing', 'from', 'the', 'alleyway', ',', 'a', 'shiver', 'went', 'down', 'his', 'spine', '.']**

Anger: **['While', 'driving', 'his', 'family', 'to', 'a', 'restaurant', 'a', 'car', 'recklessly', 'changed', 'lanes', 'barely', 'missing', 'him', ',', 'his', 'face', 'flushed', 'red', 'with', 'fury', 'knowing', 'how', 'close', 'his', 'family', 'was', 'to', 'being', 'seriously', 'harmed', '.']**

Surprise: **['She', 'was', 'startled', 'unexpectedly', 'as', 'everyone', 'sprang', 'from', 'their', 'hiding', 'spot', 'to', 'celebrate', 'her', 'birthday']**

Disgust: **['She', 'had', 'forgotten', 'to', 'take', 'out', 'the', 'trash', 'before', 'leaving', 'for', 'holiday', ',', 'when', 'she', 'returned', 'she', 'was', 'repulsed', 'by', 'the', 'stench', 'of', 'decaying', 'food', '.']**

Section 3: Implementing Naïve Bayes Classifier (60 points)

3.1: Implement and calculate the priors for each emotion category. Copy and paste the priors here. (10 points)

`P(EMO)where EMO \in {Fear, Anger, Surprise, Disgust, Sadness, Joy}`

Answer:

Total number of sentences (that belongs to 6 emotions): 442
P(Sadness)= 89 / 442 = 0.20135746606334842
P(Joy)= 89 / 442 = 0.20135746606334842
P(Fear)= 89 / 442 = 0.20135746606334842
P(Anger)= 60 / 442 = 0.13574660633484162
P(Surprise)= 57 / 442 = 0.12895927601809956
P(Disgust)= 58 / 442 = 0.13122171945701358
Total probability: 1.0

3.2: Implement and calculate the likelihoods of each word given an emotion category using Laplace smoothing. Indicate which sections in your Colab are corresponding to this question and provide necessary explanations to TA on how to run it. (20 points)

Answer: Check section 3.2 in my Google Colab
3.3: Implement the Naïve Bayes classifier to predict the emotion of a given text `S=`

`As she hugged her daughter goodbye on the first day of college, she felt both sad to see her go and joyful knowing that she was embarking on a new and exciting chapter in her life.`

Indicate which sections in your Colab are corresponding to this question and provide necessary explanations to TA on how to run it. Copy and paste the prediction probability here. (30 points)

`P(S|EMO)where EMO \in {Fear, Anger, Surprise, Disgust, Sadness, Joy}`

Answer:

```
Normalized posterior probabilities for each emotion:

P(Sadness|S) = 8.831686750987629e-17
P(Joy|S) = 8.724298157289628e-09
P(Fear|S) = 1.57323958086014e-14
P(Anger|S) = 1.0511113988568794e-13
P(Surprise|S) = 0.9999289892373084
P(Disgust|S) = 7.100203827245855e-05

Total Sum Probabilities = 1.0

Predicted emotion: Surprise
```

Section 4: Evaluating the Classifier on Test Set (20 points + 10 bonus points)

4.1: Generate a confusion matrix (6x6) and analyze the results on the **test dataset**. You can use the existing Python package. Copy and paste your confusion matrix here. (10 points)

4.2: Calculate the accuracy, precision, recall, and F1-score for the Naïve Bayes classifier of the **Joy** category on the test dataset. Copy and paste your results here and indicate sections of code in colab for this computation. (10 points)

4.3: Compare the performance of your Naïve Bayes classifier to an existing naive bayes implementation (e.g.,https://scikit-learn.org/stable/modules/naive_bayes.html) for *question 4.1. (bonus 10 points)*