Multinomial Naive Bayes Classifier

The multinomial naive Bayes classifier is a commonly used method for sentimental analysis and spam detection in emails. This classifier makes simplified naive presumptions regarding the interaction between the features. It has proven to be very effective in certain tasks in terms of classification. In order to implement this method, a bag-of-words approach can be used, where we look at the frequency of each word from a text while disregarding the order of the words. In order to use Multinomial Naive Bayes for the task of classifying movie reviews as 'entertaining' or 'boring' we need to calculate the word frequency and calculate the probabilities of the features of each class. This method has a weakness, when we multiply the probabilities of the words together, a zero probability for any word will cause the probability of the classification to become zero. In order to mitigate this problem, we add a smoothing method where we add 1 to all words. Another important aspect when using the multinomial naive bayes is to have a good quality of data in order to create a good training model (Jurafsky & Martin, 2022).

Training Set		**Stop Words**	
Category/Label	**Documents**	**With**	**Removed**
entertaining	the actor gives a convincing, charismatic performance as the multifaceted	10	6
	Spielberg gives us a visually spicy and historically accurate real life story	12	10
	His innovative mind entertains us now and will continue to entertain generations to come	14	9
boring	Unfortunately, the film has two major flaws, one in the disastrous ending	12	8
	If director actually thought this movie was worth anything	9	7
	His efforts seem fruitless, creates drama where drama shouldn't be	11	8
Test Set			
??	film is a innovative drama, entertains, but disastrous ending		

Prior from training

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

$$P(ent) = 3/6 = 1/2$$

$$P(bor) = 3/6 = 1/2$$

WITH STOP WORDS

1. Summary of training and test set:
   Using word_tokenize and FreqDist functions, training set has 68 words with 58 vocabularies. 36 words categorized as “entertaining” and 32 words categorized as “boring”.

2. Drop ”is” and ”but”

3. add-1 smoothing is used since not all words in test set are appearing in both categories.

Word	Entertaining (ent)	Boring (bor)
film	-	1
a	2	-
innovative	1	-
drama	-	2
entertains	1	-
disastrous	-	1
ending	-	1

   Likelihoods from training:

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

   Calculations for each word:

$P(\text{”film”}|\text{”ent”}) = \frac{0+1}{36+58} = \frac{1}{94}$	$P(\text{”film”}|\text{”bor”}) = \frac{1+1}{32+58} = \frac{2}{90}$
$P(\text{”a”}|\text{”ent”}) = \frac{2+1}{36+58} = \frac{3}{94}$	$P(\text{”a”}|\text{”bor”}) = \frac{0+1}{32+58} = \frac{1}{90}$
$P(\text{”innovative”}|\text{”ent”}) = \frac{1+1}{36+58} = \frac{2}{94}$	$P(\text{”innovative”}|\text{”bor”}) = \frac{0+1}{32+58} = \frac{1}{90}$
$P(\text{”drama”}|\text{”ent”}) = \frac{0+1}{36+58} = \frac{1}{94}$	$P(\text{”drama”}|\text{”bor”}) = \frac{2+1}{32+58} = \frac{3}{90}$
$P(\text{”entertains”}|\text{”ent”}) = \frac{1+1}{36+58} = \frac{2}{94}$	$P(\text{”entertains”}|\text{”bor”}) = \frac{0+1}{32+58} = \frac{1}{90}$
$P(\text{”disastrous”}|\text{”ent”}) = \frac{0+1}{36+58} = \frac{1}{94}$	$P(\text{”disastrous”}|\text{”bor”}) = \frac{1+1}{32+58} = \frac{2}{90}$
$P(\text{”ending”}|\text{”ent”}) = \frac{0+1}{36+58} = \frac{1}{94}$	$P(\text{”ending”}|\text{”bor”}) = \frac{1+1}{32+58} = \frac{2}{90}$

4. Scoring the test:

$P(\text{“ent”})P(S|\text{”ent”}) = \frac{1}{2} \; x \; \frac{1 \; x \; 3 \; x \; 2 \; x \; 1 \; x \; 2 \; x \; 1 \; x \; 1}{94^7} = 9.25\text{e-}14$

$P(\text{“bor”})P(S|\text{”bor”}) = \frac{1}{2} \; x \; \frac{2 \; x \; 1 \; x \; 1 \; x \; 3 \; x \; 1 \; x \; 2 \; x \; 2}{90^7} = 2.51\text{e-}13$

STOP WORDS REMOVED

1. Summary of training and test set:
   Using word_tokenize, stopwords, and FreqDist functions, the training set has 48 words with 44 vocabularies. 25 words categorized as "entertaining" and 23 words categorized as "boring".

2. Drop "is", "a" and "but"

3. add-1 smoothing is used since not all words in test set are appearing in both categories.

Word	Entertaining (ent)	Boring (bor)
film	-	1
innovative	1	-
drama	-	2
entertains	1	-
disastrous	-	1
ending	-	1

Likelihoods from training:

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

Calculations for each word:

P("film"|"ent") $= \frac{0+1}{25+44} = \frac{1}{69}$	P("film"|"bor") $= \frac{1+1}{23+44} = \frac{2}{67}$
P("innovative"|"ent") $= \frac{1+1}{25+44} = \frac{2}{69}$	P("innovative"|"bor") $= \frac{0+1}{23+44} = \frac{1}{67}$
P("drama"|"ent") $= \frac{0+1}{25+44} = \frac{1}{69}$	P("drama"|"bor") $= \frac{2+1}{23+44} = \frac{3}{67}$
P("entertains"|"ent") $= \frac{1+1}{25+44} = \frac{2}{69}$	P("entertains"|"bor") $= \frac{0+1}{23+44} = \frac{1}{67}$
P("disastrous"|"ent") $= \frac{0+1}{25+44} = \frac{1}{69}$	P("disastrous"|"bor") $= \frac{1+1}{23+44} = \frac{2}{67}$
P("ending"|"ent") $= \frac{0+1}{25+44} = \frac{1}{69}$	P("ending"|"bor") $= \frac{1+1}{23+44} = \frac{2}{67}$

4. Scoring the test:

P("ent")P(S|"ent") $= \frac{1}{2} \; x \; \frac{1 \; x \; 2 \; x \; 1 \; x \; 2 \; x \; 1 \; x \; 1}{69^6} = 1.85\text{e-}11$

P("bor")P(S|"bor") $= \frac{1}{2} \; x \; \frac{2 \; x \; 1 \; x \; 3 \; x \; 1 \; x \; 2 \; x \; 2}{67^6} = 1.33\text{e-}10$