Naïve Bayes as a Language Model

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UIC CS 421

Naïve Bayes can also be viewed as a language model.

Use only individual word features (unigrams)

Use all words in the text (not a subset)

Don't remove stop words or unknown words

This means that the model learned for each class is a class-specific unigram language model

This means that not only can we get likelihoods for individual words belonging to a class …we can also get likelihoods for entire sentences.

- Letting S be the list of all tokens in a sentence:
  - $P(S|c) = \prod_{i \in S} P(w_i|c)$

Computing Sentence Likelihood

Training	
Document	**Class**
Natalie was soooo thrilled that Usman had a famous new poem.	Sarcastic
She was totally 100% not annoyed that it had surpassed her poem on the bestseller list.	Sarcastic
Usman was happy that his poem about Thanksgiving was so successful.	Not Sarcastic
He congratulated Natalie for getting #2 on the bestseller list.	Not Sarcastic
Test	
Document	**Class**
Natalie told Usman she was soooo totally happy for him.	?

Word	P(Word|Sarcastic)	P(Word|Not Sarcastic)
Natalie	0.056	0.061
Usman	0.056	0.061
soooo	0.056	0.030
totally	0.056	0.030
happy	0.028	0.061

P(Sarcastic) = 0.5
P(Not Sarcastic) = 0.5

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Natalie told Usman she was soooo totally happy for him.

Word	P(Word|Sarcastic)	P(Word|Not Sarcastic)
Natalie	$\frac{1+1}{27+34} = 0.033$	$\frac{1+1}{21+34} = 0.036$
Usman	$\frac{1+1}{27+34} = 0.033$	$\frac{1+1}{21+34} = 0.036$
soooo	$\frac{1+1}{27+34} = 0.033$	$\frac{0+1}{21+34} = 0.018$
totally	$\frac{1+1}{27+34} = 0.033$	$\frac{0+1}{21+34} = 0.018$
happy	$\frac{0+1}{27+34} = 0.016$	$\frac{1+1}{21+34} = 0.036$
told	$\frac{0+1}{27+34}$	$\frac{0+1}{21+34}$
she	$\frac{1+1}{27+34}$	$\frac{0+1}{21+34}$
was	$\frac{2+1}{27+34}$	$\frac{2+1}{21+34}$
for	$\frac{0+1}{27+34}$	$\frac{1+1}{21+34}$
him	$\frac{0+1}{27+34}$	$\frac{0+1}{21+34}$

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Natalie told Usman she was soooo totally happy for him.

Word	P(Word|Sarcastic)	P(Word|Not Sarcastic)
Natalie	0.033	0.036
Usman	0.033	0.036
soooo	0.033	0.018
totally	0.033	0.018
happy	0.016	0.036
told	$\frac{0+1}{27+34} = 0.016$	$\frac{0+1}{21+34} = 0.018$
she	$\frac{1+1}{27+34} = 0.033$	$\frac{0+1}{21+34} = 0.018$
was	$\frac{2+1}{27+34} = 0.049$	$\frac{2+1}{21+34} = 0.055$
for	$\frac{0+1}{27+34} = 0.016$	$\frac{1+1}{21+34} = 0.036$
him	$\frac{0+1}{27+34} = 0.016$	$\frac{0+1}{21+34} = 0.018$

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told	0.016	0.018
she	0.033	0.018
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for	0.016	0.036
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Natalie told Usman she was soooo totally happy for him.

Computing Sentence Likelihood

Natalie told Usman she was soooo totally happy for him.

$$P(S|c) = \prod_{i \in S} P(w_i|c)$$

P("Natalie told Usman she was soooo totally happy for him"|Sarcastic) = 0.033 * 0.016 * 0.033 * 0.033 * 0.049 * 0.033 * 0.033 * 0.016 * 0.016 * 0.016 = **$1.26 * 10^{-16}$**

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P("Natalie told Usman she was soooo totally happy for him"|Not Sarcastic) = 0.036 * 0.018 * 0.036 * 0.018 * 0.055 * 0.018 * 0.018 * 0.036 * 0.036 * 0.018 = **$1.75 * 10^{-16}$**

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Slightly higher likelihood of the sentence being **not sarcastic**, but this isn't the full Naïve Bayes model …once we multiply in the prior probability, we might make a different classification decision.

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s[illegible]		
w[illegible]		
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Although, note that in this case we do not! 🤷‍♀️ This is a good example of how stop words can be problematic in text classification, particularly with extremely tiny datasets.

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