Assignment 4+Smoothing

(SNLP tutorial 4)

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Overview

- Task, Metrics
- Differential Privacy
- Homework

Assignment 4

- Exercise 1: Huffman encoding
- Exercise 2: Conditional entropy of DNA
- Bonus: Huffman encoding adaptations

OOV words

Corpus

- Train set:

- Test set:

Accumulate counts

- 6 5 3 2
- 4 2 2 2 1 1

OOV words

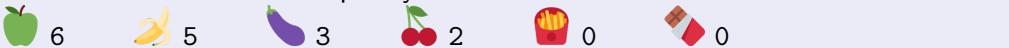
- What about and ?
- OOV rate: $2 + 1/4 + 2 + 2 + 1 + 1 + 1 = 27\%$

- Solutions? character-level, subword units

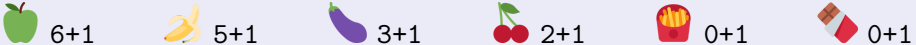
Additive smoothing (add-α-smoothing)

Unigrams

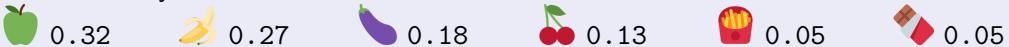
- Add zero counts to frequency table



- Increase all counts by $\alpha = 1$

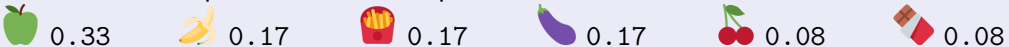


- Divide by $N = 22$



Perplexity

- Relative frequencies on test corpus:



- $\text{PP} = 2^{(0.33 \cdot 0.32 + 0.27 \cdot 0.17 + 0.18 \cdot 0.17 + 0.13 \cdot 0.17 + 2 \cdot (0.05 \cdot 0.08))} = 1.4$

Additive smoothing: Bigrams

Recall the additive smoothing formula for unigrams:

$$p_{smoothed}(w_i) = \frac{C(w_i) + \alpha}{N + \alpha|V|} \tag{1}$$

- What is N? What is V?

Remember from Assignment 2 that:

$$p(w_i|w_{i-1}) = \frac{C(w_{i-1}, w_i)}{C(w_{i-1})} \tag{2}$$

- Smoothe the bigram count: $C(w_{i-1}, w_i) \rightarrow C(w_{i-1}, w_i) + \alpha$
- Normalization: $p_{smoothed}(w_i|w_{i-1}) = \frac{C(w_{i-1}, w_i)+\alpha}{?}$

Additive smoothing: Bigrams

Corpus

Bigrams:  ← circular bigram!

Bigrams: AA, AA, AE, EA, . . . , AE, EA

Additive smoothing: Bigrams: bigram counts

- Collect bigram counts & condtional probabilities for history A

Bigram	$C(w_i, w_{i-1})$	$C(w_{i-1})$	$\frac{C(w_{i-1}, w_i)}{C(w_{i-1})}$
AE	3	6	1/2
AA	2	6	1/3
AB	1	6	1/6

Additive smoothing: Bigrams: add alpha

- We encounter an unknown bigram AF

Bigram	$C_\alpha(w_{i-1}, w_i)$	$C_\alpha(w_{i-1})$	$\frac{C_\alpha(w_{i-1},w_i)}{C_\alpha(w_{i-1})}$
AE	3+1	6+1	4/7
AA	2+1	6+1	3/7
AB	1+1	6+1	2/7
$\rightarrow$ AF	0+1	6+1	1/7

- Not a probabilitiy distribution!
- Solution: We need to adjust the divisor a tiny bit. But how tiny?

Additive smoothing: Bigrams: normalization

- add $\alpha 3$ to history count!
- Pretend that we have seen the history $|V| = 3$ times more.

Bigram	$C_\alpha(w_{i-1}) + \alpha\|V\|$	$\frac{C_\alpha(w_{i-1},w_i)}{C_\alpha(w_{i-1})+\alpha\|V\|}$
AE	$7 + 3$	$4/10$
AA	$7 + 3$	$3/10$
AB	$7 + 3$	$2/10$
$\rightarrow$ AF	$7 + 3$	$1/10$

- Now the probabilities sum up to 1: $4/10 + 3/10 + 2/10 + 1/10 = 1$

Additive smoothing: Bigrams: normalization

- We encounter another n-gram AD
- What is $|V|$ now?

Bigram	$C_\alpha(w_{i-1}) + \alpha\|V\|$	$\frac{C_\alpha(w_{i-1},w_i)}{C_\alpha(w_{i-1})+\alpha\|V\|}$
AE	$7+4$	$4/11$
AA	$7+4$	$3/11$
AB	$7+4$	$2/11$
$\rightarrow$ AF	$7+4$	$1/11$
$\rightarrow$ AD	$7+4$	$1/11$

- $C_\alpha(A)$ is constant
- Probabilities sum up to 1: $4/11 + 3/11 + 2/11 + 1/11 + 1/11 = 1$

Additive smoothing: Bigrams: general case

- General formula for smoothed bigram Probabilities:

$$p(w_i|w_{i-1}) = \frac{C(w_{i-1}, w_i) + \alpha}{C(w_{i-1}) + \alpha|V|} \tag{3}$$

- What is V?
- $|V|$ = Number of bigram **types** starting with w_{i-1}

$$p(w_i|w_{i-1}) = \frac{C(w_{i-1}, w_i) + \alpha}{C(w_{i-1}) + \alpha|V_{(w_{i-1},\bullet)}|} \tag{4}$$

- For n-grams of length n:

$$p(w_i|w_{i-1} : w_{i-n+1}) = \frac{C(w_{i-n+1} : w_i) + \alpha}{C(w_{i-n+1} : w_{i-1}) + \alpha|V_{(w_{i-n+1}:w_{i-1},\bullet)}|} \tag{5}$$

Kneser-Ney Smoothing

TODO

- absolute discounting

Cross-Validation

TODO

Estimating LOO Parameters

TODO ??

Laplace Smoothing

- add epsilon

TODO

Linear Discounting

- linear interpolation

Good-Turing Discounting

TODO

Count Trees

- remove infrequent nodes

TODO

Privacy

TODO differential privacy

Resources

1. UdS SNLP Class, WSD: https://teaching.lsv.uni-saarland.de/snlp/
2. Classical Statistical WSD: https://www.aclweb.org/anthology/P91-1034.pdf
3. n-gram count trees: http://ssli.ee.washington.edu/WS07/notes/ngrams.pdf