Natural Language Processing and Machine Translation

Language Models

Abhishek Koirala

M.Sc. in Informatics and Intelligent Systems Engineering

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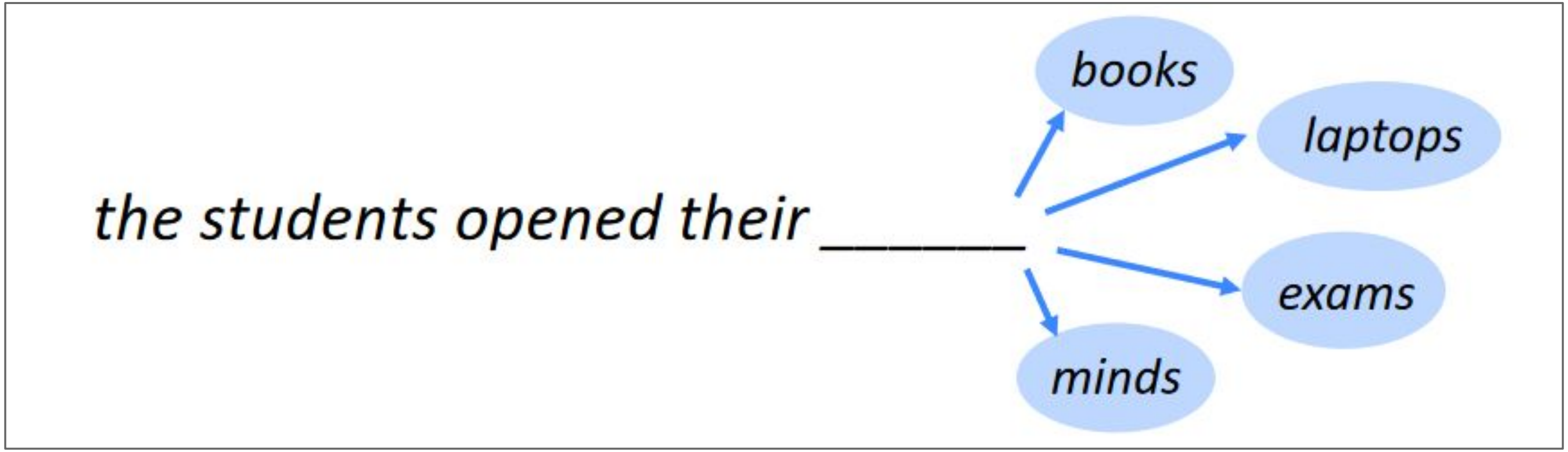
Introduction

- Use of various statistical and probabilistic techniques to determine the probability of a given sequence of words occurring in a sentence
- Analyze bodies of text data to provide a base for word predictions



https://medium.com/@antonio.lopardo/the-basics-of-language-modeling-1c8832f21079

N-gram

The cow jumps over the moon

Unigram/ 1-gram	Bigram/2-gram	3-gram	4-gram
The cow jumps over the moon	The cow cow jumps jumps over over the the moon	The cow jumps cow jumps over jumps over the over the moon	The cow jumps over cow jumps over the jumps over the moon

If X=Num of words in a given sentence K, the number of n-grams for sentence K would be:

$$Ngrams_K = X - (N - 1)$$

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N-gram Language Models

Its water is so transparent that ....

$$P(the|its\ water\ is\ so\ transparent\ that).$$

One approach to calculate this using frequency approach

$$P(the|its\ water\ is\ so\ transparent\ that) = \frac{C(its\ water\ is\ so\ transparent\ that\ the)}{C(its\ water\ is\ so\ transparent\ that)}$$

Will this give us a good estimate in all possible scenarios ??

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N-gram Language Models

Another way to do this is using **chain rule of probability**

p(w1...ws) = p(w1) . p(w2 | w1) . p(w3 | w1 w2) . p(w4 | w1 w2 w3) ..... p(wn | w1...wn-1)

But this is again computationally expensive

We make this more simpler with an assumption:

- We approximate the context of the word wk by looking at the last word of the context. (**Markov Assumption**)

Eg. for bigram

$$p(w) = \prod_{i=1}^{k+1} p(w_i | w_{i-1})$$

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N-gram language models

<s> I am a human </s>
<s> I am not a stone </s>
<s> I live in Lahore </s>

P(I|<S>)=C(<s>|I)/C(<s>)=3/3=1

P(am|I)=C(I|am)/C(I)=⅔

P(a|am)=C(am|a)/C(a)=½

P(human|a)=C(a|human)/C(a)=½

P(</s>|human)=C(human|</s>)/C(human)=1

P(not|am)=C(am|not)/C(am)=½

P(a|not)=C(not|a)/C(not)=1

P(stone|a)=C(a|stone)/C(a)=½

P(</s>|stone)=C(stone|</s>)/C(stone)=1

P(live|I)=C(I|live)/C(I)=⅓

P(in|live)=C(live|in)/C(live)=1

P(Lahore|in)=C(in|Lahore)/C(in)=1

P(</s>|Lahore)=C(Lahore|</s>)/C(Lahore)=1

P(I am a human)
= P(I|<s>) P(am|I) P(a|am) P(human|a) P(</s>|human)
= 1 * ⅔ * ½ *½ * 1
= ⅙

P(I am human)
= P(I|<s>) P(am|I) P(human|am) P(</s>|human)
= 1 * ⅔ * 0 * 1
= 0 => Does this seem correct?

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Laplace Smoothing

<s> I am a human </s>
<s> I am not a stone </s>
<s> I live in Lahore </s>

P(I|<S>)=C(<s>|I)/C(<s>)=3/3=1

P(am|I)=C(I|am)/C(I)=⅔

P(a|am)=C(am|a)/C(a)=½

P(human|a)=C(a|human)/C(a)=½

P(</s>|human)=C(human|</s>)/C(human)=1

P(not|am)=C(am|not)/C(am)=½

P(a|not)=C(not|a)/C(not)=1

P(stone|a)=C(a|stone)/C(a)=½

P(</s>|stone)=C(stone|</s>)/C(stone)=1

P(live|I)=C(I|live)/C(I)=⅓

P(in|live)=C(live|in)/C(live)=1

P(Lahore|in)=C(in|Lahore)/C(in)=1

P(</s>|Lahore)=C(Lahore|</s>)/C(Lahore)=1

The solution to the problem of unseen N-grams is to re-distribute some of the probability mass from the observed frequencies to unseen N-grams. This is a general problem in probabilistic modeling called **smoothing**.

$$P_{\text{Laplace}}(w_i) = \frac{c_i + 1}{N + V}$$

Using laplace smoothing (Vocab = 11)

P(I am human)
= P(I|<s>) P(am|I) P(human|am) P(</s>|human)
= (3+1)/(3+11) * (2+1)/(3+11) * (0+1)/(2+11) * (1+1)/(1+11)
= 4/14 * 3/14 * 1/13 * 2/12
= 0.00078

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Good Turing Discounting

- Re-estimate the amount of probability mass to assign N-gram with zero or low counts by looking at the number of N-grams with higher counts
- Use the count of things which are seen once to help estimates the count of things never seen.
- Let Nc be number of N-grams that occur c times
  - For bigrams, No, is the number of bigrams of count 0, N1, is the number of bigrams with count 1, etc
- Revised count

$$\boxed{c^{*} = (c+1)\frac{N_{c+1}}{N_c}}$$

https://www.cs.cornell.edu/courses/cs4740/2014sp/lectures/smoothing+backoff.pdf

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рахмат
danke
謝謝
spas
ngiyabonga
شكراً جزيلاً
Баярлалаа
mersi
kia ora
barka
welalin
tack
teşekkür ederim
mahalo
tapadh leat
спасибо
faafetai lava
vinaka
спасибі
blagodaram
dank je
misaotra
matondo
paldies
grazzi
kiitos
dankie
dhanyavad
nanni
nandri
thank you
gracias
хвала
asante
manana
obrigada
tenki
bedankt
bayarlalaa
gràcie
hvala
mauruuru
köszönöm
aciü
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murakoze
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taiku
go raibh maith agat
sobodi
dēkuji
sağolun
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kop khun krap
obrigado
mèsi
didi madloba
ありがとう
tanemirt
grazie
arigatô
takk
dakujem
trugarez
najis tuke
terima kasih
rahmet
diolch
dhanyavadagalu
shukriya
merce
мерси
kam sah hamnida
rahmat
তোমাকে ধন্যবাদ
감사합니다
xièxie
ευχαριστώ
merci