English Word Suggestion Based on Part of Speech Ngram

Hamana Laboratory, Gunma University

Borann Chanrathnak

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2. Online digital writing tools

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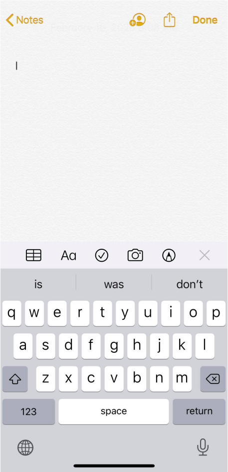

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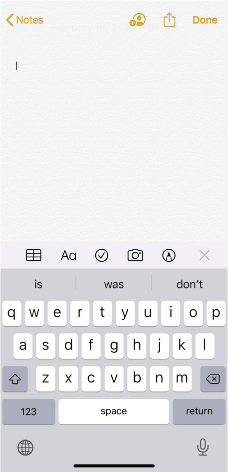

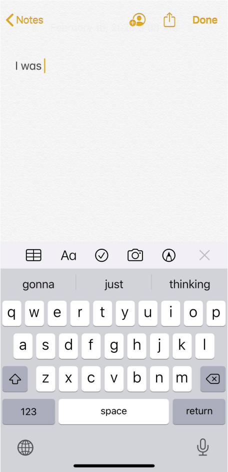

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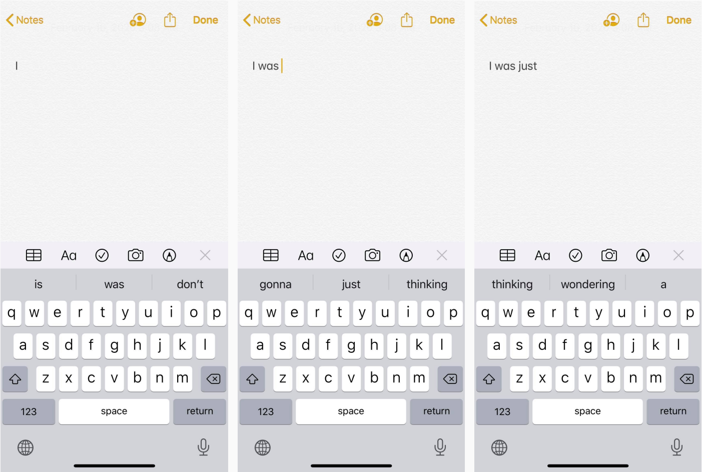

How to Predict?

"I am japanese, so I speak"

How to Predict?

"I am japanese, so I speak" $\rightarrow$

How to Predict?

"I am japanese, so I speak" $\rightarrow$ "japanese"

POS-Ngram

What does POS-Ngram mean?

Definition

Part of Speech (POS) one of the classes into which words are divided according to their grammar, such as noun, verb, adjective, etc.

Definition

N-gram is a contiguous sequence of n items from a given sample of text or speech

- **unigram (1-gram)** : (I,), (study,), (english,)
- **bigram (2-gram)** : (I, study), (study, english)
- **trigram (3-gram)** : (I, study, english)

What does POS-Ngram mean?

Definition

N-gram model is one of statistical langauge models for predicting the next item (word) based on Markov assumption, and usually abbreviated as N-gram.

Definition

POS-Ngram is an improved model using part of speech as a class indicator.

How To Compute Probability of a Sentence?

How can we compute the joint probability of a sentence?
Ex: "an apple is on the"

$$P(an\ apple\ is\ on\ the) = ?$$

Chain Rule Of Probability

Notation

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- To represent the probability of a paricular random variable X_i taking on the value "the", or $P(X_i = "the")$ we will use simplification $P(the)$.

Chain Rule Of Probability

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- To represent the probability of a paricular random variable X_i taking on the value "the", or $P(X_i = "the")$ we will use simplification $P(the)$.
- We represent a sequence of N words either as $w_1 \cdots w_n$ or w_1^n

Chain Rule Of Probability

In General

$$P(X_1 \cdots X_n) = P(X_1)P(X_2 \mid X_1)P(X_3 \mid X_1^2) \cdots P(X_n \mid X_1^{n-1})$$

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By applying chain rule to a sequence of words

$$P(w_1 \cdots w_n) = P(w_1)P(w_2 \mid w_1)P(w_3 \mid w_1^2) \cdots P(w_n \mid w_1^{n-1})$$

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Examples

- $P(an\ apple) = P(an) \times P(apple \mid an)$
- $P(an\ apple\ is) = P(an) \times P(apple \mid an) \times P(is \mid an\ apple)$

Let's Apply Chain Rule

By applying chain rule to the phrase "*an apple is on the*":

$$
\begin{aligned}
P(\text{"}an\ apple\ is\ on\ the\text{"}) &= P(an) \times P(apple|an) \times P(is|an\ apple) \\
&\times P(on|an\ apple\ is) \times P(the|an\ apple\ is\ on)
\end{aligned}
$$

In practice chain rule does not help

- We don't know the way to compute the exact probability of a word given a long sequence of preceding words, $P(w_n|w_n^{n-1})$
- Language is creative, and any particular context might have never occured before

Example

$$P(\textit{sentences} \mid \textit{this is an example of long}) = ?$$

The Presence of N-gram

The general equation for this n-gram approximation to the conditional probability of the next word in a sequence is

$$P(w_n|w_1^{n-1}) \approx P(w_n|w_{n-N+1}^{n-1})$$

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When we use bigram model to predict the conditional probability of the next word, we can approximate by

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Example

$$P(the|\ an\ apple\ is\ on) \approx P(the|\ on)$$

Bigram in Practice

By supposing that C is the counts of word from a corpus.

$$P(w_n|w_{n-1}) = \frac{C(w_{n-1}w_n)}{\sum_w C(w_{n-1}w)}$$

Bigram in Practice

By supposing that C is the counts of word from a corpus.

$$P(w_n|w_{n-1}) = \frac{C(w_{n-1}w_n)}{\sum_w C(w_{n-1}w)}$$

Example

$$P(the|\ on) = \frac{C(on\ the)}{\sum_{others} C(on\ others)}$$

The probability of a complete word sequence

Given the **bigram** assumption for the probability of an individual word, we can compute the probability of complete word sequence by:

$$P(w_1^n) \approx \prod_{k=1}^{n} P(w_k \mid w_{k-1})$$

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$$P(w_1^n) \approx \prod_{k=1}^{n} P(w_k \mid w_{k-1})$$

Example

$$P(an\ apple\ is\ on\ the) = P(apple \mid an) \times P(is \mid apple) \times P(on \mid is) \\ \times P(on \mid is) \times P(the \mid on)$$

OOV & Smoothing

OOV stands for **Out Of Vocabulary**

- Words appear only in a test set but not in the training set.
- OOV problem occurs even when we work on big data.

Types of smoothing

- Laplace smoothing (Add-one smoothing)
- Add-k smoothing
- Interpolation
- $\cdots$

Interpolation

We mix the probability estimates from all the n-gram estimators, weighing and combining the trigram, bigram, and unigram counts.

Interpolation

To estimate $P(w_n \mid w_{n-2}w_{n-1})$ we use simple interpolation as follows:

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In case of Trigram

$$\begin{aligned}\hat{P}(w_n|w_{n-2}w_{n-1}) &= \lambda_1 P(w_n|w_{n-2}w_{n-1}) \\ &+ \lambda_2 P(w_n|w_{n-1}) \\ &+ \lambda_3 P(w_n)\end{aligned}$$

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where we choose λ_i such that $\sum_i \lambda_i = 1$

How are the λ values set?

- They can be learned from a **held-out** corpus
- Can be found by **EM** algorithm
- For the purpose of this project, we assume without loss of generality that $\lambda_i > \lambda_j (\forall i < j)$

POS-Ngram

Formula

$$P(w_n \mid w_1^{n-1}) = \sum_{c_n} P(w_n \mid c_n) \times P(c_n \mid c_{n-N+1}^{n-1})$$

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Example

c_1:Noun	cat, dog, thought, $\cdots$
c_2:Verb	go, speak, $\cdots$
c_1:Noun, c_2:Verb	play, $\cdots$

POS-Ngram

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Example

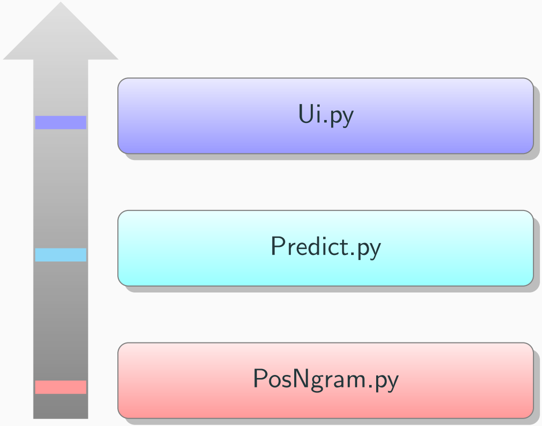
c_1:Noun	cat, dog, thought, $\cdots$
c_2:Verb	go, speak, $\cdots$
c_1:Noun, c_2:Verb	play, $\cdots$

It means that to predict the next word w_n

1. Compute $P(c_n|c_{n-N+1}^{n-1}) \sim P(w_n|w_{n-N+1}^{n-1})$
2. $P(w_n \mid c_n) = \frac{C(w_n, c_n)}{C(c_n)}$
3. w_n^* is defined by $\arg\max_{w_n} P(w_n \mid w_1^{n-1})$

Implementation

Programming Structure



Implementation

- Programming Language : Python
- Ui : Tkinter
- NLTK (Natural Language ToolKit)

Function	Argument	Result
word_tokenize	"I like english."	["I", "like", "english", "."]
pos_tag	["I", "like"]	[("I", "PRN"), ("like", "VBP")]

References

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2. N-gram Language Modeling Tutorial (Lecture notes courtesy of Prof. Mari Ostendorf, 2007-06-21)
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DEMO

Thank You.