Chinese Spelling Check based on N-gram and String Matching Algorithm

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Abstract

This paper presents a Chinese spelling check approach based on language models combined with string match algorithm to treat the problems resulted from the influence caused by Cantonese mother tone. N-grams first used to detecting the probability of sentence constructed by the writers, a string matching algorithm called Knuth-Morris-Pratt (KMP) Algorithm is used to detect and correct the error. According to the experimental results, the proposed approach can detect the error and provide the corresponding correction.

1 Introduction

In recent years, Chinese became more and more popular. Not only the Asian learning it as a mother language, but also people around the world learning as the second language. But Chinese is not easy to learn for almost every kinds of people. Due to the diversity of Chinese characters and flexibility of grammars, Chinese spelling correction plays an important role in both foreign learners and Natural Language Processing researchers.

Traditional Chinese is a sophisticated art. With Cantonese, it could be even harder. The high-educated may sometimes spell it wrong, not to mention those who are learning it. Because of the following reasons, Traditional Chinese is more difficult to learn than other languages. First, the Chinese’s grammar is more complicated and more flexible than English’s. For Cantonese usage, the orderings of some characters are sometimes incorrect. Second, Chinese characters are evolved from by Hieroglyphic. Every single character has its own meanings, but two or more characters combined to a word can express a whole different meaning. Therefore, we can simply classify the errors to Typo, which is spelling error, Cantonese usage, and ordering error. In this paper, we proposed the Chinese spelling check with Cantonese correction system using N-gram language model and Knuth-Morris-Pratt (KMP) algorithm. It can detect the spelling error and Cantonese usage form a sentence, then give the suggested correction.

In NLP-TEA 2017, a share task for Chinese spelling check (CSC) aims to detect and correct the spell errors in text. There are three error types defined in Table 1. ‘Typo’ for spelling error, ‘Cantonese’ for only Cantonese usage, ‘reorder’ for incorrect order in Cantonese usage. Some typical examples of the errors are shown in Table 1. For this shared task, each input could have multiple errors, which means that it might need several phrases to process each input sentence. As the result of that, the proposed system is divided as two phrases, Preprocessing phrase and Chinese spelling check with Cantonese correction phrase.

| Error types      | Examples of erroneous sentences | Examples of correct sentences |
|------------------|--------------------------------|------------------------------|
| 拼字錯誤 (Typo) | 我喜歡吃楊瓜炒蛋飯。 | 我喜歡吃涼瓜炒蛋飯。 |
| 粵語字詞 (Cantonese)| 佢比你高 | 他比你高 |
| 語序錯誤 (Ordering) | 我先走然後去打球 | 我先走然後去打球 |

Table 1: Some typical examples of the errors
For each input sentence, the system should output the location, length, and the corresponding correction. In order to address the problem, we need to establish Cantonese to Traditional Chinese dictionary. NLP-TEA 2017 released a dictionary about 1000 words, then we according to an open traditional Chinese and Cantonese dictionary (http://kaifangcidian.com/han/yue) added up to 8000 words. Figure 1 shows the example of Cantonese usage errors detected by the proposed system and Figure 2 shows the example of typo error errors detected by the proposed system.

- **Example 1**
  Input: 我們全家去度假
  Output: "全家去度假"

- **Example 2**
  Input: 她突然地對我說：「快點換衣服！不然就被上司批了！」
  Output: "批了" 削

- **Example 3**
  Input: 他問我該怎樣說：「我想你一套戲筆。」
  Output: "戲筆" 小編

- **Example 4**
  Input: 我在書局工作時，他們會招待外國人士的家園，他們成日講，可是我們不喜歡他們。經常去書房，可是我們不喜歡他們。
  Output: "香港" 便

- **Example 5**
  Input: 為什麼所有人也結婚男主角可以離婚？
  Output: "結婚" 便

**Figure 1:** Examples of Cantonese usage errors output by proposed system

- **Example 1**
  Input: 我們全家去度假，慶祝新一年到來。
  Output: "慶祝新一年到來"

- **Example 2**
  Input: 她開始慢慢地說道：「我花多少時間上段車了！」
  Output: "我想你一套戲筆。"

- **Example 3**
  Input: 他問我該怎樣說：「我想你一套戲筆。」
  Output: "戲筆" 小編

- **Example 4**
  Input: 每年的情人節，爸爸都會送他的朋友花店，送花就是媽媽工作的花店，爸爸會給媽媽送最美的玫瑰花給她們。
  Output: "玫瑰花" 便

- **Example 5**
  Input: 現代科技的發展日新月異，不斷進步。
  Output: "日新月異" 便

**Figure 2:** Examples of Typo errors output by proposed system

This paper is organized as follows: Section 2 describe the proposed method of Chinese spelling check with Cantonese correction system. Section 3 we analyze the performance in experimental results of the proposed system. Finally, Section 4 the conclusion of this paper.

## 2 The Proposed Method

In this section, the processing flow is shown as follow. The proposed system is divided as two main phrases: Preprocessing phrase and Chinese spelling check with Cantonese correction phrase. In Pre-processing phrase, we first extracting the information from the data that NLP-TEA 2017 released. First CKIP (Chinese Knowledge and Information Processing) Auto tag was applied to do word segmentation and obtain part-of-speech(POS). Then we proceed to Chinese spelling check phrase. Based on the POS, we determine whether the words in the sentence is correct, detail will describe in section 2.1. In section 2.2, we will describe the process of Cantonese correction and the algorithm we applied.

### 2.1 Language Models for Error Chec-king

In this section, we will explain how the works, and the method we used for checking words in sentences.

Equation 1 is the possibility of a string of characters from N-gram language model. For example, a string “我(I) 吃了(ate) 漢堡(hamburger)” can obtain the possibility $P("我(I) 吃了(ate) 漢堡(hamburger)")$ is equal to the production of $P("我(I)")P("吃了(ate)")$ and $P("漢堡(hamburger)")$ or $P("我(I)吃了(ate)")$. In which $P("漢堡(hamburger)")$ or $P("我(I)吃了(ate)")$. With this approach, we can count the word and calculate the words’ possibility. Furthermore, use this possibility to measure whether the word is correct or not.

Equation 1: Equation of the N-gram language model

$$P(S) = P(w_1, w_2, \ldots, w_n) = P(w_n | w_1, w_2, \ldots, w_{n-1})P(w_{n-1} | w_1, w_2, \ldots, w_{n-2}) \ldots P(w_2 | w_1)P(w_1)$$
After, we introduced the E-HowNet and a dictionary of Similar Pronunciation & Shape in Chinese character. We input the pre-processed data into proposed system, comparing with E-HowNet dictionary, processing flow shown as Figure 3.

![Figure 3: Example of comparing flow](image)

With the collection of possibly incorrect words, we find the similar character from the dictionary of Similar Pronunciation & Shape in Chinese character to exchange the character in word separately. Then compare with E-HowNet dictionary again, if the exchanged word exists, means the exchanged word is correct and save it into a file. The following Figure 4 shows an example of word exchanging, we exchange a character separately, then compare with E-HowNet dictionary, if the exchanged result exists in E-HowNet, the process will stop and move on to the next word.

![Figure 4: The exchange process of the word](image)

### 2.2 Knuth-Morris-Pratt Algorithm for Correction

The correction system’s main algorithm is based on KMP string matching algorithm. The KMP algorithm is used to search the specific string in a sentence. KMP is known for its highly effectiveness because it can search the specific string without starting over. In the middle of searching, we can also note down the position of the target string, which helps us to find out where the Cantonese usage is. Figure 5 shows an example of KMP algorithm, as the figure shows, we can skip lots of searching iteration.

![Figure 5: Example of KMP algorithm](image)

When it comes to Cantonese correction, it is a lot easier than English string, because most of the Cantonese word are the combination of two or three character, word’s length is often shorter than the English word. By the using of KMP algorithm, any words that built in the dictionary appears in sentences, we will note the position of the word and the translation of Cantonese usage. After search all the data, we will output a file that contain every result of the sentences, and according to this file output in the form of demanded format.

### 3 Experiments and Results

This experiment is based on the training data and testing data from NLP-TEA 2017. Each of the data contains 1000 sentences. After this experiment those sentences would be labeled with error tags and revise them or correct tags. And the results would determine by the performance standard given by NLP-TEA 2017 workshop. The evaluation matrices are shown as follow:

\[
Precision = \frac{TP}{TP + FP} \tag{2}
\]

\[
Recall = \frac{TP}{TP + FN} \tag{3}
\]

\[
Performance_{Detection} = \frac{2 \times Precision \times Recall}{Precision + Recall} \tag{4}
\]

The confusion matrix is shown below in Table 2.

| System Results | Positive | Negative |
|----------------|----------|----------|
| Golden Standard Positive | TP (True Positive) | FP (False Negative) |
| Golden Standard Negative | FN (False Positive) | TN (True Negative) |

Table 2: Confusion Matrix

Table 3 shows the detection performance evaluated by NLP-TEA 2017 workshop. TP, FP and FN
are 243, 143, and 509 respectively. By the formulas above, we can obtain precision, recall and performance are 62.9534%, 32.3138% and 42.7065% respectively.

| Metric | Value   |
|--------|---------|
| TP     | 243     |
| FP     | 143     |
| FN     | 509     |
| Precision | 62.9534% |
| Recall  | 32.3138% |
| Performance | 42.7065% |

Table 3: Detection performance by proposed system

There are other two standards for evaluations given by NLP-TEA 2017 workshop, Correction Performance and Overall System Performance. Correction performance is for each detected error, contestants’ system would deliver one or more (five at most) correction suggestions, if correction suggestions are correct means that the union between the golden standard suggestions and the contestants’ suggestions is not null. Following is the formula for Correction performance,

\[
\text{Performance}_{\text{Correction}} = \frac{1}{|W|} \sum_{i=1}^{|W|} \frac{|G_i \cap U_i|}{|U_i|}
\]  

Overall system performance means NLP-TEA 2017 ranked performance of the system as follows,

\[
\text{Performance}_{\text{Overall}} = \frac{2 \times \text{Performance}_{\text{Detection}} \times \text{Performance}_{\text{Correction}}}{(\text{Performance}_{\text{Detection}} + \text{Performance}_{\text{Correction}})}
\]

The result of proposed system evaluated by NLP-TEA 2017 is shown as follow:

| Type             | Value   |
|------------------|---------|
| Correction Performance | 95.4737% |
| Overall System Performance | 59.0149% |

Table 4. Correction performance and overall system performance by our system

4 Conclusions

This paper main purpose is solving the NLP-TEA 2017 shared task for Chinese spelling check with Cantonese usage. Our proposed methods include KMP algorithm string matching and N-gram language model. According to the result of proposed system, it shows our system have some weakness should be revised. Recall rate is not ideal, it means that the proposed system should revised the algorithm of detecting Chinese spelling. But there is an advantage in the proposed system, the performance evaluation given by NLP-TEA 2017 shows that the correction performance of our system archives 95%. Therefore, we believe the proposed system is feasible. In the future, we will make an effort to improve the overall performance, especially on error detection to increase the recall rate.

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