Synthetic Error Dataset Generation Mimicking Bengali Writing Pattern

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Abstract. While writing Bengali using English keyboard, users often make spelling mistakes. The accuracy of any Bengali spell checker or paragraph correction module largely depends on the kind of error dataset it is based on. Manual generation of such error dataset is a cumbersome process. In this research, We present an algorithm for automatic misspelled Bengali word generation from correct word through analyzing Bengali writing pattern using QWERTY layout English keyboard. As part of our analysis, we have formed a list of most commonly used Bengali words, phonetically similar replaceable clusters, frequently mispressed replaceable clusters, frequently mispressed insertion prone clusters and some rules for Juktakkhar (constant letter clusters) handling while generating errors.

Keywords: Bengali error dataset · Phonetically similar · Constant cluster · Spell checker

1 Introduction

Bengali is the seventh most spoken language in the world [9]. There are approximately 228 million native speakers of Bengali [1]. Bengali language went under a thriving Sanskritization which started in the 12th century and continued throughout the middle ages. This resulted in the vast gap between the pronunciation and the script. In Bengali, there are also a large number of constant clusters or Juktakkhars. Owing to this complexity, there are two most common reasons for misspelling. One is the phonetic similarity of Bengali characters and another one is the difference between the representation of the grapheme and the phonetic utterances. For example, "সহজ" and "শহজ" both have the same pronunciation though the correct spelling is "সহজ".

In our work, we consider "Avro" [2] for writing Bengali through English keyboard. Avro Keyboard supports phonetic layout named "Avro Phonetic" that allows us to type Bengali through the Romanized transliteration along with fixed keyboard layout. It is one of the most popular writing tools for Bengali. Here, we have selected "QWERTY" layout English keyboard, the most popular keyboard layout among users since early 1930 [8].

At present, there are a number of spell checkers available for Bengali such as Soundex [11], Double Metaphone encoding [13], a hybrid of Soundex, Metaphone and string matching [10] and so on. The datasets on which these algorithms were
tested were collected manually. Different users of Avro make mistakes in different ways. There is no study available on this issue. A robust analysis based automatic error word generation algorithm from correct word can come in handy while working with large amount of data. Introducing probability to such algorithm can help create varieties of error datasets from a large Bengali corpus within seconds, which in turn can help statistical data hungry machine learning based models to learn user behaviors for accomplishing various tasks.

In this research, we introduce a probability based algorithm for Bengali error dataset generation. Our algorithm mimics human writing error generating varieties of error with each run. In brief, our contributions are as follows:

1. Open source code for error word generation from input word
2. List of most commonly used Juktakhors along with 20 rules for handling them for error introduction
3. List of phonetically similar replaceable clusters, frequently mispressed replaceable clusters and frequently mispressed insertion prone clusters

All the above lists and the code are available for download [here].

2 RELATED WORK

A Bengali spell checker using Double Metaphone encoding was constructed in [13]. Another study [11] used Soundex code for error checking and fixing for Thai language. The Soundex algorithm was also used with Bengali language [12]. First, they converted Bengali word into Bengali phonetic code and then applied Soundex. Saha et al. [10] provided relevant suggestions for misspelled Bengali word correction. They combined edit distance, string matching, Soundex and Metaphone in their approach.

Mandal et al. proposed a Clustering-based approach for Bengali Spell checker [7]. They used Partitioning Around Medoids (PAM) algorithm [4]. Dynamic “Edit Distance Algorithm” was used in [3] for Kafi Noonoo language spell checking. The spell checker needs to consider different forms of the same word and can be time consuming. Kenneth et al. [6] developed a spell checker based on Shanon’s noisy channel model which is used to detect misspelling in English.

All of these researches work on finding the misspelled words and error patterns [5] and try to correct them. For machine learning based context level spell checker development and for proper evaluation of any new word level spell checker, we work on error pattern analysis for Bengali writing and provide an algorithm for automatic error corpus generation.

3 Our Dataset

We have collected 6.5 million sentences from various reputed news papers such as “Prothom Alo”, “Noya Diganta” and “BDNews24” through web scraping from online. The publishing time ranges from 2017 to 2019. The corpus consists of various topics such as politics, sports, economics, entertainment and literature. We have selected 8637 most
frequently occurring (appeared more than 1000 times in our corpus) words from our collected Bengali corpus for error dataset generation experiments. Some sample words along with two generated sample error words for each correct word have been provided in Section 5.

4 Methodology

The steps of error word generation from an input correct word in our algorithm have been shown in Figure 1. They are described as follows:

4.1 Distinguishing Between Normal Letter and Juktakkhor

We have selected total 170 Juktakkhors that are most commonly used in Bengali. We can identify a Juktakkhor if we check for the symbol '◌' in between two alphabets. For example, regarding the word "পােঞ্জরী -> প + ◌া + ে◌ + ন + ◌্ + জ + র + ◌ী", the normal letters are 'প', '◌া', 'ে◌', 'র', '◌ী' and the Juktakkhor is "ঞ্জ -> ন, ◌্, জ".

We provide five sample Juktakkhors in Table 1 with examples. The complete list has been provided here.

| Sl. | column no. 1 |
|-----|--------------|
| 1   | "ক্ট = ক + ◌্ + ট; যেমন- ডক্টর" |
| 2   | "ক্ত = ক + ◌্ + ত; যেমন- রক্ত " |
| 3   | "কৰ্ন = ক + ◌্ + র; যেমন- চকর" |
| 4   | "ক্ষ = ক + ◌্ + ষ; যেমন- পক্ষ " |
| 5   | "ক্ষ্ম = ক + ◌্ + ষ + ◌্ + ম; যেমন- লক্ষ্মী" |

Table 1. Some Words Containing Juktakkhors
4.2 Juktakkhor Handling

Through detailed analysis, we have come up with 20 rules regarding the generation of Juktakkhor related errors which are realistic. Five sample rules out of the 20 are as follows:

1. "জ্ঞ = জ + ঞ ", if this constant cluster 'জ্ঞ' is found in front of a word, it may change with letter 'গ' by mistake, for example, "জ্ঞান -> গান". Otherwise, no change is needed, for example "িবজ্ঞ".

2. "গ– = গ + য", if it is found in the beginning, it could be 'গা' by mistake. For example, "গাস -> গাস". If found elsewhere, then it can convert to 'জ্ঞ'. Example: "ভাগা -> ভাজ্ঞ, ভািগ–স -> ভািজ্ঞশ".

3. "চ্ছ = চ + ছ" can be mistakenly replaced by "ছঝ -> ছছ/ ছ". Example: "লািচ্ছ -> লাছিছ"

4. If there is 'য ফলা' -> '◌–' at the end of a Juktakkhor, it may be omitted by mistake. Example: "সামগৰ্– -> সামগৰ्".

5. If there is 'য ফলা' -> '◌–' in the beginning or at the middle of a word, it can be replaced with '◌া' or 'ে◌'. For example, "ব–বহার -> বাবহার, েববহার".

We provide all the 20 rules in detail here. Rest of the subsections under the current section deal with single letters.

4.3 Phonetically Similar Cluster Replacement

Phonetically similar alphabets in Bengali have the same pronunciation or phonetic utterance. If two of the letters have the same type of phonetic similarity, then these letters can be interchanged for making an error word. Five sample letters along with their replaceable letter siblings have been provided in Table 2. For example, if we want to write 'ক', we have to press letter 'k' which will suggest us 'ক'. Though, for the alphabet 'খ', we press 'kh' in Avro. The letter 'h' can be omitted by mistake and can turn into 'ক'. That is why, in row number 1, there is no replacement for 'ক' but for letter 'খ', the replacement is 'ক'. The full table has been given here.

| Serial No | Alphabets | Replaceable Alphabets |
|-----------|-----------|-----------------------|
| 1         | 'ক'       | []                    |
| 2         | 'খ'       | 'ক'                   |
| 3         | 'ঘ'       | 'গ'                   |
| 4         | 'অ'       | 'ও'                   |
| 5         | 'স'       | 'শ', 'ষ'              |

Table 2. Phonetically Similar Cluster Replacement Table
4.4 Single Letter Mispressed Cluster Replacement

We are writing Bengali through English QWERTY keyboard. So, if we intend to write ‘ক’, we have to press button 'k' on the keyboard. As letter 'j' and 'l' are adjacent to letter 'k' in English QWERTY keyboard, 'জ' or 'ল' can accidentally replace 'ক'. Five sample mispressed clusters are shown in Figure 3. The full list has been given here.

| Serial No. | Alphabets | Replaceable Alphabets |
|------------|-----------|-----------------------|
| 1          | ‘ক’       | ‘ল’, ‘য’              |
| 2          | ‘খ’       | ‘কগ’, ‘কজ’, ‘লহ’, ‘ঝ’ |
| 3          | ‘গ’       | ‘ফ’, ‘হ’              |
| 4          | ‘ন’       | ‘ব’, ‘ম’              |
| 5          | ‘ল’       | ‘ক’                   |

Table 3. Single Letter Mispressed Cluster Replacement Table

4.5 Single Letter Mispressed Cluster Insertion

When we write a word of reasonably high length, there is a chance for a letter to be inserted by mistake. Suppose, a user wants to write “আমজনতা” using Avro. After pressing the letter ‘j’ for writing ‘জ’ the user can accidentally press letter ‘k’ and can insert ‘ক’ after ‘জ’. This type of error is considered in the single letter mispressed cluster replacement class. As ‘j’ is at the right side of the keyboard, the immediate right key ‘k’ can be accidentally pressed. Similar analogy can be given for the keys situated to the left.

Five such examples have been provided in Table 4. The full list of such probable mistakes have been provided here.

| Serial No. | Alphabets | Insertion Prone Alphabet |
|------------|-----------|-------------------------|
| 1          | ‘ক’       | ‘ল’                     |
| 2          | ‘খ’       | ‘গ’                     |
| 3          | ‘গ’       | ‘ফ’, ‘হ’               |
| 4          | ‘ড’       | ‘স’                     |
| 5          | ‘ন’       | ‘ম’                     |

Table 4. Single Letter Mispressed Cluster Insertion Table

5 Results and Discussion

There are four probability values to tune in our algorithm. They are as follows:
– Phonetically similar cluster letter replacement probability (PP)
– Mispressed cluster letter replacement probability (MP)
– Juktakhorr change probability (JP)
– Mispressed cluster letter insertion probability (IP)

Through a lot of manual analysis, we have found out that the common values of PP, MP, JP and IP are 0.25, 0.2, 0.3 and 0.2 respectively. Ten sample correct words along with two error words for each of them have been provided in Table 5. These errors have been generated using our algorithm where the common values of the four probabilities have been used.

Insertion and mispressed cluster replacement take place mostly in words of length greater than three where each Juktakhorr is counted as only one letter. The number of these two kinds of errors generally do not occur more than once per word. We handle these cases in our algorithm. By tuning the values of PP, MP, JP and IP, you can make your dataset more or less error prone. For example, by making the value of IP equal to zero, you can exclude all sorts of insertion from your dataset. Increase of these four probability values can help model the error behavior of a beginner Avro user while decreasing them can help model the errors of an expert Avro user.

Although our algorithm generates misspelled word from an input correct word, it can be used to generate incorrect Bengali corpus from a correct corpus of large size as well. A corpus can ultimately be broken down into words. Our error generation process is stochastic. As a result, with the same values of the four probability parameters and with the same corpus, multiple error datasets can be generated in seconds which will look completely different by simply running the algorithm multiple times.

| sl. | Correct word | Possible error words |
|-----|--------------|----------------------|
| 1   | "কািলয়াকইর" | "কািলয়াৈকড়, কািলয়াকইর" |
| 2   | "টাঙ্গাইল"  | "তাঙ্গাইল, টাঙ্গাইল" |
| 3   | "টৰ্ােক"  | "েতরােক, তৰ্ােক" |
| 4   | "েপটৰ্লেবামা" | "েপতরলেবামা, েপতৰ্লব্মা" |
| 5   | "িতনজন"  | "িতণজন, িতনেজান" |
| 6   | "দগ্ধ"  | "দগধ, দগদ" |
| 7   | "ব–বসায়ী" | "েববসায়ী, েববসািয়" |
| 8   | "েগৰ্প্তার" | "গেরপ্তার, েগেরপতার" |
| 9   | "েচষ্টা"  | "েচষতা, েচস্তা" |

Table 5. Algorithm Generated Sample Error Words

6 Conclusion

In this research, we present a unique algorithm for generating Bengali error words from correct words which can be used for evaluating the performance of various word and
context level spell checkers for Bengali language. The code has been made open source. As by product of the analysis, we have obtained important insights regarding Juktakkhor and single letter related errors which include replacement, insertion and deletion. We have also made these findings public through this research which will hopefully facilitate further research in Bengali. Future study can focus on making a learning based contextual paragraph correction module. Pattern of human error can also be learnt by generating large amount of error data using our algorithm. Such automated learning can be used for building helpful word or character level suggestion generation module for Bengali writers.

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