Multi Script Text Transliteration to Punjabi

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Abstract

Machine Transliteration is becoming an important research area in Machine Translation, which ensures phonology of target language word. This paper describes the transliteration system that has been developed for multi script text. The proposed system is capable of transliterating English and Hindi text into equivalent Punjabi text using a rule based transliteration approach. Transliteration is more phonetic process because transliteration is more closely related with utterance. Thus there is need to perform phonetic analysis in addition to orthography for forming rules. The accuracy of English-Punjabi and Hindi-Punjabi transliteration is found to be 94% and 98% respectively.

Keywords: Grapheme, Orthography, Phonetic, Translation, Transliteration, Transliteration Rules

1. Introduction

Transliteration means transliterating a word written in one language to another language without compromising with its phonetic properties. Machine translation is a process that transforms/translate message written in one script into message written in target script. It keeps exact meaning of the word. The most important requirement of machine transliteration system is to preserve the phonetic properties of source language after the transliteration in target language. Thus during transliteration, we have to maintain syllables' sound in words. In this paper we have presented an approach toward Multi Script Text Transliteration. The system of multi script transliteration can transliterate English and Hindi text into target Punjabi text.

The remaining part of this paper is organized in 4 sections. In section 2 we have described the related work that is done in the field of machine transliteration. Then we have described basic approach and various rules for multi script transliteration in section 3. In section 4, performance evaluation is discoursed. Finally in section 5, we have given conclusion of it.

2. Related Work

In transliteration, significant research has been done for Indian scripts and for foreign scripts. Knight and Graehl have presented a statistical model. The model is based on phoneme and it uses finite state transducer. This model applies various rules for mapping to perform backward transliteration. To transliterate words from Japanese back to English, they have proposed a method for automatic backward transliteration. Lee and Choi have presented a statistical transliteration model for transliteration from English language to Korean language. They have compared two SMT based methods i.e. direct method and pivot method. After comparing two methods, they have proposed a more effective method for transliteration that is hybrid one. Oh and Choi discussed phoneme based English language to Korean language transliteration system. Phonetic information, orthography information, and information regarding context is used in this system. Punjabi Machine Transliteration System has developed by Malik that uses transliteration rules to map words written in Shahmukhi script to its corresponding words written in Gurmukhi script. Saini and Lehal...
have performed transliteration from Shahmukhi script to Punjabi language. They have proposed a corpus based system for transliteration. The proposed system has been successfully tested on a small data of story, article, and poetry. It has claimed 91.37% of average transliteration accuracy\(^1\). To transliterate Hindi words into Punjabi equivalent, a transliteration system has proposed by Goyal and Lehal. Complex set of rules have implemented for more accurate transliteration\(^5\). Vijaya et al. have developed a system called “WEKA” that can perform transliteration from English language to Tamil language. They have demonstrated a transliteration model based on multi class classification approach. It is a Rule based system that has resulted accuracy rate of 84.82%\(^16\).

Josan and Lehal have implemented a system for Punjabi to Hindi words transliteration. They have combined simple approach of character to character mapping with various rules and Soundex based enhancements. There is some dependency or contextual rules that are manually crafted\(^7\). Kaur and Josan have proposed transliteration system from English to Punjabi. It is statistical machine transliteration system that is created by using MOSES. MOSES is a statistical machine transliteration tool. The system has attained average accuracy of 63.31%\(^6\). Deep and Goyal have proposed a by using various mapping rules to transliterate person names from Punjabi to English. It is grapheme based method. The proposed technique has demonstrated transliteration for common names of persons, cities, states, rivers etc. and achieved 93.22% accuracy\(^7\). Josan and Kaur have proposed Punjabi to Hindi text transliteration model. It is a statistical model that is builds on statistical techniques. It has claimed accuracy rate of 87.72%\(^6\). Dhore et al. have focused on transliteration of Hindi and Marathi to English using a phonetic based direct approach\(^3\). Rathod and Dhore have presented machine transliteration for Hindi and Marathi to English using Support Vector Machine. The system is tested for person names and place names and achieved accuracy of 86.52% for 5-gram\(^14\). Bhalla et al. have proposed English to Punjabi transliteration scheme using various transliteration rules. For name entities such as proper names and location names, probabilities are calculated. The proposed scheme has claimed 88.19% accuracy\(^1\). Joshi et al. have used statistical machine learning approach to do transliteration from Roman script to Devanagari script\(^8\).

3. Methodology

3.1 Approach Followed

Rule based approach is followed for multi script text transliteration system. To achieve high performance and more accurate result of transliteration we have considered grapheme information and phonetic information during rule formation.

3.2 Proposed Machine Transliteration Process

To produce final transliteration result in target language i.e. Punjabi, the multi script input text passes through various phases, as shown in following Figure 1,

![Figure 1. Basic Transliteration Approach.](image)

3.2.1 Preprocessing

The main step of this module is to identify the language. The language is identified according to the Unicode of input words.

3.2.2 Segmentation

This module segments the source string. It generates transliteration units of Hindi/English language. It segments English and Hindi strings.

3.2.3 Transliteration

Based on framed rules, transliteration module maps English and Hindi text into resultant Punjabi text.
Preceding and following characters in a given word are also taken into consideration for more appropriate result.

3.3 English-Punjabi Transliteration Rules

In most of the cases, consonants of English language are directly mapped to the consonants of Punjabi language. But only direct character to character mapping is not enough for performing transliteration, because it may lead to poor result of proposed system. So there is need to develop different rules to improve accuracy of the system.

3.3.1 First Vowel Character and Last Vowel Character in Word

| Character Combinations at First Position | Source Word | Target Mapping | Target Word |
|------------------------------------------|-------------|----------------|-------------|
| 'a' followed by consonant                | aman        | ਅਮਨ          | ਅਮਨ        |
| 'an'                                     | ankit       | ਅਕਿਤ          | ਅਕਿਤ        |
| 'ea'                                     | eagle       | ਈਗਲ          | ਈਗਲ        |
| 'ei'                                     | eight       | ਈਟ            | ਈਟ          |
| 'in'                                     | India       | ਇੰਡੀਆ        | ਇੰਡੀਆ      |
| 'oi'                                     | oil         | ਓਇਲ          | ਓਇਲ        |
| 'u' followed by 'double consonant'       | utter       | ਉੱਤਰ          | ਉੱਤਰ        |

3.3.2 CVCC Pattern (Double Consonants)

If there are double consonants in English word then they are transliterated into Punjabi gemination symbol i.e. ‘A d d a k’. There are 2 geminates that represent nasalized sound i.e. ‘mm’ and ‘nn’. So in most of the cases they are written with ‘Tippi’.

| Character Combinations | Source Word | Target Mapping | Target Word |
|------------------------|-------------|----------------|-------------|
| 'a' + double consonant | bhatt       | ਬੱਟ           | ਬੱਟ        |
| 'e' + double consonant | dress       | ਦ੍ਰੈਸ        | ਦ੍ਰੈਸ      |
| 'i' + double consonant | gill        | ਗਿਲ          | ਗਿਲ      |
| 'o' + double consonant | boss        | ਬੋਸ          | ਬੋਸ        |
| 'u' + double consonant | full        | ਫੁੱਲ          | ਫੁੱਲ      |

3.3.3 CVCC Pattern (Short Vowels) and CVCe Pattern

| Short Vowel | Source Word | Target Mapping | Target Word |
|-------------|-------------|----------------|-------------|
| 'a'         | fan, scan   | ਫੈਨ, ਸਕੈਨ    | ਫੈਨ, ਸਕੈਨ |
| 'e'         | bed, pen    | ਬੈੱਡ, ਪੈੱਨ    | ਬੈੱਡ, ਪੈੱਨ |
| 'i'         | big, swim   | ਬਿੱਗ, ਸਵਿੱਮ    | ਬਿੱਗ, ਸਵਿੱਮ |
| 'o'         | dog, stop   | ਬੋਗ, ਸਟੋਪ    | ਬੋਗ, ਸਟੋਪ |
| 'u'         | cut, bus    | ਕੱਟ, ਬੱਸ        | ਕੱਟ, ਬੱਸ  |

3.3.4 Resolving Ambiguities

In every language there are some words or characters that represent ambiguous pronunciation. For example, English
consonant 's' represent different pronunciations like 'ਸ' or 'ਜ' in Punjabi. For example pronunciation of word 'base' or 'page'. Other ambiguous character is 'ਗ'. There is need to refer to surrounding characters in order to resolve this problem. Rules for handling such ambiguous characters are discussed in Table 6.

3.3.5 Silent Letters

Various rules are also framed for different silent letter combinations like ck, wr, kn, mn, mb, mp, dg, gh, wh etc. E.g.: trickਕ੍ਰਿਕਤ, wholeਵਹਲ, writeਲਿਟਵਾਇਟ, knowਕਾਨੂਨ, columnਕਲਮੂਨ, companyਕੰਪਨੀਕਾਮੂਨ, fridgeਫ੍ਰੈਜਿਕੈਫ, thoughtਥੌਟਥੌਟ, etc.

3.3.6 Unreduced Vowel (Schwa and Consonant)

Certain words in English language are often pronounced with full vowels with unstressed syllables. For example words careਕੇਅਰ, affairਅੱਫੇਅਰ, realਕੀਰਾਲ, potentialਪੋਟੈਂਸ਼ੀਅਲ, cruelਕਰੁਅਲ, hereਹੇਅਰ, gorgeousਗੋਰਜੀਅਸ, etc.

| Character Combinations | Source Word | Mapping Target Word |
|-------------------------|-------------|---------------------|
| 'g' followed by 'en'/\'in'/\'ic'/\'im' | General, margin, logic | 
| 'ange'/\'enge' | Orange, challenge | 
| 'ਗ' preceded by 'a'/\'d' + followed by 'e' | page bridge | 
| 'ਸ' preceded by 'ou'/\'a' + followed by 'e' | mouse, base | 
| last 's' preceded by 'sse'/\'che'/\'ie' | classes, benches, parties | 
| 'ਸ' followed & preceded by vowel | Season | 

Table 6. Rules for Ambiguity Resolution

3.4 Hindi-Punjabi Transliteration Rules

Most of the letters in Hindi have one to one correspondence with Punjabi letters. Hindi and Punjabi are more closely related languages because there are various similarities in the syntax and vocabulary of both languages, the sound of most of the letters is same in both scripts. But only direct mapping does not provide accurate result. There is need to develop different rules for more accurate transliterations.

3.4.1 Rules for Ambiguity Resolution

Hindi words may have more than one representation based on the perception of the transliterator. For example Hindi word 'प्यास' can be represented in Punjabi as 'ਪਿਆਸ', 'ਪੀਆਸ', 'ਪਿਯਾਸ', 'ਪਯਾਸ'. Most of the ambiguous words are

| Character Combinations | Hindi Word | Mapping Target Word |
|-------------------------|-------------|---------------------|
| 'ਯ' is at first position | 
| 'ਯਾ' / 'ਯੋ' / 'ਯਾ' | 
| 'ਯੋ' / 'ਯੋ' / 'ਯੋ' are at last position | 
| 'ਯ' is preceded by half character | 
| 'ਯ' is followed by 'ਭ' | 
| 'ਯ' is followed by '਼' | 
| 'ਯ' is preceded by '਼' | 
| 'ਯ' is preceded by '਼' | 
| 'ਯ' is preceded by '਼' | 
| second and last character is 'ਯ' and previous is consonant | 

| Character Combinations | Hindi Word | Mapping Target Word |
|-------------------------|-------------|---------------------|
| 'ਯ' is preceded by '਼' / '਼' | 
| 
| Table 7. Rules for Ambiguity Resolution in Hindi |
resulted due to the presence of Hindi consonant 'य'. The framed rules for resolving ambiguities are discussed in following Table 7.

### 3.4.2 Rules for Middle Vowel Character

Hindi vowels are mapped to different target characters based on their position in given word. For example Hindi vowel 'ि' is not always mapped to 'ी'. Sometimes it is mapped to 'ँ' according to its position and surrounding characters in a given word. Table 8 shows various rules proposed for middle vowel character.

### 3.4.3 Rules for Half Characters

Half character form is used to represent sound duplication in Hindi language. But in Punjabi, gemination adhak 'ं' is there to duplicate consonant sound. The mapping of half character in target language is greatly depends on the next character combination. The mapping of such characters is shown in following Table 9.

### Table 8. Rules for Middle Vowel

| Character Combinations | Hindi Word | Punjabi Mapping | Punjabi Word |
|------------------------|------------|-----------------|--------------|
| ‘ह’ is preceded by ‘े’ | सेहल      | ‘ि’            | मखिंद        |
| या is preceded by ‘े’  | तेयार      | ‘ि’            | उफिण्ड        |
| ‘ह’ is followed by ‘ू’ | महफूज    | ‘च’            | भंजिन्ड        |
| ‘ि’ is followed and preceded by ‘ा’ | जातविद ची | ‘ँ’           | नजीवच        |
| ‘ि’ is preceded by half character | अगनिथि ि‘ि’ | भंजीभि        |
| ‘ि’ is at second last position and ‘या’ is at last | एशियि ‘ि’ | टेसीभि        |
| ‘ि’ is at last | सुक्तियि ‘ि’ | मखिंदि        |

### 3.4.4 Rules for Nasalized Characters

Nasalization in Hindi is presented by anusvara, chandrabindu and some nasalized consonants. Nasal character ‘Anusvara’ and ‘Chandrabindu’ of Hindi are mapped to either ‘Bindi’ or ‘Tippi’ in Punjabi according to the matching rules. Commonly used nasalization consonants in Hindi are ‘म’, ‘न’ and ‘ण’. When written with vowels or half character form then they are either mapped to ‘Bindi’ or ‘Tippi’ in Punjabi. Table 10 shows various rules proposed for handling Hindi nasalized characters.

### Table 10. Rules for Nasalized Characters

| Character Combinations | Hindi Word | Punjabi Mapping | Punjabi Word |
|------------------------|------------|-----------------|--------------|
| ‘ं’ is not preceded by ‘ै’/ ‘ौ’ | मंत्री      | ‘े’            | भंजी        |
| ‘ं’ is preceded by ‘ै’/ ‘ौ’ | कंग्रेस      | ‘े’            | भंजीमं    |
| ‘ं’ is preceded by half character | कंग्रेस ‘ँ’ | भंजीमं        |
| ‘ं’ is preceded by ‘ौ’/ ‘ौ’/ ‘ौ’ | मुकुंद    | ‘े’            | भंजीपुं    |
| ‘ं’ is preceded by ‘ौ’/ ‘ौ’/ ‘ौ’ | दायरा      | ‘े’            | भंजीपुं    |
| ‘ं’ is preceded by ‘ौ’/ ‘ौ’/ ‘ौ’ | संघीयां      | ‘े’            | भंजीपुं    |
| ‘ं’ is preceded by ‘ौ’/ ‘ौ’/ ‘ौ’ | व्यापारिक    | ‘े’            | भंजीपुं    |
| ‘ं’ is preceded by ‘ौ’/ ‘ौ’/ ‘ौ’ | व्यापारिक      | ‘े’            | भंजीपुं    |
| ‘ं’ is preceded by ‘ौ’/ ‘ौ’/ ‘ौ’ | प्रधानमंत्री    | ‘े’            | भंजीपुं    |
3.4.5 Rules for Common Conjunct Consonants

Conjunct consonant is a combination of two or more consonants which are pronounced together without the pronunciation of the inherent ‘a’ vowel between them. Hindi conjunct consonants have no direct mapping in Punjabi. These letters are mapped according to the rules as shown in Table 11.

| Hindi Characters to form Conjunct | Hindi Conjunct Consonants | Corresponding Punjabi Characters |
|-----------------------------------|---------------------------|---------------------------------|
| क + उ | क्ष | च + श |
| ज + उ | ज्ञ | ज + भ |
| क + ऐ | क्र | च + उ |
| त + ऐ | त्र | त + र |
| द + ऐ | द्र | द + र |
| श + ऐ | श्र | श + र |
| द + अ | द्ध | द + ध |

Table 11. Hindi Conjunct Consonants Mapping

4. Performance Evaluation

Word Accuracy Rate is used to evaluate machine transliteration system. It is defined in percentage i.e. number of accurate transliteration by total transliterations produced by proposed system. This system is successfully evaluated on data of news of more than 10,000 words and other domains like names of persons, locations etc. The word accuracy rate of proposed transliteration system is shown in following Table 12. Figure 2 shows the snapshot of multi script text transliteration system.

| Language | Accuracy (%) |
|----------|--------------|
| English  | 94%          |
| Hindi    | 98%          |

Table 12. Accuracy of Transliteration System

5. Conclusion

Here we have presented machine transliteration system that is developed for multi script text using a rule based approach. Transliteration does not rely only on source grapheme, it is a complex process, which. Because the transliteration is more phonetic, it is difficult to attain accurate results without considering phonetic information. Phonetic transliteration is followed to generate Punjabi equivalent of English and Hindi that works according to the transliteration rules. Besides direct character-to-character mapping, various rules have also been devised for transliteration in order to resolve various ambiguities and thus to obtain more accurate transliteration. Both orthographic and phonetic information is considered.

It is not easy task of developing transliteration system for different languages like English and Punjabi due to lot of differences in syntax and vocabulary. Transliteration of different languages pair is little bit difficult because there are many factors that affect the result such as difference in...
source and target script in writing, difference in number of alphabets of source and target language, phonetic properties, and length of word. The accuracy of Hindi to Punjabi transliteration is very good as both are closely related languages. English to Punjabi transliteration system also provides promising result.

This system is evaluated on data that is taken from different news and overall accuracy of the system is very good. It also does accurate transliteration of some names of person and location. Proposed system can be further improved by adding more rules for unique and unknown words.

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