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Schwa Deletion in Hindi Language Speech Synthesis

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ABSTRACT--- Schwa deletion is important factor for conversion of Grapheme to Phoneme. In Hindi language each consonant has weak vowel. This weak vowel is called as inherent schwa. These schwa is deleted some cases in pronunciation. Written form and speech forms are different in Indian language. Schwa plays important role in speech form. Deletion and retention of weak vowel decides how words are pronounced. Words morphology is main factors that affects pronunciation. In current paper, we describe schwa handling, deletion and retention rules. Based on different rule we developed schwa deletion algorithm. This algorithm has been tested over 6000 high frequency words. We received accuracy result up to 80%. Based on result an application has been developed to provide user interface for the text processing component of text to speech system.

Keywords - Schwa, grapheme to phoneme, weak vowel, inherent schwa, pronunciation

I. INTRODUCTION

Hindi is the major language in India spoken by 41% population of India and other language speakers (for each language) are less than 9% as per census India data [12]. However, good quality Hindi Text To Speech (TTS) is not available to deploy in real time applications. Though, many Indian language prototypes are available, the quality is not up to commercial use. The quality of Text To Speech (TTS) greatly depends upon linguistic knowledge such as grapheme to phoneme mapping, schwa deletion, syllable structure and pronunciation dictionary.

Pronunciation lexicons are the interface between grapheme (written form) and phoneme (interpretation / spoken form). For a natural language it is not possible to explicitly list all the words in that language. So, when a new word comes up which is not explicitly listed, the lexical lookup fails in that case as discussed by Ohala [3]. This necessitates conversion from grapheme to phoneme to generate pronunciation lexicon in text to speech systems. Hence, rule based grapheme-to-phoneme processes any input orthographic unit sequence to build pronounceable phoneme sequence as discussed in signal processing and acoustic portal [11]. But, orthographic form deviates from the pronounceable form. The way a word is written is not as it is pronounced. Complexities like nasals, ligatures have to be formulated.

In Hindi languages, schwa deletion plays a crucial role in appropriate pronunciation. Orthographic form does not provide any indicators that where schwa needs to be dropped. Schwa deletion is extremely important for intelligibility speech. Schwa is a mid-central unstressed vowel that occurred normally in unstressed syllables.

Each consonant in Hindi has inherent schwa (weak vowel) which is not shown orthographically.

Example : कलम =/k1l1m/

These are deleted in some cases in pronunciation. To handle schwa deletion and insertion, already work has been done to define schwa deletion rules and algorithm. For Hindi, two main issues are handled in Narasimhan, Sproat, Kiaraz work [1]. First, not every schwa following a consonant is pronounced within the word. Second, in multi morphemic words, the presence of a morpheme boundary can block schwa deletion where it might otherwise occur. Linguistic literature by Ohala [3] has discussed schwa deletion rules and its behavior in morphological boundaries. Pray [4] made a proposal that schwa deletion rule applies from right to left.

Example : निकलवा =/nik1lwa/.

But, application of these rules on words like करवट =/ k1r1w1t'/ produces wrong output करव्ट =/ k1r1wt'/. The correct pronunciation is कर्वट =/k1rw1t'/. Analysis of data concludes that traversal from left-to-right, produces less such exceptions. Further, morphological separation of root words increases accuracy of identification and deletion of schwa. Practically, present schwa deletion algorithm [5] need many traversals through input string.

Our proposed schwa deletion method based on different schwa deletion rules. Pronunciation lexicon is the interface between visual form of text and auditory form i.e. speech. In TTS, target waveform selection is determined by phonemic representation of input text. Standard Hindi dictionaries contain meaning and phonemic pronunciation of word. But, none of dictionaries consider issue of pronunciation lexicon which as per World Wide Web Consortium (W3C) [13] is taking account of. Some institutes working on linguistics have prepared pronunciation lexicons. A pronunciation lexicon specifies pronunciation variants of word. Applications of TTS, automatic speech recognition (ASR) uses dynamic vocabulary.

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But, it is impractical to establish pronunciation lexicon with full coverage and therefore automatic grapheme to phoneme module is called for words which are not present in lexicon. Even pronunciation lexicon in TTS like systems take large space and searching slows down the performance of system.

Figure 1 shows Text processing flow of text to speech system. Invalid word किताब is corrected using text cleaning module before passing it to grapheme to phoneme module. It is useful to avoids wrong phonetic mapping of word किताब. After generation of grapheme to phoneme, word is passed to schwa deletion module for further processing.

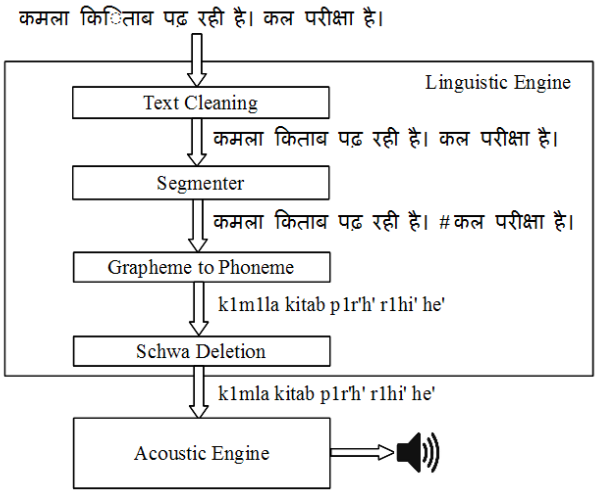

Fig. 1. Text Processing Flow.

II. GRAPHEME-TO-PHONEME

Grapheme to phoneme is a process of mapping word represented by sequence of graphemes to its pronunciation form, represented by a sequence of phonemes. Data driven algorithms are used to infer rules for grapheme-to-phoneme (G2P) automatically [11]. The data driven approach works similar as rule based approach, with question set stored in decision tree. It needs huge manual training for self-learning. In this approach, input word is scanned for matching in trained dataset and alignment is done for corresponding pronunciation. But, there are issues in alignment as there is not one-to-one mapping every time. Grapheme and phoneme lengths are always of not same length, hence null grapheme or null phoneme must be inserted for proper alignment [10].

Example: a. Single grapheme -> two phonemes
क्ष = /ksh'/
b. Two graphemes -> single phoneme
क़ = /q/

The most common notation is International Phonetic Alphabet [14]. But, symbols of International Phonetic Alphabet are more used in paper than to computers [8]. Instead of special characters used in International Phonetic Alphabet, we defined our own set of characters phonetic representation using ASCII- table [15]. Traditional rule based approach does not consider context based examples. Mapping of grapheme to phoneme is dependent upon context. So, more than one rule are needed for mapping.

Examples: Anuswara is mapped depending upon next context.

अंबा = Anuswara is mapped as m = /1mba/

अंडा = Anuswara is mapped as n = /1nd'a/

Anuswara is mapped to corresponding varga nasal of next consonant.

III. SCHWA (WEAK VOWEL) DELETION AND RETENTION

The different rules of schwa mapping, deletion and retention are explained below;

A. Schwa to vowel mapping for ह /h/

Orthographic form of words containing ह is pronounced differently. Schwa succeeding ह is mapped to matra ◌ु while pronunciation. Observing pronunciation of such a data by native speakers, rules are formed and validated. If word has schwa + h + schwa in phonetic, then schwa is mapped to e' matra as e'+h+e' [9].

Examples: a. कहकर = /ke'he'k1r/
b .बहन = /be'he'n/
c. बहना = /be'he'na/
d. सहकारी = /se'he'kari'/

B. Schwa (weak vowel) retention

- Schwa in first syllable is always retained.

Examples: a. अलग =/1l1g/
b. समर=/s1m1r/

- Schwa following conjugate syllable with final consonant as y / r / l /w is retained.

Examples: a. श्राव्य=/sh'rawy1/
b. साफल्य = /saph'1ly1/

- Schwa following conjugate syllable is always retained.

Examples: a. आमंत्रण = /am1ntr1n'/
b. संप्रदाय= /s1mpr1day/

- Schwa after final character h is always retained.

Examples: a. लोह=/loh1/
b. विरह=/wir1h1/

- If schwa is preceding full vowel then schwa is retained.

Examples: a. अलग =/1l1g/
b. समई = /s1m1i'/

- If य /y/ is final character preceded by vowels like a, i, i', u , u' then, schwa is retained. Whereas if preceded vowel is 1, e, e' then schwa is deleted.

Examples: a. प्रिय = /priy1/
b. काव्य = /kawy1/
c. लय = /l1y/

- Schwa (weak vowel) deletion

If schwa deletion is not combining more than two consonants then the schwa is deleted.

Examples: a. लोकतंत्र = /lokt1ntr1/ ,
b. पन्द्रह = /p1ndr1h1/

- Schwa is deleted only when there is preceding and succeeding vowel.

Examples: a. सतरंज = /s1tr1nj/

IV. ALGORITHM FOR SCHWA DELETION

Input word: String of phonemes.
Output: Input word with some of the schwas deleted [6, 7].

1. Mark all the full vowels in string of phonemes.
2. If vowel Count < 3 then do not delete schwa (1). As schwa in first syllable is always retained and second schwa is inserted only in specific conditions as motioned in schwa deletion rules
3. Else for vowel Count >= 3
   check vowel at vowel Position =2,

3.1. If vowel == Schwa (1) then check for consonant count between vowel Position = 1 and vowel Position =3

3.2. If consonant Count > 2 then do not delete schwa (1).

3.3. Else count consonants between vowelPos2 and vowelPos3.

3.4. If consonant Count = 0 then do not delete schwa (1). As succeeding matra will combine with consonant and it will change word itself.

3.5. Else delete schwa (1).
Nasal is considered as consonant.

V. APPLICATION

An Application has been developed to provide user interface for the text processing component. It takes word as input for text processing and generates pronounceable form of word i.e. phoneme string. Input can be taken in two forms: By browsing text file containing line separated words and by inputting word in text box. Output can be saved in text file (Figure 2).

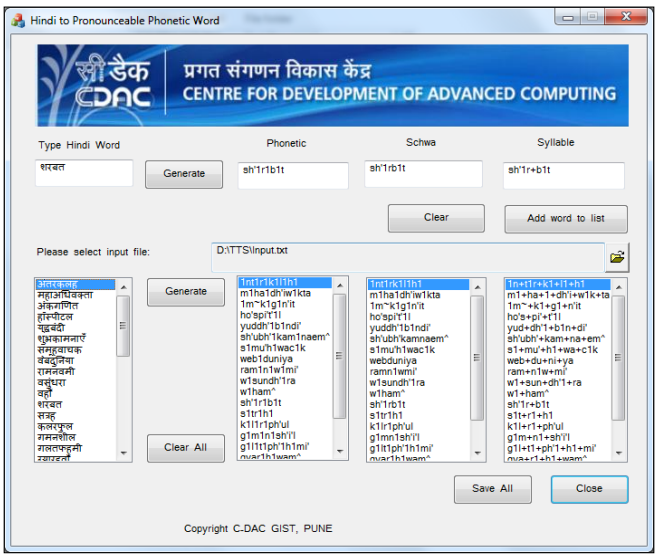

Fig. 2. Hindi to Pronounceable Phonetic word.

VI. RESULTS

Testing has been done on high frequency 6000 Hindi words. Testers having phonological knowledge of Hindi were used. Testers were of category native speakers, researchers in linguistics, testers for language technology products (see Table1). where Vowel classification is shown in Table 2.

Grapheme to phoneme conversion is direct one to one mapping with Hindi specific rules. So, it gives expected result for all the strings. Schwa deletion is rule based so there are possibilities of wrong schwa deletion and retention [1, 2].

Complete Data under test contains:
Input = 6000 words
Wrong schwa deletions = 120 words
Correct result set = 4800 words

If schwa deletion gives wrong output then the split syllable will also be wrong. If word is formed by joining two different root words or attaching prefix or suffix then schwa deletion gets wrong and word is split inaccurately.

Table 1. Sample Test Data Set

Hindi Unicode Word	Phonetic	Schwa Deleted	Syllable splitter	Mark Wrong Schwa deletion	Mark Wrong Split word
अंतरकलह	1nt1r1k1l1h1	1nt1rk1l1h1	1n+t1r+k1+l1+h1	Correct	Correct
महाअधिवक्ता	m1ha1dh'iw1kta	m1ha1dh'iw1kta	m1+ha+1+dh'i+w1k+ta	Correct	Correct
अंकगणित	1m~k1g1n'it	1m~k1gn'it	1m~+k1g+n'it	Wrong	Wrong
हॉस्पीटल	ho'spi't'1l	ho'spi't'1l	ho's+pi'+t'1l	Correct	Correct
शुभकामनाएँ	sh'ubh'1kam1naem^	sh'ubh'kamnaem^	sh'ubh'+kam+na+em^	Correct	Correct
समूहवाचक	s1mu'h1wac1k	s1mu'h1wac1k	s1+mu'+h1+wa+c1k	Correct	Correct
रामनवमी	ram1n1w1mi'	ramn1wmi'	ram+n1w+mi'	Correct	Correct
वसुंधरा	w1sundh'1ra	w1sundh'1ra	w1+sun+dh'1+ra	Correct	Correct

वहाँ	w1ham^	w1ham^	w1+ham^	Correct	Correct
शरबत	sh'1r1b1t	sh'1rb1t	sh'1r+b1t	Correct	Correct
सत्रह	s1tr1h1	s1tr1h1	s1t+r1+h1	Correct	Correct
कलरफुल	k1l1r1ph'ul	k1lr1ph'ul	k1l+r1+ph'ul	Wrong	Wrong
सुप्रिया	supriya	Supriya	sup+ri+ya	Correct	Wrong
			Result	80.00%	75.00%

Table 2. Vowel classification

Articulation	Monophthongs (Short)	Monophthongs (long)	Diphthongs
Guttural	अ /1/	आ /a/	
Palatal	इ /i/	ई /i'/	
Labial	उ /u/	ऊ /u'/	
Retroflex	ऋ /ri'/	-	
Palato-Guttural		ए /e/	ऐ /e'/
Labio-Guttural		ओ /o/	औ /au'/

VII. CONCLUSION

Schwa is a mid-central unstressed vowel that occurred normally in unstressed syllables. Accuracy of schwa deletion and retention can be improved by applying morphological knowledge. A set of rules have been developed for Hindi language. Based on different rule schwa deletion algorithm is developed. This algorithm is tested on high frequency Hindi words. The resultant data used will be useful for text to speech system.

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