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Vowel Analysis for Indian English

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Abstract

In the area of speech recognition accent plays a vital role. In this paper, we focus on the accent variations in Indian English with emphasis on the vowel analysis. Vowel analysis for Indian English is not performed extensively. In the present work, the formants of vowels for different accents are considered for comparison. We have considered four different accents of Indian English namely North Indian (NI), South Indian (SI), East Indian (EI) and West Indian (WI). The present investigation is performed using PRAAT tool with Indian English data set. Formant analyses have been carried out in two stages: (i) formant mean analysis, and (ii) the formant space analysis. Result from formant mean analysis shows that there is significant variation in accent from the first four formants (F1, F2, F3 and F4) individually. In addition, the formant space analysis depicts a gradual drift in different accent in the F1 vs. F2 formant space. Furthermore, we have plotted the triangle plot for better understanding the occurrence of vowel extremes in the accents. Results show that there exists a prominent difference in the accents of Indian English when formant features are considered.

Keywords: Indian English; Accent Variation; Acoustic-Phonetic; Formant; Vowel analysis

1. Introduction

India is a country which comprises of 23 official languages including English and also consists of more than 2000 dialects spoken throughout the country. English has been the prime source of language in the education system and Indian English (IE) is referred to as the English spoken by the Indians as their second language[1]. Even within the IE, there are many variations largely due to the L1(native language) of speaker influence the L2 (English) as well as usage, educational, social and regional background. English is a stress-timed language, however IE is syllable-timed language due to the influence of L1[2]. This circumstantiates IE to be a complex linguistic variety for analysis.

Acoustic Phonetic features extracted from the speech signal can be generally used to understand accent variation[3,4]. From the literature, it has been noticed that the acoustic-phonetic features of vowels are widely used to differentiate

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among the accents. The acoustic-phonetic features of speech are determined by a set of parameters such as pitch, intensity, duration and formant frequencies[5].

In recent past, research work has been carried towards the accent variation and the impact of L1 influence on English. A disclosure of the distinctions in the accents on the premise of formants or cepstrum elements and realization of the acoustic phonemic units of spoken American English, British English and Australian English has been studied by Seyed Ghorshi et al.[3]. The intra-accent variation by taking two sets of American English have been performed, which clearly discriminates one accent with the other. An extensive work was carried out by Herman Kamper et al. on the realization and significance of accents in South African English in speech recognition[6,7]. Initially, they realized three different varieties of South African English and later found five different varieties of South African English by calculating metrics based on the pronunciation dictionary. Hema and Melissa studied the influence of native language impact on the Indian English by analyzing the sound and timing patterns of Hindi and Telugu speakers[8]. A study on the vowel analysis for the North Indian English was performed by Olga and Janet. Their result deduced North Indian English to be a separate or a sub variety of Indian English[9]. Acoustic and durational properties of Indian English vowels were perpetrated to show a contrast for Hindi and Punjabi speakers[10]. Disha and Bharadwaja broadly categorised Indian English in two parts as North Indian and south Indian accents[11]. A dissimilarity between these two accents was observed to be nearly 14% in terms of word error rate and even after the adaptation there was a difference of 9% in the word error rate. This discrepancy was attributed as the pronunciation dictionary was inclined towards South Indian accent.

In this paper, we focus on the comparison of vowels and its influence on the accents of the Indian English. In this work Indian English is broadly divided into four major groups based on the regions which includes North Indian (NI), South Indian (SI), East Indian (EI) and West Indian (WI) to which the speaker belongs.The main focus is on the variation of IE accents considering vowels, that could be determined by formant analysis. The organization of the paper is as follows: section 2 comprises of the experimental design, section 3 constitute of the experimental analysis and results of vowels. The conclusions from our work are summarized in section 4.

2. Experimental Design

The experimental design consists of the acoustic-phonetic features and their evulsion process from the speech data. The speech features (formants, pitch, intensity, duration, etc.) related to the sound can be extracted from the spectrum. In this work, formants extracted from the spectrum are used as features for the vowel analysis. The dataset used for this work comprises of the IE speakers with different accents.

2.1. Spectrum

Spectrum is visually represented using a spectrogram, where three dimensional representation of the speech intensity in different frequency bands over a time is depicted[12]. Spectrum shows the distinctive characteristics between the voiced/unvoiced speech and vowel/consonant in spoken speech. The classification of voiced speech is done as it has high energy and low frequency whereas the unvoiced speech has high energy and high frequency. In most cases, a vowel corresponds to the lower frequency band and consonants corresponds to higher frequency band[5]. Formants can be seen in the spectrogram as dark bands. The darker the band of the formant on the spectrogram the stronger the sound.

2.2. Formant frequencies

A formant is a concentration of acoustic energy around a particular frequency in the speech wave. Each formant corresponds to a resonance in the vocal tract[12]. There are several formants, each at a different frequency; formants occur at roughly 1000Hz intervals. At any point in time (as with spectra) there may be any number of formants, in case of speech most information related to vowels are determined in the first four formants, referred to as $F1, F2, F3$ and $F4$. $F1$ frequency can be calculated as $F1 = c/4L$, where c is the speed of the sound and L is the length of the tube. The next occurring formant can be calculated by $Fz = F1(2z - 1)$, where z can be $2, 3$ or 4.

2.3. Dataset

As we have mentioned that India comprises of 22 official languages and consists of more than 2000 dialects it would be very tedious to collect data. Also a perfect demarcation between the accents would be difficult. For the present work, we have broadly divided the Indian English accents into 4 different types namely North Indian (NI), South Indian (SI), East Indian (EI) and West Indian (WI). The speech data is collected for a total of 16 speakers comprising of 4 speakers from each divided region. The speakers were aged between 20 to 60 and we have considered only male speaker for the analysis. Vowels extracted from NPTEL lecture videos [13] have been used as the dataset for this study. The 13 distinct vowels considered in this study and their notation is shown in Table 1.

Table 1. Phonetic symbols representation

Phone	a	e	i	o	u	a:	a;	e:	i:	o:	u:	v:	y:
IPA	ʌ	e	i	o	u	a	æ	eː	iː	oː	uː	ɔː	æː

2.4. Software

We have used PRAAT software for determining various phonetic features of the speech [14]. PRAAT is a flexible tool for speech analysis, as it is an open source software which is supported by most of the operating systems. It performs speech analysis, synthesis, manipulation, labeling and segmentation, graphics and has many other functionalities. We are using PRAAT for speech analysis as it comprises of spectral, pitch, formant, intensity and emotional state analysis [15].

3. Experimental Results by Vowel Analysis

This section summarizes the details of various investigations on the differences in vowels by considering formants for NI, SI, EI and WI accents of Indian English.

3.1. Formant Mean Analysis

To study the distinctive characteristics of the vowel trajectories, formant frequencies (F1, F2, F3 and F4) have been considered. These vowel formants will help to identify the distinction in accents of Indian English. Vowels can be classified in sound by three properties: length (tense/lax), position (high/low and front/back) and shape of lips (rounded, neural and spread). The characteristics of vowels such as the back and front articulation are associated with the high and low values of F2 respectively. Similarly, the close and open articulation are associated with the high and low values of the F1 formants respectively. Back and front refers to horizontal tongue positions during the articulation of a vowel. The height of the vowel refers to the vertical position of the tongue. F3 shows the distinction between rounded and unrounded vowels. Mostly, F3 and F4 formant analysis have been done on singing voice.

The average formants of vowels for NI, SI, EI and WI accents of IE are calculated. The average of the first, second, third and fourth formants of the vowels and diphthongs for the four accents of Indian English is shown in Figure 1. It can be deduced from the results that on an average WI accent have highest F1 values and lowest F4 values however, low F1 value for /o/ and high F4 value for /u/ was identified. SI on an average have the lowest F2 values. NI have a highest F4 value for /u/. East on an average has the highest F3 and F4 values. These inferences from the formant frequencies exhibit different comportment of vowels for each accents.

3.2. Formant Spaces Analysis

The vowel representation can be appropriately established by F1 vs F2 formant which deals with the age, gender, accent variability [16]. Here, the F1 vs F2 representation for analyzing variation in the accents of English across India was examined. F1 vs F2 formant spaces of the SI, NI, EI and WI accents of Indian English is shown in Figure 2. All

Fig. 1. Formant mean analysis for Indian English for NI, SI, EI and WI.

Fig. 2. F1 vs. F2 formant space analysis for vowel for IE accent.

these accents of Indian English show variations in comparison with one another. Vowels like /i:/, /u:/, /e:/ are raising and fronting in EI accent. A raising of vowel /a;/ from WI towards NI is clearly noticed. The WI accent vowel /a;/ is low, fronted and open when compared to other accents. The vowels in the SI are central and more towards back.
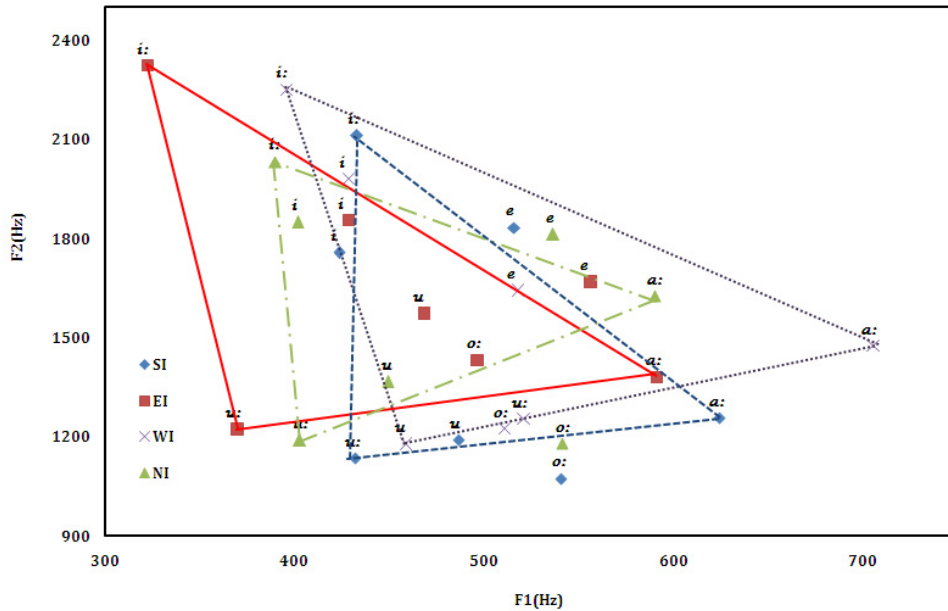
Fig. 3. A vowel triangle analysis for IE vowel accent.

Vowels /u/ and /o/ of the WI accent have similar formant spaces. It is clear that the WI accent vowels are much more open than the SI, NI and WI accents of IE. It is also noticed that the EI long vowels are more closed (/i:/, /u:/) when compared to others. It should be noticed that all the four NI, SI, EI and WI accents of IE differ in vowel pattern from each other. From the analysis of formant spaces, it is evident that a comprehensible variation of the accents of IE for vowels can be portrayed.

The triangle plot for the four accents (NI, SI, EI and WI) considered in this paper for analysis is shown in figure 3. The vowel triangle represents the extremes of the formants space on the F1-F2 plane. We have considered 7 vowels responsible for the accent variation such as /i:/, /i/, /e/, /o:/, /u/, /u:/ and /a:/. These vowels show an extreme difference with every other vowel distinctly. In this the /i:/ represents the low F1 and high F2, /u:/ represents low F1 and low F2 and /a:/ represents high F1 and low F2. We have also noticed that /u:/ of the WI is not having the low F1 and F2 values so we considered /u/ instead. This can also be said that the feature properties of /u/ and /u:/ are completely contrasting with other accents. These vowel variations also strongly emphasizes on the difference on vowel position from one accent to the other. From the above analysis, we can conclude that the vowel triangle formed for each accent shows a significant difference due to its L2 influence.

4. Conclusion

In this paper, accent variation of the Indian English has been investigated using vowel analysis. This perusal is entirely based on the formant frequency as it has been a prominent indicator for vowels. The accent variation of vowels was analyzed using the PRAAT software. To analyze the vowels we broadly divided IE accents to four different categories; NI, SI, EI and WI. The formant means shows that WI has highest F1 and lowest F4 values, SI has lowest F2 values, NI has highest F4 value for /u/ and EI has highest F3 and F4 values. The formant space for different accents of Indian English affirms that the formant frequencies of vowels for each accent vary significantly. Further, from the vowel triangle the variation of phoneme /u/ of WI from other accents was clearly distinguished. Each of the IE accent followed a certain unique trend for using the vowels which causes the variation from one another. So, we can conclude that the accent variation is prominent in IE vowels through formant analysis. These variations in the

vowel pronunciation could be due to the L1 influence which differentiates each accents of IE. In future, we intend to do an extensive analysis in the consonants and its contribution in the accent variation apart from vowels.

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