ACOUSTIC PHONETIC AND PROSODIC CORRELATES OF HINDI STOP CONSONANTS

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ABSTRACT

This paper presents the result of some studies on acoustic correlates of segmental and prosodic features of Hindi stop consonants.The parameters havebeen used to classify the consonants according to their articulatory manner and place of production and also used to synthesize them using a synthesis by rule technique.Sixteen plosive sounds(voiced, unvoiced, aspirated, unaspirated) were recorded in CVC and VCV syllables using vowel /a/ by ten standard male speakers. The spectral analysis was done using a sound spectrograph, the FFT/LPC analysis programme and the microprosodic feature analysis programmes.The latter analysis was done on a PC(AT) with adequate facilities of A/D and D/A conversion.The segmental acoustic characteristics such as formants and thier transitions with adjuscent vowels(within each 8 or 10 msec frame.),bandwidths, gap(with/without voicebar),burst frequency,aspiration noise etc. and the prosodic characteristics such as variations in durations,fundamental frequency and amplitude were determined.

The individual sounds have been specified on the basis of distinctive acoustic characteristics and classify into various categories such as V/UV,Asp/Unasp etc. These characteristics have been very usefull in synthesizing Hindi words using a digital formant synthesizer based on synthesis by rule technique.

INTRODUCTION

The study of acoustic phonetic and the prosodic charateristics is essential to understand the basic nature ofthe speech sounds as well as to simulate and to develop automatic speech recognition and synthesis systems. These charateristics of speech are highly language dependent and vary considerably from one context to another context.Therefore a data base of the acoustic charateristics reflecting the segmental and suprasegmental characteristics of speech sounds is required for a spoken language under study.

The persent paper describes results of some studies conducted to study the acoustic correlates ofHindi stop consonants which describe their phonetic and prosodic features.

Hindi Stop Consonants

Hindi stop consonants, unlike many western spoken languages are distinguished by the features of aspiration as wellas voicing.There are four distinct places of articulation to produce them.Depending upon the place and manner of articulation, the consonants can be classified as shown intable 1. The paletal sounds are produced with retroflexion and hence they could be classified as retroflexes also.

Procedure

These sixteen stop consonants were combined with vowel /a/ to form CVC type as well as VCV type syllables. In CVC syllables, the final position of the syllable VC was kept the same and only initial cosonant was changed (e.g.pal,bhal etc.)whereas in the case of VCV syllables,the vowel /a/ was kept the same inthe initial as well as final position. These were recorded by 10 male speakers in a studio.

The analysis of the utterances were done using a sound spectrograph as well as a computer having A/D and D/A facilities. The signal processing software used for the analysis included FFT/LPC etc. Acoustic features such as formant frequencies and thier transition, fundamental frequency and duration of different segment of sounds were computed. The time varying display of suprasegmental features of the utterances was obtained using a SNDSYS programme and a prosodic analyzer(Inst.of Phonetics, Aix-en Provence). Microprosodic details such as variations in the fundamental frequency and amplitude was determined from these displays.

Results

The sonogram of the CVC and VCV syllables for a given speaker containing consonant t, th, d, and dh are shown in figurel.It may be seen from these displys that there are distinctive acoustic features which can be used to classify them. The aspiration noise associated with th is different from the aspiration noise associated with d. In the latter case amplitude of turbulance has superimposed upon it and voicing continues through out the spectrum. Similarly there are differences in the nature of plosive burst, voicebar and the formant transitions.

Durational Characteristics

The duration of different segments related to consonatal features have been analyzed. The features selected for measuring duration include the plosive gap/voicebar, the burst,aspiration, vowel transition and the steady portion of the vowel.The figures show duration computed by avaraging the duration obtained from various samples of all the speakers in CVC and VCV context.The following observations were made from this table.

a)Duration of the Gap/VB

Unv. unasp > unv.asp > voiced unasp > voiced asp
Bilab.> Velar > Dental > retroflex

b)Duration of Aspiration
Voiced Asp. >> unv. asp
(Neary same for all places of articulation)

c)Duration of the Burst

Voiced Asp.> Voiced unasp.>
unv. asp > unv.unasp.
Velar > Retroflex >
Dental > Bilabial

d)Voice onset time
Asp. > un. asp.
Velar > Retroflex >
Dental > Bilabial

It is also observed that the rate of first formant transition is much higher than the rate of second formant transition.

The rate,direction and target frequencies of adjuscent vowels play a major role in the classification of consonants.

Target frequencies

The target frequencies of the second and third formant of vowels obtained with different categories of consonants are shown in table 2. .These values are obtained by averaging the initial as well as final values of CVC ans VCV syllables.It may be observed from this table that the target frequencies ofsecond and third formants for the consonants belonging to different places of articulation are quite different. However, the target frequencies of fourth formant are not so distinct.It reflects more the characteristic of an speaker.In the case of retroflex sounds, the third formant indicate two different target frequencies in the VC and CV contexts. In the former case the third formant merges with the second formant whereas in the latter case there isa break in the third formant.

Rate of Formant Transitions

The average rate of formant transitions are much higher for the first formant as compared to the second and third formant transitions.

Fundamental Frequency

Measurements of fundamental frequency of different segments of CV and VC syllable have shown that the F of a voiced plosive is higher than that of the voiced aspirated plosive. Similarly F during voicing of plosion is much less than voicing during the vowel articulation. The fundamental frequency of the vowel in a CV syllable is higher than that in a VC syllable. The value of F of the vowel followed by an unvoiced plosive is higher than the value obtained with voiced plosive. In the former case there is an abrupt rise.This feature can work as a landmark (Cue)for indicating the presence of voiced or unvoiced consonant.

Conclusion

The results obtained in the above experiments show that the stop consonants possess some special and distinctive acoustic features.These can be classified on the basis of the features mentioned in the above results.

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TABLE 1

	Bilabial	Dental	Retroflex	Velar
Unasp unv.	p	t	ṭ	k
Unasp voiced	b	d	ḍ	g
Asp. unv.	ph	th	ṭh	kh
Asp. voiced	bh	dh	ḍh	gh

TABLE 2

	Second Formant	Third Formant	Fourth Formant
Bilabial	1000 ± 50	2300 ± 100	3400 ± 100
Dental	1500 ± 75	2600 ± 100	3600 ± 100
Retroflex	1800 ± 50	2700 ± 100 (CV), 1800 ± 100 (VC)	3600 ± 100
Velars	1300 ± 80	2500 ± 100	3500 ± 100