Volume 5, Issue 2, February 2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Identify Vowels in Punjabi Speech Signal Using Formant Frequencies

Parwinder Kaur*, Ranpreet Kaur
RIMT-Institute of Engineering and Technology
India

Abstract— In this paper, Punjabi vowels have been identified using formant frequencies. Formant frequencies are the resonant frequencies of human vocal tract when pronouncing a vowel. In Punjabi, there are ten vowels. In this work, these vowel sounds have been recorded from ten different speakers using sound forge software and these recorded samples are used to calculate the formant frequencies using LPC technique in matlab. On the basis of formant frequencies, vowels have been identified in the speech signal. The results obtained from this system can be utilized in automatic speech recognition systems developed for Punjabi language.

Keywords— Speech. Formant frequency, LPC technique, Punjabi, matlab.

I. INTRODUCTION

In phonetics the basic units of speech are vowels and consonants. All the languages contain the both kinds of phonemes and always it is hard to draw a line dividing these two categories. Vowels can be characterized as periodic sounds produced with the vibration of vocal cords and the airflow from the lungs is not blocked [1]. Consonants are often non-periodic sounds produced with the obstruction of airflow from the lungs and with or without vocal cords vibration. Vowels form the nuclei of the syllables whereas the consonants form the onset and coda.

Speech consists of acoustic pressure waves created by the voluntary movements of anatomical structures in the human speech production system. These wave-forms are broadly classified into voiced and unvoiced speech. Voiced sounds (vowels for example), produce quasi-periodic pulses of air which are acoustically filtered as they propagate through the vocal tract. The main distinction between vowels and consonants is that vowels resonate in the throat. Formants are exactly the resonant frequencies of a vocal tract when pronouncing a vowel. In this paper we attempt to carry out Vowel Recognition through Formant Analysis in Punjabi language, wherein we detect which of the ten Punjabi vowels is spoken by the Speaker. Here we describe a standard approach for classification of vowels in continuous speech based on three formants: F1, F2 and F3.

II. PUNJABI VOWELS

The term ‘vowel’ is commonly used to mean both vowel sounds and the written symbols that represent them.

In phonetics, a **vowel** (from the Latin word ‘vocalis’, meaning ‘uttering voice’ or ‘speaking’) is a sound in spoken language that is characterized by an open configuration of the vocal tract, in contrast to **consonants**, which are characterized by a constriction or closure at one or more points along the vocal tract. Vowels are understood to be syllabic, meaning that they usually form the **peak** or **nucleus** (the central part) of a syllable - whereas consonants form the **onset** (any consonant or sequence of consonants preceding the nucleus) and **coda**(any consonant or sequence of consonants following the nucleus).

Vowels are extremely important to singing. They almost always carry the greatest energy in the speech signal because, during vowel phonation, the vocal tract is most open. Vowels are also stable segments of speech during which the articulators do not move, allowing the resonance frequencies of the vocal tract to remain more stable (minus the characteristic waxing and waning of the frequencies due to the rapid and periodic opening and closing of the vocal folds during phonation). Because of these characteristics, vowels are probably the easiest speech category to recognize in a spectrogram - an electronic device that measures peaks in the harmonic spectrum of the voice during singing. A singer needs to learn to sing vowels while not allowing consonants, which resonate and ‘project’ more poorly than vowels do, to get in the way.

A. ਅ Mukta

Mukta literally means free and therefore, has no symbol. It is equivalent to a in *above* or e in (British) *dancer*. Hence, mukta vowel will be denoted by /a/.

ਅ + ਸ = ਅਸ /as/ = us

B. ਆ Kanna

Kanna is equivalent to a in *alter* or *father*. Hence, we will denote kanna vowel with /aa/.

ਸਾ /saa/ = saw

Vowels in Punjabi come in pairs, a short vowel and a long one. Here mukta and kanna form one such pair where mukta is the short vowel and kanna the long one. ਇ and ਈ; ਉ and ਊ; ਏ and ਐ; ਓ and ਔ are other pairs.

C. ਇ Sihari

Sihari is equivalent to i in *pin* or *thin*. Hence, we will denote sihari vowel with /i/.

ਆ + ਇ + ਸ = ਆਇਸ /aais/ = ice

A distinct characteristic of sihari is that unlike other matras it precedes the letter it is spoken after.

D. ਈ Bihari

Bihari is equivalent to ea in *teacher* or ee in *seek*. We will denote bihari vowel with /ii/ in this module. See the following examples of use of bihari.

ਸੀ = see

E. ਉ Aunkarh

Aunkarh is equivalent to u *put* or oo in *book*. We will denote aunkarh vowel with /u/.

ਹਾ + ਉ + ਸ = ਹਾਉਸ /haaus/ = house

F. ਊ Dulenkarh

Dulenkarh is equivalent to oo in *boot*. We will denote dulenkarh vowel with /oo/.

ਹੂ /hoo/ = who

G. ਏ Lanv

Lanv is equivalent to a as in *hate* or *rate*. We will denote lanv vowel with /e/.

ਏ + ਸ = ਏਸ = ace

H. ਐ Dulawan

Dulawan is equivalent to a in *matter* or *hat*. We will denote dulawan vowel with /ae/.

ਅ + ਸੈ + ਸ = ਅਸੈਸ = assess

I. ਓ Horha

Horha is equivalent to o sound as in English home. Horha vowel will be denoted with /o/.

ਸੋ = sow

J. ਔ Kanaorha

Kanaorha is equivalent to o as in *odd* or *hot*. Kanaorha will be denoted with /ao/.

ਸੌ + ਸ = ਸੌਸ = sauce

Vowel			Name		IPA
Ind.	Dep.	with /k/	Letter	Unicode	
ਅ	(none)	ਕ	Mukta	A	[ə]
ਆ	◌ਾ	ਕਾ	Kanna	AA	[ɑ]
ਇ	ਿ◌	ਕਿ	Sihari	I	[ɪ]
ਈ	◌ੀ	ਕੀ	Bihari	II	[i]
ਉ	◌ੁ	ਕੁ	Onkar	U	[ʊ]
ਊ	◌ੂ	ਕੂ	Dulankar	UU	[u]
ਏ	◌ੇ	ਕੇ	Lavan	EE	[e]
ਐ	◌ੈ	ਕੈ	Dulavan	AI	[ɛ]
ਓ	◌ੋ	ਕੋ	Hora	O	[o]
ਔ	◌ੌ	ਕੌ	Kanuara	AU	[ɔ]

Fig. 1 vowel chart

The information that humans require to distinguish between vowels can be represented purely quantitatively by the frequency content of the vowel sounds; that is, the different vowel qualities are realized in acoustic analyses of vowels by the relative values of the formants - the acoustic resonances of the vocal tract. Each vowel has its own distribution of acoustic energy that distinguishes it from all other vowels. Vowels will almost always have four or more distinguishable formants. However, the first two formants are the most important in determining vowel quality and in differentiating it from other vowels.

Each vowel, therefore, has its own 'fingerprint', which is defined or characterized by its unique frequencies at the first and second formants. These formants are usually referred to as the '**vowel formants**'. They are not adjustable for each given vowel or variant of each vowel. For example, the formant frequencies for the [i] vowel for any given voice are more or less constant and remain within very specific limits in the frequency range. For this reason, these vowel formants may also be called '**fixed formants**'. If these vowel formants are not produced by the vocal tract, the particular vowel can't exist. Conversely, whenever the formants for a particular vowel are present, that vowel is heard.

III. FORMANTS

In speech, the resonant frequencies of the vocal tract (that is the frequencies that resonate the loudest) are called **formants**. We can see them as the peaks in a spectrum. With vowels, the frequencies of the formants determine which vowel you hear and, in general, are responsible for the differences in quality among different periodic sounds. At any one point in time (as with spectra) there may be any number of formants, but for speech the most informative are the first three, appropriately referred to as F1, F2, and F3

IV. USING LPC TECHNIQUE IN SPEECH ANALYSIS

Linear Predictive Coding (LPC) is a tool used mostly in audio signal processing and speech processing for representing the spectral envelope of a digital signal of speech in compressed form, using the information of a linear predictive model. It is one of the most powerful speech analysis techniques, and one of the most useful methods for encoding good quality speech at a low bit rate and provides extremely accurate estimates of speech parameters (taken from Wikipedia).

V. METHODOLOGY

For the analysis of the speech signal, we have carried out the recording of ten speakers in Punjabi. Speakers of different age group, from different regions of Punjabi have been taken. Firstly, all vowels for each speaker were recorded and using LPC technique, formant frequencies of each vowel were calculated. Based on these formant frequencies calculated, system is trained and tested for vowel identification. The spectrogram showing the formant frequencies of the Punjabi speech signal is shown below in fig.2.

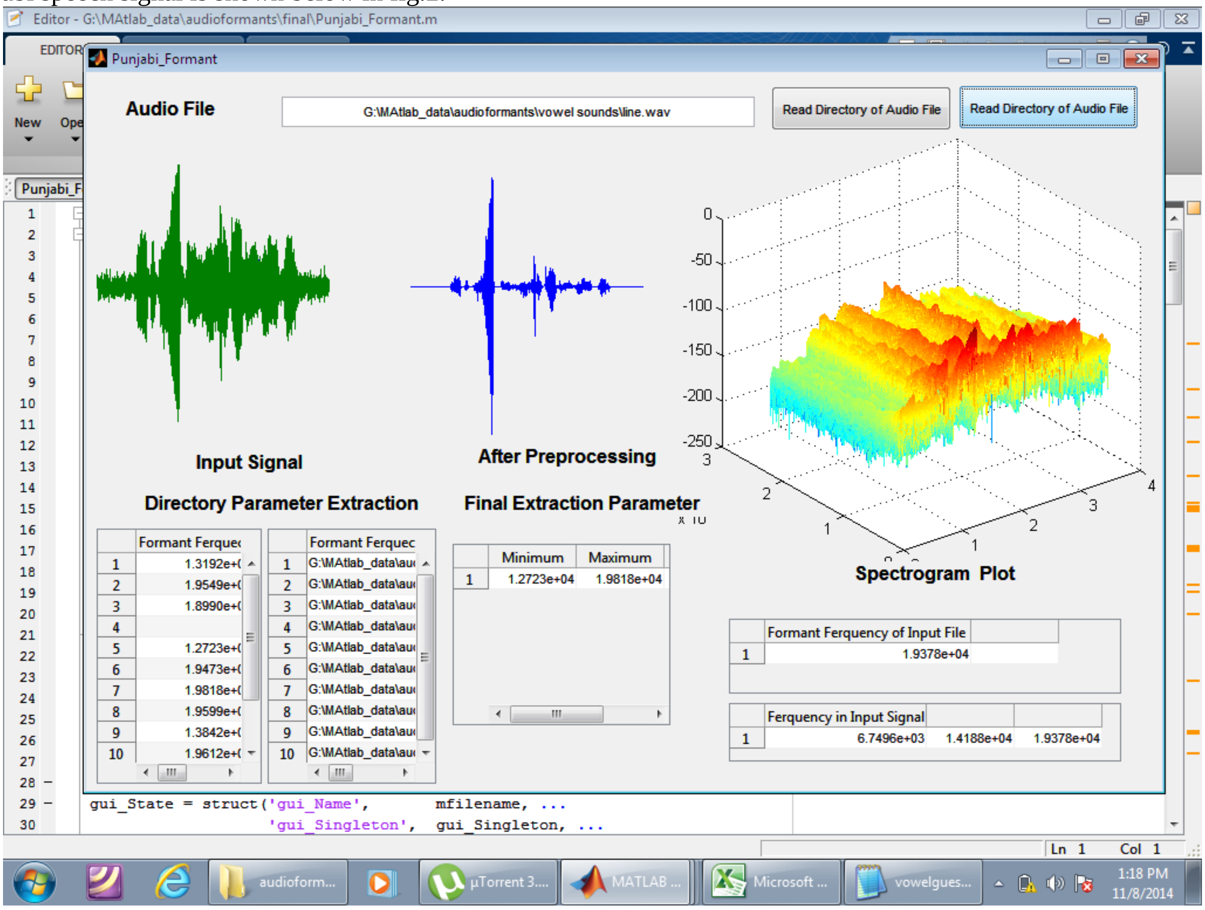

Fig.2 Formant frequencies of the Punjabi speech signal

VI. CONCLUSIONS

In this paper we have presented a simple method for recognizing the ten vowels of the Punjabi language. The method we have used is based on recognition of frequencies of first three formants that are present in vowels. By using of LPC method for determining the frequencies and amplitudes of formants in speech, we have set the frequency ranges of formants F1, F2 and F3 for all vowels.

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