Synthesis & Analysis of Marathi Speech: Hearing Aid tutorial algorithm

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***Abstract* - This paper is an overview of the state of the art to design an algorithm for hearing aid for Marathi speech. The main topics include two items: Hearing loss, Hearing aids& Performance for Marathi speech in different conditions. The objective of this study were to study about the hearing loss, study about hearing aids with hearing impairments, and bring to use the data of this study to design new algorithm for hearing aids in the future. In conclusion, the most hearing loss uses two method consist of questionnaire about hearing, and screening strategy, which to be carried out a clear process and period of time for screening regularly. There are guarantees for separate normal hearing and hearing loss in adults. The main improve digital signal processing strategies of hearing aids include noise reduction and acoustic feedback reduction generates to provide amplification and better output sound quality. The popular simulation program for digital signal processing because the tools and functions in the management. Main objective of this paper is to measure performance of HA in different background condition for Marathi speech. This includes recognition of consonants Vowels, Syllables recognition by HA user in different background situation.**

***Keywords*- Hearing Aid, Hearing Loss, Marathi Speech, Vowels, Consonants**

I. Introduction

In India, 63 million people (6.3%) suffer from significant hearing loss. The National Sample Survey (NSS) 58th round (2002) surveyed disability in Indian households and found that hearing disability was second most common cause of disability and top most cause of sensory deficit. In urban areas, loss was 9% of all disability and in rural areas, it was 10%. Depending upon the extent of a person inability to properly, the degree of hearing disability was ascertained it was estimated that the number of person with hearing disability per 100000 persons was 291; it was higher in rural (310) compared with urban regions (236). In the same survey, about 32% of the people had profound (person could not hear at all or could hear only loud sounds) and 39% had severe hearing disability (person could hear only shouted words). The survey results revealed that about 7% of people were born with a hearing disability. About 56% and 62% reported the onset of hearing disability at ≥ 60 years of age in the rural and urban areas, respectively. The incidence of hearing disability during that year was reported to be 7 per 100000 populations.

II. Hearing Aid

Hearing aids use the same basic parts to carry sounds from the environment into your ear and make them louder. Most hearing aids are digital, and all are powered with a hearing aid battery.
Small microphones collect sounds from the environment. A computer chip with an amplifier converts the incoming sound into digital code. It analyzes and adjusts the sound based on your hearing loss, listening needs and the level of the sounds around you. The amplified signals are then converted back into sound waves and delivered to your ears through speakers.

Hearing aid styles

Hearing aids vary a great deal in price, size, special features and the way they're placed in your ear.
The following are common hearing aid styles, beginning with the smallest, least visible in the ear. Hearing aid designers keep making smaller hearing aids to meet the demand for a hearing aid that is not very noticeable. But the smaller aids may not have the power to give you the improved hearing you may expect.

A. Completely in the canal (CIC) or mini CIC

A completely-in-the-canal hearing aid is moulded to fit inside your ear canal. It improves mild to moderate hearing loss in adults.

- Is the smallest and least visible type
- Is less likely to pick up wind noise
- Uses very small batteries, which have shorter life and can be difficult to handle
- Doesn't contain extra features, such as volume control or a directional microphone
- Is susceptible to earwax clogging the speaker

B. In the canal

An in-the-canal (ITC) hearing aid is custom moulded and fits partly in the ear canal. This style can improve mild to moderate hearing loss in adults.

- Is less visible in the ear than larger styles
- Includes features that won't fit on completely-in-the-canal aids, difficult to adjust due to its small size

- Is susceptible to earwax clogging the speaker

C. In the ear

An in-the-ear (ITE) hearing aid is custom made in two styles — one that fills most of the bowl-shaped area of your outer ear (full shell) and one that fills only the lower part (half shell). Both are helpful for people with mild to severe hearing loss.

- Includes features that don't fit on smaller style hearing aids, such as a volume control
- May be easier to handle
- Uses a larger battery for longer battery life
- Is susceptible to earwax clogging the speaker
- May pick up more wind noise than smaller devices & more visible in the ear than smaller devices

D. Behind the ear

A behind-the-ear (BTE) hearing aid hooks over the top of your ear and rests behind the ear. A tube connects the hearing aid to a custom earpiece called an earmold that fits in your ear canal. This type is appropriate for people of all ages and those with almost any type of hearing loss.

- Traditionally has been the largest type of hearing aid & newer mini designs are streamlined and barely visible
- Is capable of more amplification than are other styles, May pick up more wind noise than other styles

E. Receiver in canal or receiver in the ear

The receiver-in-canal (RIC) and receiver-in-the-ear (RITE) styles are similar to a behind-the-ear hearing aid with the speaker or receiver in the canal or in the ear. A tiny wire, rather than tubing, connects the pieces.

- Has a less visible behind-the-ear portion
- Is susceptible to earwax clogging the speaker

F. Open fit

An open-fit hearing aid is a variation of the behind-the-ear hearing aid with a thin tube. This style keeps the ear canal very open, allowing for low-frequency sounds to enter the ear naturally and for high-frequency sounds to be amplified through the hearing aid. This makes the style a good choice for people with mild to moderate hearing loss.

- Is less visible
- Doesn't plug the ear like the small in-the-canal hearing aids do, making your own voice sound better to you
- May be more difficult to handle and adjust due to small parts

Figure 1- Types of Hearing Aid: Completely in the canal (A), in the canal (B), in the ear (C), behind the ear (D), receiver in canal or receiver in the ear (E) & open fit (F).

III. Hearing Aid Comparison

Hearing aid comfort is related to both physical and acoustic qualities. Demonstration hearing aids will not be custom-fit for ear canal, but they can be programmed for hearing loss. It will usually only takes a few minutes for the hearing care professional to hook the hearing aids to the computer and program them for a patient to try. They may even do this before patient arrive for your hearing aid consultation appointment. Following list of ways to compare hearing aids and pick a couple of ideas to use for each set of hearing aids.

- Listen to the sound of your own voice.
- Listen to the hearing aid in different program settings and speech background environments.
- Try it with the phone.

Signs of hearing loss

While a history of hearing loss in your family or exposure to high noise levels may cause hearing loss, the easiest way to identify hearing loss is to notice how your hearing affects your daily life. You are probably the best judge of whether your hearing has declined. You should have your hearing checked if you have experienced more than a couple of these signs of hearing loss

- Tired or stressed from trying to hear.
- Believe that everybody mumbles.
- Find it easier to understand others when you are looking directly at their faces.
- Frequently ask others to repeat themselves.
- Increase television or radio volume to a point that others complain.
- Have difficulty understanding speech in noisy places like cars, restaurants and theaters.
- Fail to understand doctor's instructions about medications.
- Make inappropriate responses because you didn't understand the question.
- Miss essential sounds like doorbells, alarm clocks, smoke alarms.
- Have trouble hearing on the telephone.
- Turn one ear towards a speaker to hear well.

Hearing Aid in today's market

In the past decade, hearing aids have changed considerably. The new technology means:

- Newer aids are much more cosmetically appealing.
- Current aids can provide a cleaner, higher quality sound than those of a few years ago because of changes in how the sound is processed, as over 90% of hearing aids today have digital, rather than older analog technology.
- They provide more listening comfort due to better automatic control of volume & frequency response.
- The dispenser can readily adjust newer models in the office, rather than having to send them back to the factory for adjustments.

"Table 1- Types of Hearing Aid with their Specifications"

Type Of Hearing Aid ⟹	**Receiver-In-Canal (RIC)**	**Completely in the canal (CIC)**	**Behind the ear (BTE)**	**In the canal (ITC)**	**In the ear (ITE)**
Wireless Connectivity	Yes	Yes	Yes	Yes	Not performed as per patient requirement
Tinnitus Solutions	Yes	Yes	Yes	Yes	Yes
Hearing Loss	Mild to Severe	Mild to Moderate	Moderate to Severe	Mild to Mildly Severe	Mild to Severe
Hearing Loss in dB	Between 20-90dB	Between 20-60dB	Between 40-90dB	60-90 db	For all ranges of HL in dB

Technology

In addition to changing styles, hearing aids have experienced dramatic improvements in the technology, or circuitry, used to amplify sound and how the aid is modified to your hearing needs. Conventional Analog hearing aids amplify speech and noise alike, although they may have features and adjustments that can modify the sounds differentially. Until recently, this was the basic technology of hearing aids. This type of aid is generally the least expensive, but it may not be reprogrammed if your hearing changes over time. Digital Programmable (DSP or digitized sound processing) hearing aids convert sound waves into digital signals. A computer chip in the aid converts sound waves to numbers and then analyzes and manipulates the numbers according to a set of rules (algorithms) programmed into the chip. The computer chip can tell, mathematically, if the incoming sound has the sound wave pattern of noise or of speech. It blocks out continuous background noise, while selectively amplifying the sound patterns of speech. DSP allows for more flexibility in programming the aid so the sound it transmits matches your specific pattern of hearing loss. This is typically the more expensive design, although sales of DSP accounted for over 90 percent of all hearing aids sales after 2006.

IV. Basics Marathi Language

Marathi is an Indo-Aryan language spoken predominantly by Marathi people of Maharashtra. It is the official language and co-official language in Maharashtra and Goa states of Western India respectively, and is one of the 22 scheduled languages of India. There were 93 million speakers in 2011; Marathi ranks 19th in the list of most spoken languages in the world. Marathi has the fourth largest number of native speakers in India. Marathi has some of the oldest literature of all modern Indo-Aryan languages, dating from about 900 AD. The major dialects of Marathi are Standard Marathi and the Varhadi dialect. Malvani Konkani has been heavily influenced by Marathi varieties. Marathi distinguishes inclusive and exclusive forms of 'we'. It has a three-way gender system that features the neuter in addition to the masculine and the feminine.

Marathi phonology

The phoneme inventory of the Marathi language is similar to that of many other Indo-Aryan languages. An IPA chart of all contrastive sounds in Marathi is given below.

Consonants

Many Marathi consonants come in three different forms: aspirated, un-aspirated and retroflex. Aspiration means with a puff of air, and is the difference between the sounds of the letter p in English pin (aspirated) and spit (un-aspirated). Retroflex consonants, on the other hand, are not really found in English. They should be pronounced with the tongue tip curled back. Practice with a native speaker, or just pronounce as usual you'll usually still get the message across.

Vowels and vowel diacritics

क	ka	[kə]	ख	kha	[kʰə]	ग	ga	[gə]	घ	gha	[gʱə]	ङ	ṅa	[ŋə]
च	ca	[tsə/tʃə]	छ	cha	[tsʰə]	ज	ja	[ɟə/zə]	झ	jha	[ɟʱə/zʱə]	ञ	ña	[ɲə]
ट	ṭa	[ʈə]	ठ	ṭha	[ʈʰə]	ड	ḍa	[ɖə]	ढ	ḍha	[ɖʱə]	ण	ṇa	[ɳə]
त	ta	[t̪ə]	थ	tha	[t̪ʰə]	द	da	[d̪ə]	ध	dha	[d̪ʱə]	न	na	[n̪ə]
प	pa	[pə]	फ	pha	[pʰə/fə]	ब	ba	[bə]	भ	bha	[bʱə]	म	ma	[mə]
य	ya	[jə]	र	ra	[rə]	ऱ	ṟa	[ɾə]	ल	la	[lə]	व	va	[və/wə]
श	śa	[ʃə]	ष	ṣa	[ʂə]	स	sa	[sə]						
ह	ha	[ɦə]	ळ	la	[ɭə]	क्ष	kṣa	[kʃə]	ज्ञ	jña	[ɟɲə]	श्र	śra	[ʃrə]

Notes

च [ç] ज [ɟ] झ [ɟʱ] when followed by front vowels (i, e, etc) and in loanwords

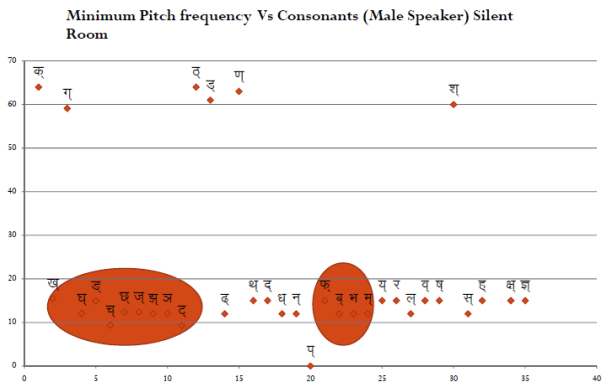
Devanagari	Transliteration	Devanagari	Transliteration	Devanagari	Transliteration	Devanagari	Transliteration
क	K	ञ	nY	ध	dh	ल	l
ख	kh	ट	T	न	n	व	v
ग	G	ठ	Th	प	p	श	sh
घ	gh	ड	D	फ	ph	ष	Sh
ङ	G	ढ	Dh	ब	b	स	s
च	ch	ण	N	भ	bh	ह	h
छ	Ch	त	T	म	m	ळ	L
ज	J	थ	Th	य	y	क्ष	kSh
झ	Jh	द	D	र	r	ज्ञ	dny

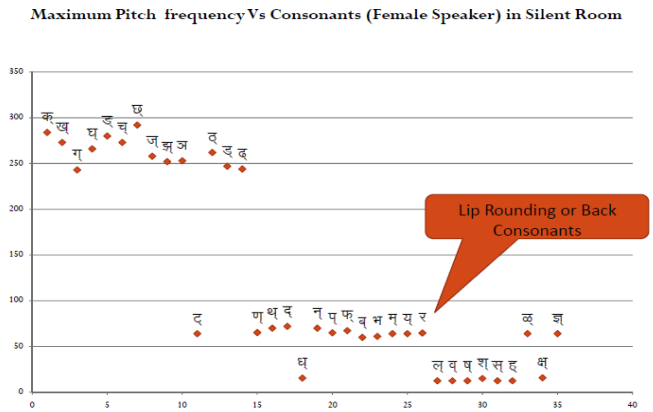
V. Marathi Speech Analysis & Observations

We record few Marathi speech samples using PRAAT V. 4.2.1, PRAAT is a very flexible tool to do speech analysis. It offers a wide range of standard and non-standard procedures, including spectrographic analysis, articulatory synthesis, and neural networks. We record both genders Marathi vowels, Consonants &syllables in different background situation to calculate varies speech parameters like pitch frequency,formanat frequency, median pitch.

- As compared to vowels, Consonants are closed to each other.
- There are groups of some consonants having closer minimum & maximum pitch frequency. Consonants in each group are having same phonetics, pronunciations, tongue movement which will confuse patient (lip reading is not effective).
- We need to differentiate them before processing in our algorithm.
- Noisy background affects on Min & Max pitch frequency of both gender.
- Consonants are too much closer to each other. Patient is hard to hear consonants properly.
- Consonants are higher pitched than vowels
- Consonants are spoken more softly than vowels so typically person with hearing loss will have trouble hearing the consonants in the first place. He may be hanging on by a thread.
- Consonants convey most of the word information; they are much more important to putting it together

For Consonants





Formant frequency - The speech researcher defines formants as "the spectral peaks of the sound spectrum |P (f)|"

- Formants are often measured as amplitude peaks in the frequency spectrum of the sound, using a spectrogram or a spectrum analyzer and, in the case of the voice; this gives an estimate of the vocal tract resonances.
- The formant with the lowest frequency is called F_1, the second F_2, and the third F_3. Most often the two first formants, F_1 and F_2, are enough to disambiguate the vowel.
- In vowels spoken with a high fundamental frequency, as in a female or child voice.
- The first formant (F1) in vowels is inversely related to vowel height: The higher the vowel, the lower the first formant (and vice versa).

Vocal height	**Vowel**	**F_1 in silent (M)**	**vowel**	**F_1 in noisy(F)**
HIGH	इ	479	ऐ	590
HIGH	ई	491	ए	689
MID HIGH	ऋ	538	औ	711
MID HIGH	ए	540.7	उ	715
MID HIGH	उ	548	ऊ	751
MID HIGH	ऐ	559	अ	757
MID HIGH	ऊ	571	ओ	782
MID LOW	ओ	640	ई	857
MID LOW	औ	640	ऑ	863
MID LOW	अः	721	ऋ	874
MID LOW	ॲ	793.2	इ	885
LOW	ऑ	828.7	ॲ	893
LOW	आ	831	आ	920
LOW	अ	921	अः	923
LOW	अं	966	अं	990

- Intensity plays vital role in speech, as compared to male & female speaker intensity variation; it is found that female speech intensity is lower than male speaker.
- Female speaker's vowels & consonants are more softly spoken as compared to male. Due to this non recognition count of vowels & consonants increases.
- In both speakers there is few common Non recognition consonants found.
- Speech intensity works on inverse square law between sound source & Listener.
- Pitch frequency, Formant frequency & Intensity are key parameters for listeners.
- With help of audiologist we can analyze our patient's requirement then we will set parameter in our proposed algorithm.
- We need to more concentrate on Female & Child speech as it contain higher frequency in vowels & consonants.
- Many more background situation & moods of speaker we have to consider (Here we are taking only Normal Mood of speaker) before to build proposed algorithm.
- We can build proposed algorithm for limited / any one speaker environment (live Speech Processing).
- Speech Processing Time is key factor.

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