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Survey on Hearing Aids

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Abstract: In the world population Approximately 10% of the people are suffers from some type of hearing loss. Hearing loss is not just a technical loss of volume. Rather, hearing deficiency can increase sensitivity and reduce tolerance to certain sounds while diminishing sensitivity to others. yet only a small percentage of this statistic use a hearing aid. The basic concepts underlying speech and signal processing are studied in this suryey paper briefly, followed by a short historical descriptions of the development of hearing aids. The major difficulties and opportunities are identified, and the various approaches used in attempting to develop a practical `hearing aid are discussed.

Keywords: hearing loss**,** acoustic amplification, digital hearing aids, programmable hearing aids, digital signal processing ,SNHL

I. INTRODUCTION

The need of communication and compute has yielded a vast array of inventions.. These two powerful forces have grown together for generations and have yielded several remarkable offspring. Whereas from 10,000 BC to 1700 AD was an era where human ears remained relatively pristine to external factors that could prove fatal to human health. Nothing could hamper one’s ability to hear unless he got eaten by a carnivorous animal and instances of this sort. Information technology is perhaps the most widely known, but there are other less well-known progeny, such as the ubiquitous microchip doing its bit (pun intended) in almost every modern electrical device. In the pre-digital era, hearing aids did little more than amplify sound. Today, the hearing aid is a far more complex instrument in which amplification is combined with advanced forms of signal processing for speech enhancement, noise reduction, self-adapting directional inputs, feedback cancellation, data monitoring, and acoustic scene analysis, as well as the means for a wireless link with other communication systems. This article traces the application of digital signal processing (DSP) approaches to hearing aid applications and how these approaches introduced new ways of thinking regarding the fundamentals of acoustic amplification. The article is clearly biased in the direction of the author's own thinking as one who played a role in the development of digital hearing aids.

Following two centuries, saw ear trumpets being used by some hard of hearing people, which also didn’t mark the indispensable need for hearing aids. Even the 19th century popularized silent (captioned) movies which enabled the hard of hearing clan to easily interpret whatever was being conveyed. But in this century itself, the first electronic hearing aid was patented.

1950s brought the telecoils (coiled structures to revive reception) and 1960s the Behind the Ear (BTE) Hearing Aids [1][2]. Since then, in the form of In the Ear (ITE) Hearing Aids, Amplified Phones, Assistive Listening System, invention of Cued Speech, technology took off and never looked back since then. But the major milestone was achieved with the introduction of Cochlear Implants [1][2].

II. I.SIGNS and SYMPTOMS of HEARING LOSS

When we observe

- one person is shouting while he is talking to others
- One need the TV or radio turned up louder than other people
- One often ask people to repeat themselves because He can’t hear or understand them, especially in groups or when there is background noise
- One can hear better out of one ear than the other
- One is getting strain to hear
- One think people 'mumble' when they speak

III. THE QUESTIONS FACING by the YOUTH

The three questions facing by the youth today are

1. How can I tell if the volume on my iPod or MP3 player is loud enough to cause hearing damage?
   One can make use of three simple measures to see if the volume on the personal music player is set too high: If you are playing something over it and can’t hear somebody talking to you at a normal voice level from a distance of three feet or less, it’s certainly too loud; if a person next to you can hear the music

emanating from your headsets (music device), it is indeed too loud; and if you have to scream out to hear yourself while talking and listening to music, it is way too loud.

2. A) What's worse?
   B) Ear buds or over-the-ear headphones?

It is advised that ear buds could bring in more of a potential threat to listeners because they sit closer to the ear out as effectively as traditional headphones. Ear buds, that don't block out noise well may cause the user to turn the volume up, which could lead to hearing loss over a period of time. However, experts believe that listening to music beyond optimum levels and that too for hours, presents a risk, no matter what type and quality of headphone is worn.

3. How long does it take for my hearing to get damaged from listening to a personal music player?

Listening to a music player at moderate levels likely will not pose problems. But higher volume levels bring forth the cons. One might face increased risk of permanent hearing loss if music is

IV. TYPES of HEARING LOSS

(i) **Sensorineural** - a hearing loss that usually develops due to damage to the small sensory cells in the inner ear, called hair cells. This damage can occur as a result of disease, illness, age, injury from exposure to noise or certain medicines, or as the result of a genetic disorder.

(ii) **Conductive** – a hearing loss that occurs when sound waves cannot transmit through the outer or middle ear or both. This can, for example, be caused by earwax, fluid in the middle ear space, or a punctured eardrum. Medical or surgical treatment can often restore hearing in people with a conductive hearing loss.[3][9]

(iii) **Mixed** – a combination of sensoneural and conductive hearing loss.

The following fig1 shows all the parts of the ear for these three causes

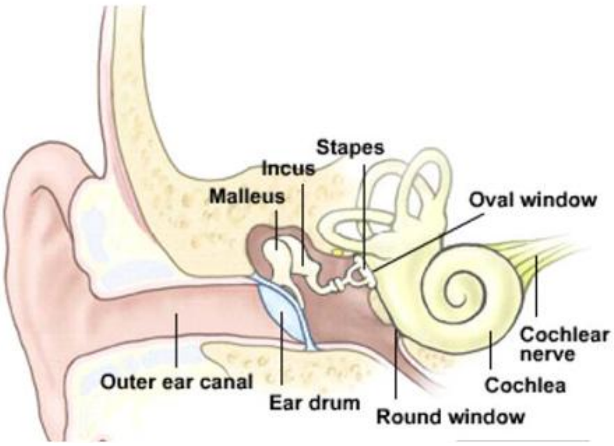

Fig1: Parts of ear-cause hearing loss

Only a relatively small portion of adult hearing problems, such as ear infection and middle ear diseases, are medically or surgically treatable. If the condition cannot be treated medically or surgically, hearing aids may be beneficial. Selection of hearing aids should be based on the type and severity of hearing loss, listening needs, and lifestyle.

V. SOLUTIONS for HEARING LOSS

There are two solutions for this hearing loss are

(i) Personal Sound Amplification Products (PSAPs) and
(ii) Hearing Aids

(i) PSAPs

These are not medical devices. Wearable electronic consumer products. Amplifying environmental sound for non-hearing impaired consumers for use in a variety of listening situations. Not intended or labeled to compensate for hearing loss

(ii) Hearing Aids

What is a hearing aid?

A hearing aid is a small electronic device that you wear in or behind your ear. It makes some sounds louder so that a person with hearing loss can listen, communicate, and participate more fully in daily activities. A hearing aid can help people hear more in both quiet and noisy situations. However, only about one out of five people who would benefit from a hearing aid actually uses one. A hearing aid has three basic parts: a microphone, amplifier, and speaker. The hearing aid receives sound through a microphone, which converts the sound waves to electrical signals and sends them to an amplifier. The amplifier increases the power of the signals and then sends them to the ear through a speaker. Or simply we can say ‘’any wearable sound-amplifying medical device’’ Aiding persons with, or compensating for impaired hearing Basic Electronic Components are Microphone, Amplifier circuitry, Miniature loudspeaker/receiver,Battery.

VI. HEARING AID TECHNOLOGY

Hearing aids are described as analog or digital, depending on the technology they use to process sound. Digital hearing aids are the newest kind of hearing aids.[9]

i) **Analog:** Converting physical sound waves into electrical waves and Making the continuous sound waves larger.

Working

Analog hearing aids have a microphone that picks up sound and converts the sound into small electrical signals. These signals vary according to the pattern of the sound. The signals are then amplified (madelouder) by transistors and fed to the earphone or receiver on the hearing aid so you can hear them. Most of the better analogue hearing aids compress the sound using ‘automatic gain control’ (AGC). This amplifies quiet sounds until they are loud enough to be heard, but gives less amplification to sounds that are already loud, so you’re protected against uncomfortably loud sound levels.

Analogue hearing aids don’t have all the features that come with digital aids, but they are the least expensive hearing aids available. Most manufacturers have ‘phased out’ analogue instruments as the cost of digital products reduces. Digital aids now cover the full range from basic to premium. The cost varies with processing power and other features.

ii) **Digital:** Converting sound waves to their binary format where the sound is represented by a series of 1’s and 0’s By allowing manipulating sounds in relatively flexible ways to achieve more programming options

Working

Digital aids work in a different way. They take the signal from the microphone and convert it into ‘bits’ of data – numbers that can be manipulated by a tiny computer in the hearing aid. This makes it possible totailor and process sounds very precisely, in ways that are impossible with analogue aids. The better digital aids can be very finely adjusted to suit your individual needs. You may also be able to switch between different settings suitable for different listening conditions. Many digital aids even adjust themselves automatically to suit different sound environments

VII. STYLES of HEARING AIDS

1. Behind-the-ear (BTE) aids:

A plastic case containing most parts; resting behind the ear connected to an ear mold Easy to be cleaned and handled, relatively sturdy. These are better for people who suffer from humidity in the ear canal or need a lot of power.

Fig2:BTE

2."Mini" BTE (or "on-the-ear") Aids: A very thin tube connects the aid to the ear canal.May have an open-fit ear tip or a regular ear mold With “open fit” – Reduced occlusion ("plugged up“) sensations, increased comfort, relatively less visible

They tend to need repairing more often than behind-the-ear aids. If you have severe hearing loss, or very narrow ear canals, these aids will probably not suit you.

Fig3: Mini BTE

3. In-the-ear (ITE) aids: All parts contained in a shell, which fills in the ear canal Relatively easier to handle than smaller aids such as ITC & CIC

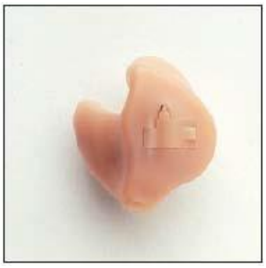

Fig4: ITE

4. **In-the-canal (ITC) aids & completely-in-the-canal (CIC) aids:** All parts contained in tiny cases, which fits partly or completely in the ear canal Smallest in size, which makes it difficult to handle and adjust for some users

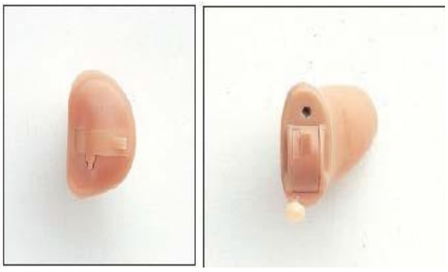

Fig5: ITC&CIC

These may be suitable if you have sight problems, or problems using very small switches or buttons. Some models are very powerful.

VIII. HEARING AID COMPONENTS

All hearing aids consist of the same major components. The components [5][6] of a hearing aid are held together in a protective case often made of plastic as shown in fig6.

i) **Microphone:** The first major component is the hearing aid microphone, which picks up sounds from the air and converts them into electrical signals.

ii). **Amplifier:** The hearing aid amplifier increases the intensity of the signals from the microphone. Filters modify the sounds, so that only sounds relevant for the user are amplified.

iii**).'Loudspeaker':** The third basic component of a hearing aid is the 'loudspeaker' (receiver). It converts electrical signals into the acoustic signals heard by the user.

iv). **Small computer:** In addition to these three common components of a hearing aid, digital hearing aids include a small computer programmed to manipulate the signals to fit the hearing loss of the individual user. Some hearing aids are equipped with special control functions for individual adjustments. Many hearing aids offer remote control, facilitating adjustments, particularly for users with dexterity problems. The special batteries required by all hearing aids come in many sizes and with varying capacities. A standard battery lasts between 5 and 14 days, depending on the type of hearing aid, capacity, type of battery and how much the hearing aid is used.

Fig.6

IX. DIGITAL EARING AIDS

I). A Brief History of Digital Hearing Aids

Early Applications of **Digital** Techniques Sampled-data systems were first used in automatic control work as well as in the transmission of information. Theoretical analyses of these early systerns led to the development of several important theorems, most notably the sampling theorem described earlier that determines the minirnurn sampling rate necessary to specify ambiguously a continuous signal of known bandwidth. Although the theoretical underpinnings of discrete digital signal analysis were well developed some time ago , it was not until the advent of the digital computer that these techniques started to take on a new, practical importance.

A concomitant development of great consequence for the digital processing of audio signals was the development of analog-to- digital and digital-to-analog converters fast enough and with enough precision for the conversion of audio signals to digital form, and *vice versa.* A typical system for telephone-quality speech would have a sampling rate of ten thousand (10000) Hz with and bit to IO-bit accuracy. A high fidelity system would require a sampling rate of at least forty thousand(40000)Hz with IS-bit accuracy or better .Much of the early research on the digital processing of audio signals focused on speech analysis, speech synthesis, and vo-coder design . During that early period in the development of digital audio, the time taken by a computer to process audio signals was extremely long.

Typically, a fairly simple speech-processing algorithm (by today's standards) would take authentic time. As a consequence, almost all of the research on the early development of digital signal processing for audio applications was done off-line. Even with this major limitation, it was far more efficient to develop experimental audio systems using off-line computer simulation rather than by building experimental prototypes. The latter approach is typically far more costly and time consuming than that of computer simulation. Further, experimental prototypes often do not meet all design requirements. The use of computer simulation has grown dramatically as a research and development tool and it is now widely used in almost all industrial research laboratories. An important step in the development of computer- simulation techniques in digital audio was the introduction of high-level languages for Facilitating the simulation of audio systems. One such language was BLODI, an acronym for Block Diagram Cornpiler, developed by Kelly, Lochbaum and V.yssotsky in 1961.

This language could be used to simulate any realizable audio system specified in block diagram form. BLODI has been used for a wide range of applications including the computer simulation of a high gain telephone with frequency shaping for hearing impaired persons. That simulation, conducted by the author in 1967, was probably the first use of a digital computer in simulating a hearing aid. It was recognized at the time that a computer could also be used to adaptively adjust the frequency response and other characteristics of a hearing aid SO as to best meet the needs of the user: however, because of severe practical limitations on the speed of simulation and the constraint that all processing be done off-line this potentially useful approach was not pursued until well over a decade later. The advent of the laboratory cornputer brought the realization of a digital hearing aid one step closer. An important feature of the laboratory cornputer is the relative ease with which 11: can be used to control laboratory equipment. Computer controlled audio systems for research in audition were developed soon after the introduction of the modern laboratory computer. The earliest of these systems were configured around a LING-8, the predecessor of the highly successful DEG PDP-8 laboratory computer, An early system of this type was developed by Braida and his associates at the Massachusetts Institute of Technology (personal communication with author) and has been heavily used in research in psychoacoustics. A more modern version of the system has been used extensively in experiments on acoustic amplification and signal processing for hearing impairment. Although not designed specifically as such, this early system was in essence a computer-controlled master hearing aid used for research in acoustic amplification.

ii). All-Digital Hearing Aids

In an all-digital hearing aid both the processing of the audio signals and the control of the processing are done by digital means. Further, all sampled waveforms are converted to binary form for ease of processing and then converted back to analog form after processing to drive the earphone. Graupe appears to have been the first to implement such a system using an 8080 microprocessor. The approach used was conceptually similar to that of the digitally controlled analog system except that the fitter, limiter, and one or more of the amplifiers have been replaced by equivalent digital. components. Further, because of the great Audibility of control afforded by the microprocessor, it was possible to program the system to be self-adaptive, thereby opening the door to the use of advanced signal-processing techniques for noise reduction and intelligibility enhancement. Although the *8088* microprocessor used by Graupe was both slow and relatively large in size, he clearly anticipated the day when microprocessors would be fast enough and small enough for use in a practical hearing aid.

At about this tirne (the late 1970s) the concept of an all-digital programmable hearing aid *was* also being developed in Germany as well as at the Institute for Hearing Research in Nottingharn, England (personal communication between M. Haggard and the author). The approach followed by the latter group[5] was that of using a self-standing digital filter controlled by a standard microcomputer, a technique that was to be adopted later by several other research laboratories. Although the concept of a digital hearing aid was anticipated at an early date, two major technical problems had to be resolved before anyone could develop a practical all-digital instrument. The first was the development of a digital signal processor fast enough to operate in real tirne. The second, more difficult problem (which has yet to be resolved satisfactorily) is that of developing digital circuitry that is srnall enough and sufficiently low in power consumption for practical use in a small, wearable unit.

The first breakthrough came with the development of the array processor in which an array of numbers is processed simultaneously, instead of only one number at a time as in a conventional digital computer. The saving in processing time resulting from the use of this technique is sufficient to allow for real-time processing of audio signals. High-speed array processors were introduced toward the end of the nineteen seventies and shortly afterwards an all-digital hearing aid was developed configured around one of these units Although still too large to be wearable, that instrumental has been used effectively as a master hearing aid in a series of experimental investigations on the prescriptive fitting and evaluation of digital hearing aids . Another important development was the introduction of a family of high-speed digital-processing (DSP) chips in 1982. Although not as East as an array processor, these chips are fast enough for Limited real-time processing of speech signals. Because of their small size, these chips can be packaged in a until small enough to be wearable. Experimental body-worn digital hearing aids were developed soon after high-speed DSP chips became available [4]

The basic operations performed by a hearing aid are amplification, filtering, and output limiting. Amplification in a digital system is achieved by simply multiplying the samples representing the audio signal by a constant . The magnitude of constant determines the amount of amplification. Amplitude limiting is also achieved fairly simply, by setting a maximum allowable value for the samples contained in the digital representation. An alternative method of output limiting is to adjust the amplification constant

iii). Advantage of DHAs (Digital hearing)

Digital hearing aids promise many advantages over conventional hearing aids.
These include:

Programmability, Much greater precision in adjusting electroacoustic parameters, Self-monitoring capabilities, Logical operations for self-testing and self-cali-"oation Control of acoustic feedback(a serious practical problem with high-gain hearing aids). The use of advanced signal-processing techniques for noise reduction Automatic control of signal levels, and Self-adaptive adjustment to changing acoustic environments. Only a few of these features are likely to be included in the first generation of wearable digital aids can be subdivided into three broad groups:

1) Signal-processing capabilities that are analogous to, but superior to, those offered by conventional analog hearing aids.
2) Signal-processing capabilities that are ~~unique to digital systems and which cannot be implemented in conventional analog hearing aids.
3) Methods of processing and controlling signals that change our way of thinking about how hearing aids should be designed prescribed, and fitted.

The third type of advantage is the most subtle and the most important. Because any digital hearing aid can be programmed not only to amplify, but also to generate, audio signals. As such, the instrument can be programmed to serve as an audiometer in order to facilitate the measurement of audio logical characteristics relevant to the prescriptive fitting of hearing aids. Using this approach, it is possible to circumvent the very difficult problem of correcting for the frequency dependent differences in sound level between the traditional audiometer headphone and the patient's own hearing-aid receiver.[7] The idea of using a hearing aid as an audiometer was born out of the realization that the primary differences between the two devices are those of software (i.e., the controlling program) rather than fundamental differences in hardware.

Another important stimulus to our thinking has been the use of computer simulation. As noted elsewhere in this paper, the development of computer- simulation techniques to facilitate the design and development of vocoders and other telephone oriented speech processing systems led to the realization that computers could also be used to simulate hearing aids, and that eventually digital processing of audio signals would be possible in a hearing aid. Further, the first working digital hearing aid was achieved using real-time.

Computer simulation and thereby providing a glimpse of the many possible features that could be incorporated in the digital hearing aids of the future.

X. HEARING AID BENEFITS & LIMITATIONS

Benefits of Having a Hearing Aids

Modern hearing systems improve safety and increase quality of life. In addition, they demonstrably improve oral expression. With a modern hearing aid you not only understand others better but others can understand you better to.[8][9]

- They increase your safety: you not only become aware of hazards earlier, you also recognize where the danger is coming from more reliably.
- Whether it's the doorbell, telephone or loudspeaker announcements, you are much less likely to miss auditory cues and information.
- It makes things easier for those around you: you no longer have to ask anyone to repeat announcements or to speak more loudly.
- You stand out less: you no longer talk too loudly or turn the TV and radio volume up too high.
- You avoid misunderstandings: in conversations you perceive not only words but also emphasis, nuances and volume, and therefore understand your conversation partner better.
- You are more successful: several studies have shown that even slight hearing problems reduce earnings potential.

Limitations

Do not restore normal hearing All sounds, including background noise and undesired sounds, are made louder. Sounds, including own voice, might seem too loud at first. May need to be replaced every several years

XI. COMMON HEARING AID FEATURES

Directional microphones Sound from a specific direction amplified to a greater levelMay help listeners to understand speech in noisy environments

Feedback suppression Squeals suppressed when the hearing aid gets too close to the phone or has a loose-fitting earmold

T-coil (Telephone switch) Sound picked up from the telephone when switching to the "T- coil" setting. Help to reduce the chance of hearing aid "whistling". Also works well in environments (e.g., theaters, auditoriums, etc.) where there is induction loop or FM installation

XII. PRESENT SCENARIO in INDIA

The sensorineural loss is more prominent in our society today [4]. Deafness, profound hearing loss, is now a global problem which in turn is a consequence of these forms of hearing losses. Sensorineural form of hearing loss (SNHL) appears as a result of troubles with the inner ear. It mostly observed when the nerve endings in the ear that conduct sound in the ear are damaged, diseased, work unexpectedly, or have worn out. A study seeks to identify the present causes of profound sensorineural hearing loss in Indian society particularly [4], which in our environment is almost synonymous to a life sentence of silence and isolation.

Out of the total 175 respondents in that study, 58% were male and the rest were female. 34% respondents possessed their own cell-phones, mp3 players and other entertainment medias for more than two years while 64% had purchased it recent times. The statistics only seem to worsen in the rural sector. Age-wise distribution observed is as given in Figure 7. [5]: However, the causes of, attitudes toward, and management options for deafness (extreme state of hearing loss) differ considerably from region to region. With these statistics engorgement every year, hearing impairment has been of prime concern for the society and so is the need for devices that could aid the disabled in reviving hearing. The age-wise distribution as per the statistics gathered after carrying out a number of surveys.

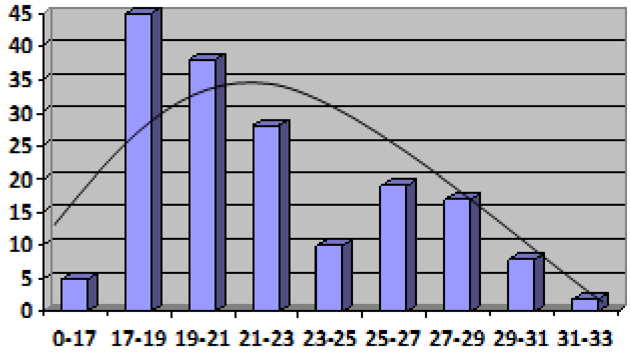

Fig 7.

Std.dev=3.85
Mean=2.14
N=165.02

XIII. CONCULSITION

As we have several forms of hearing impairment appearing in human beings at some stage of life or the other, there is an essential need for hearing aids. Statistically, youth are the worst hit of all categories of people. After this extensive study of hearing aids we can conclude that usage of hearing aid improvise human lives. Although in India because of lack of awareness and cost still it is not reaching common people.

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