A Survey of Hearing loss and Hearing Aids

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Abstract—This paper overview of the state of the art the main topics include two items: Hearing loss and Hearing aids. 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.

Keywords—Hearing survey, Hearing loss, Hearing, Hearing Aids, Ear.

I. INTRODUCTION

HEARING loss problem is the key issue because an abnormal is often not painful symptoms. The medical on hearing loss is call a hidden disabled like as other disabled group. The hearing loss affects children such as delay in the development communication skills, communication difficulties often lead to social separation and it affects adults of the most common over the age of 60 years and contributes to difficulties in speech comprehension. The problem with any part of the ear in left ear or right ear or ears [1], there are many cause of hearing loss [2] such as exposure to loud noise from headphones, aging so how treatment are varies depending on hearing level.

The treatments with drugs or surgery are more complex because of many factors of patients such as diabetes patients, which hearing loss and cannot treatment.

There are help the patient with hearing aids to assist in making sound amplifier hear well.

The paper outline is as follows. Section II describes methods, focusing on audiogram and processes of this study. Section III describes the hearing process in humans. Section IV discusses literature review of hearing loss and hearing aids; and section V conclusion and future directions.

II. METHODS

A. Audiogram

An audiogram is the graph result of a hearing test in the left ear and right ear and measure in Hertz (Hz). There are two main components: frequency and intensity. The audiologist was test sound you could hear at each frequency. The frequency or pitch is range from low to high and read from left to right on the audiogram and use horizontal axis. The ones used most testing at frequencies are 250, 500, 1000, 2000, 4000 and 8000 Hz.

The intensity is concern to loud level and measure in decibels (dB). Typically, the softest sounds are at the top in vertical axis at -10 dB (zero dB) and other hand the loudest sound at the button in axis Y at 120 dB.

B. Processes of this study

This study overview that hearing loss and hearing aids as in Fig. 1 suggests processes through the hearing. There are divided in to three parts: First part for the hearing loss (A) is knowledge and literature review of hearing loss, Second part for hearing evaluation (B). There are eight steps as follow bottom flowchart. There are four steps:

1) Begin of testing
2) Sound: listening sound at frequencies 250, 500, 1000, 2000, 4000 and 8000 Hz
3) Audiogram: Show listening graph at frequencies as in choice 2)
4) Interpreter of audiometry: Indicates that result of audiometry in each ear from translation audiogram, if normal hearing then end of testing, if abnormal hearing then go to third parts

The third part for hearing aids (C) is knowledge and literature review of hearing aids.

III. HEARING PROCESS IN HUMANS

Hearing level are six categories of hearing loss: Normal, Slight, Mild, Moderate, Moderately-severe, Severe and Profound as in TABLE I [1],[3] such as the rang for normal hearing is defined as hearing thresholds of less than an equal to 25 dB at all frequencies

<table>
<thead>
<tr>
<th>Hearing level range (dB) HL</th>
<th>Degree of hearing loss</th>
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<tbody>
<tr>
<td>-10 to 15</td>
<td>Normal</td>
</tr>
<tr>
<td>16 to 25</td>
<td>Slight</td>
</tr>
<tr>
<td>26 - 40</td>
<td>Mild</td>
</tr>
<tr>
<td>41 - 55</td>
<td>Moderate</td>
</tr>
<tr>
<td>56 - 70</td>
<td>Moderately-severe</td>
</tr>
<tr>
<td>71- 90</td>
<td>Severe</td>
</tr>
<tr>
<td>&gt; 90</td>
<td>Profound</td>
</tr>
</tbody>
</table>

*a dB HL = Decibels Hearing loss mean the patient’s hearing loss range in decibels. Zero (0) dB HL is no sound at all. -10 to 15° = In fact, begin at -10 dB HL or lower [4]*

Fig. 2 has two parts, include (a) the anatomy of the ear and (b) Process of hearing. The ear is divided into three parts; outer ear, middle ear and inner ear. First parts, Outer ears consist of ear flap or pinnae and ear canal; pinnae are visible part of ear that folds of skin and cartilage; ear canal is a tube which connects outer ear with inner ear. There are collect sound waves and send them into ear drum through ear canal of middle ear. Second parts, Middle ear consist of ear drum, hammer, anvil and stirrup; ear drum is position at the end of ear canal that sound waves transfer to ear canal strike the ear drum with causing to vibrate; hammer is a tiny bone when sound waves cause ear drum to vibrate, the hammer strikes the anvil; the anvil is a tiny bone which make the signal louder; the stirrup is a tiny bone which the sound waves to the inner ear. Third part, Inner ears consist of cochlea and auditory nerve; the cochlea is a snail shaped chamber which liquid and hair cells inside it. When the stirrup hits the cochlea it sends waves through the liquid and the tiny sensitive hair cells make up start of the auditory nerve which carries this information to the brain that interprets sounds [6].

IV. LITERATURE REVIEW

A. Hearing loss

One in three people over the age of 65 years and number of 165 million people worldwide are hearing loss [7]. The number of people with hearing loss will grow. The hearing loss cause a problem at any point in the hearing pathway (pathway is from outer to inner ears) and depending on what part of the loss is not working properly. There are two categories: First, conductive hearing loss, which is something not working in the part of outer and middle ear for example ear canal, eardrum and middle ear bones. This is caused earwax, fluid or infections in middle ear, small holes in ear drum. People with a conductive hearing loss can be corrected medically or surgically. Second, sensorineural hearing loss, which is something not working in the part of inner ear for example cochlea, nerve, vestibular organs. This is the most common type of hearing loss and is caused damage to tiny cell in inner ear, that help transmit sound to your brain. These can break because of very loud noises is a main cause of hearing loss [7], age, head injury, virus infections in inner ear [2]. Many different approaches have been proposed to solve this issue. The literatures of hearing loss are screening and review of hearing loss as in Fig 3.

- Review the prevalence and impact of untreated hearing loss and screening in primary care (L. A. Bushman et al., 2012)
- Screening for auditory impairment with physiologic testing (AudioScope) or self-administered questionnaire: HHIE-S Hearing Handicap Inventory for the Elderly-Screening version (B. Yueh et al., 2007)
- Hearing loss associated with other functional limitation and constitutes a serious health problem with important implications (J. López-Torres Hidalgo, et al., 2009)
- Describe the incidence and predictors of hearing aid ownership and use among older adults (B. Gopinath et al., 2011)
- Screening in adults with questionnaire and tone emission test (P. B. Becerril-Ramírez et al., 2013)

Fig. 3 Review of hearing loss

The screening of hearing loss: [8] screening: physiologic testing using AudioScope (a hand-held device that can be used for hearing screening) , a self-administered questionnaire using HHIE-S (Hearing Handicap Inventory for the Elderly-
Screening version, which designed to assess the effects of hearing impairment on the emotional and social adjustment of elderly people) and both tests. The results showed that both test is highest percentage of patients who screened positive for hearing loss was 63.6%. [9] screening for hypoacusia (medical history and the hearing threshold through liminal tonal audiometry) using HHIE-S. The results showed that the hearing loss in people over 65 years associated with other functional limitations and this problem of hearing loss affects to health. There is a need to improve screening for hearing loss. [10] The measured of hearing levels with pure-tone audiometry use to analyses examining associations between bilateral hearing loss hearing loss severity and incidence of hearing aid ownership and use. The results found that age, question-defined hearing handicap and measured HL were significant predictors with hearing aid ownership and use. [11] found that the best screening strategy are combination of the questionnaire and the tone emission with a precision of 90%.

The review of hearing loss: [2] One of the current recommendations for screening are HHIE-S and an AudioScope. There are problems for this recommendation: current adult hearing screening lack information for screening and how frequently providers should re-screen.

Likewise; as Table II, Lists the screening tools of hearing loss. These are both screening tools generate high precisions.

<table>
<thead>
<tr>
<th>TABLE II</th>
<th>SUMMARY SCREENING TOOLS OF HEARING LOSS</th>
</tr>
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<tbody>
<tr>
<td>References</td>
<td>Hearing level tool</td>
</tr>
<tr>
<td><strong>Screening</strong></td>
<td></td>
</tr>
<tr>
<td>[8]</td>
<td>AudioScope</td>
</tr>
<tr>
<td>[9]</td>
<td>Pure-tone audiometry</td>
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<tr>
<td>[10]</td>
<td>Tone emission</td>
</tr>
<tr>
<td><strong>Review</strong></td>
<td></td>
</tr>
<tr>
<td>[2]</td>
<td>AudioScope</td>
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</table>

HHIE-S* = the Hearing Handicap Inventory for the Elderly-Screening. Both* = used Hearing level tool and Questionnaire.

### B. Hearing aids

Hearing aids are small electronic devices. There are used to amplify the frequencies as mean make sounds louder for hearing loss people can listen, communication in daily activities. There are many types depending on where they are worn: behind the ear, in the ear, in the canal and completely in the canal. In addition, the most all hearing aids are fully digital technology [3]. Digital allow for better programming and make it possible such as feedback control therefore all paper of hearing aid in this study are related to digital technology.

The overall performance of hearing aids is improved digital signal processing strategies of hearing aids include noise reduction and acoustic feedback reduction so more different approaches have been proposed to solve this issue. In Fig. 4, this study reveals that the literatures of hearing aids are dividing to four categories: Development, Evaluation, Technique and EEG (Electroencephalography).

The first, Development: [12] are develop a pocket-type digital hearing is call PDN-01B, which suitable for low-resource countries such as Thailand and the cons: shape design was old fashioned but it was a good response from the users in rural areas.

The second, Evaluation: [13] are evaluation of adaptive noise reduction algorithms for dual-microphone hearing aids to compare fixed directional microphone, adaptive directional microphone and adaptive beamformer. The results show that all the noise reduction strategies an improved SNR (signal to noise ratio) in complex noise and the adaptive beamformer generally performs best in signal noise source.

The next, Technique: [14] are applies interactive EC (Evolutionary computation) to hearing aids fitting and evaluation hearing aids simulator with human subjects. The advantages are optimize a hearing aids base on how user hearing with W3: whatever + whenever + wherever fitting. [15] is to setup a fast self-test of finding the hearing level because of difficulty and concentration for long time. There are two ideas to reduce time and steps. The results show that steps were reduced by test in some frequencies under 30 dB were skipped.

The next, the most commonly used methods in digital hearing aids for improved signal processing strategies of hearing aids include noise reduction and acoustic feedback reduction such as to adjust the gain function with fixed gain functions [16], to new multi-channel loudness compensation method based on high frequency compression and shift indicate reduces the negative impact during conventional loudness compensation and the recognition rate of the voiceless increases 30% than conventional method [17] and to create the final model with logistic regression and chi-squared strategies indicate the decision of audiologists for to fit a BTE aid (Behind the Ear) or an ITE aid (In the ear aids) [18].

![Fig. 4 Review of hearing aids](image)
The next, the most commonly used simulation tools [19] for digital signal processor based hearing aids were performance, better hearing fitting and main. In the same way, [19] was designed block model for optimum weight consist of digital signal processing and adaptive algorithm with LMS (Least Mean Square) and NLMS (Normalize Least Mean Square) in Matlab program (simulation tool). The results show that the NLMS maintained a faster speed with smallest mean square error when step size is varied. Moreover, [17] proposed a new multi-channel loudness compensation method based on high frequency compression and shift for digital hearing aids, which was run in simulation tools. The results show that decrease the negative impact during conventional loudness compensation and the recognition rate of the voiceless increases 30% than conventional method.

Table III. Lists the techniques of hearing aids. These are the methods and simulation program found in most hearing aids.

<table>
<thead>
<tr>
<th>References</th>
<th>Methods</th>
<th>Hearing level</th>
<th>Hearing fitting</th>
<th>Simulation program</th>
<th>Simulator with human</th>
</tr>
</thead>
<tbody>
<tr>
<td>[14]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[19]</td>
<td>✔ Adjust gain function</td>
<td></td>
<td></td>
<td>✔ Mathlab</td>
<td></td>
</tr>
<tr>
<td>[16]</td>
<td>✔ Compression and shift</td>
<td>✔</td>
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<td>[15]</td>
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<tr>
<td>[17]</td>
<td>✔ Logistic regression and chi-squared</td>
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The last, EEG: [21] proposed a method to classify EEG time series signals recorded form left and right ears with the extracted fractal features. The extracted fractal features were associated with hearing threshold perception and a neural network model for ears. The classification results show that the left ear-right ear of normal hearing and abnormal hearing was reported as 90% and 95% with specificity of 90%, sensitivity of 100% and promising for can be safely adopted in screening the hearing threshold level.

V. CONCLUSION AND FUTURE DIRECTIONS

In conclusion, the correlation of hearing loss and hearing aids was significant. The current most screening uses two method contain questioner with HHIE-S and an AudioScope. In addition, the result found that the both screening tools of hearing loss for generate high precisions.

The most of hearing aids improve techniques for enhances digital signal processing such as Adjust gain function, compression and shift. And using simulation program for digital signal processor based hearing aids were performance.

In the future, we will be the data of this study to design new algorithm for hearing aids.

REFERENCES

[7] W. H. organization, "Million of people in the world have hearing loss that can be treated or prevented.” 2013.


