Обзоры

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Artificial Intelligence and Hearing Disorders

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Currently, artificial intelligence (AI) is actually classified as various software systems and the methods and algorithms used in them, the main feature of which is the ability to solve intellectual problems tasks the way a person thinking about their solution would do it.

Among the many important applications of the technology landscapes of the AI, it is necessary to highlight neural networks, machine and deep learning, which are most often used in medical practice (Fig.1).

AI has the potential to significantly improve the listening experience for individuals with hearing loss [4, 22, 28, 31, 36].

The global digital transformation enables computational audiology for advanced clinical applications that can reduce the global burden of hearing loss. It’s important to describe the emerging hearing-related artificial intelligence applications and argue for their potential to improve access, precision, and efficiency of hearing health care services [1, 6, 13,16,18, 24].

More than 5 percent (466 million) of the world’s population is affected by hearing loss (432 million adults, 34 million children). It is predicted that over 900 million people, or one out of ten, will experience hearing loss by 2050 [3,7,14,15, 25, 30].

According to WHO, by 2030 the number of patients with deafness will exceed more than the 40%.

Up to 70% of all violations of the hearing disorders are due to the senso-neural hearing loss.

Out of 1000 newborns, 1 child is born with complete deafness [2, 12, 20, 24, 31].

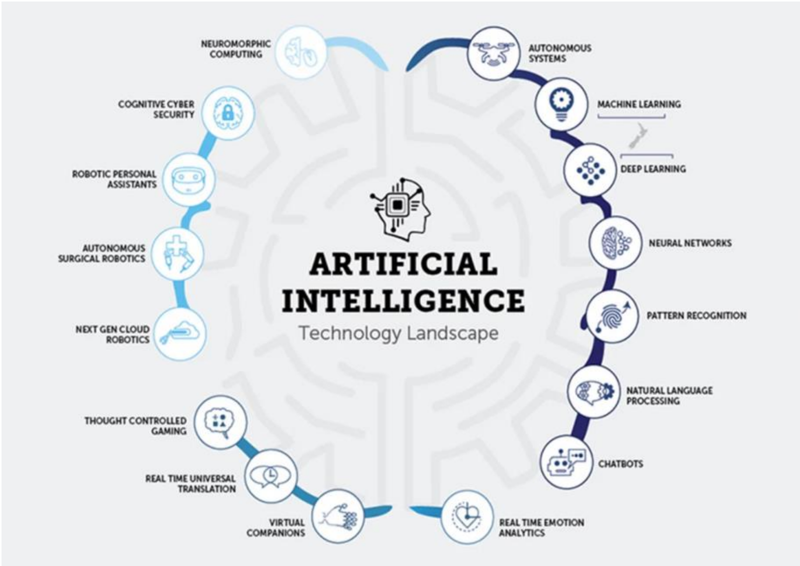

Fig.1.Technology Landscape

The late recognition of hearing disorders identification might delay the development of speech, language, cognitive functions of the child.

Such procedures include five steps followed by an order, which include a collection of patient case history, otoscopy, audiometric hearing tests, tympanometry and acoustic reflex [8, 23, 29, 33, 35].

Hearing loss is among the most prominent diseases harming children as well as younger and older adults, and can contribute to impairment if they are not properly diagnosed earlier [5, 9, 11, 19, 26, 32, 36].

An otorhinolaryngologist categorizes the symptoms of a patient according to his/her expertise and after the specific evaluation of the symptoms of hearing loss (Fig.2).

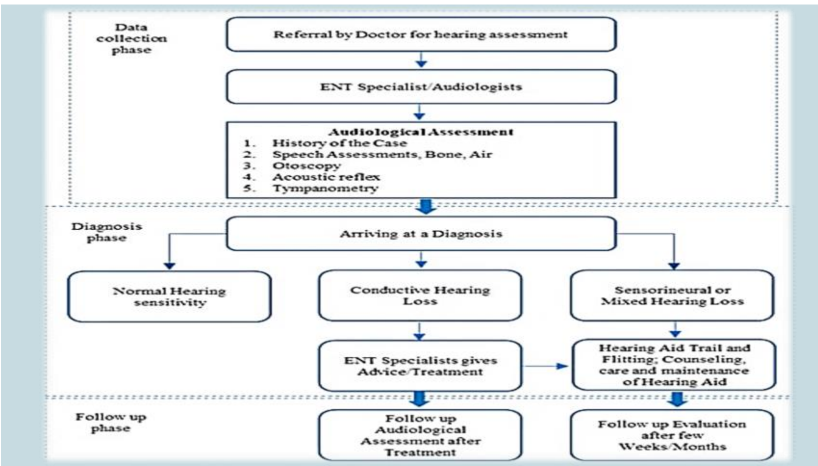

Fig.2.The main steps to diagnose the hearing disorders

The hearing-loss symptoms diagnostic procedures included following steps (Fig.3):

- case history
- air, bone, speech assessment
- tympanometry
- acoustic reflex

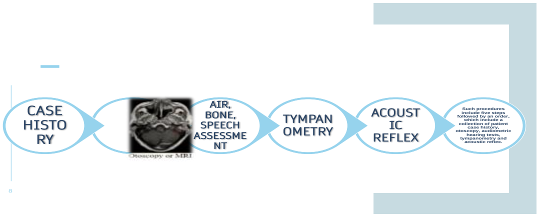

Fig.3. Hearing-loss symptoms diagnostic procedure

Physicians depend on their insight and experience and on a fundamentally indicative or symptomatic approach to decide on the possible ailment of a patient. However, numerous phases of problem identification and longer strategies can prompt a longer time for consulting.

The major processing stages of the auditory system (Fig. 4, 5) are the following- sound that enters the ear canal causes vibrations of the ear drum. These vibrations are transmitted by the ossicle bones in the middle ear to the fluid-filled cochlea in the inner ear. Hair cells in the inner ear amplify and transduce motion of the cochlear fluid into electrical signals that are sent to the brain. Several specialized pathways in the brainstem process these signals, and the resulting information is integrated in the cortex to produce a coherent auditory experience [6, 10, 19, 25, 30, 34].

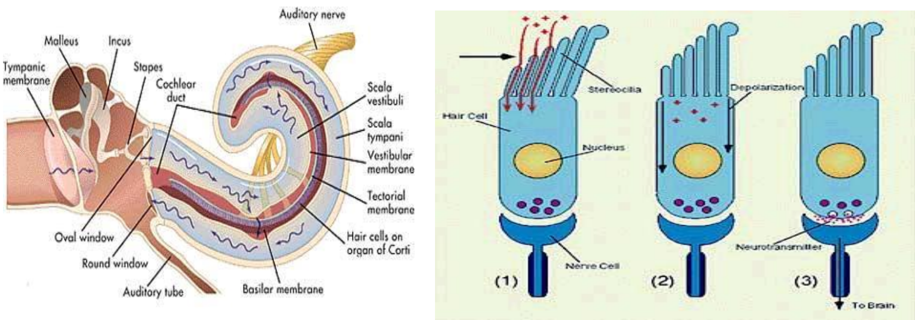

Fig.4. The major processing stages of the auditory system

The auditory system is a marvel of signal processing. Its combination of microsecond temporal precision, sensitivity over more than five orders of sound magnitude and flexibility to support tasks ranging from sound localization to music appreciation is still without parallel in other natural or artificial systems [1, 5, 10, 17, 21, 27, 30].

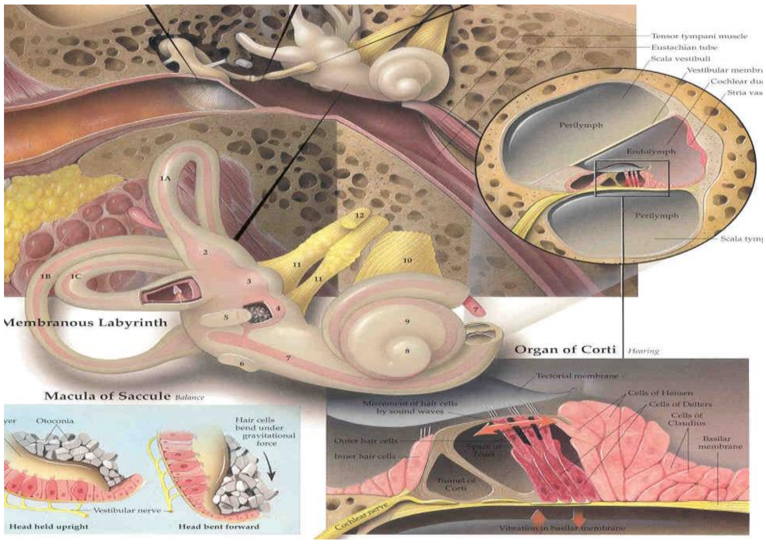

Fig.5. The anatomy of the auditory system indicated its structural complexity

The complexity of the auditory system is reflected in its disorders [1, 2, 6, 11, 17, 26, 31, 35]. The system is susceptible to disruption at any of its stages, resulting in a variety of perceptual impairments such as deafness (a loss of sensitivity to sounds), hyperacusis (an increase in sensitivity that causes sounds to become uncomfortable or painful) or tinnitus (the constant perception of a phantom sound, often a ringing or whistling). To help identify the underlying causes of a perceptual impairment, hearing assessments are designed to provide clinicians with a wide range of data reflecting the status of the different processing stages, including:

- mechanical and acoustic measurements of the ear; electrophysiological and imaging measurements of the ear and brain;
- psychoacoustic and cognitive measurements of perception.

Fortunately, many of the most common services in hearing healthcare can be readily automated or controlled remotely through telemedicine. One current method of them is audiometry [4, 6, 8, 19, 27, 29, 32].

Auditory function studies are carried out using two groups of methods:

Subjective (psychoacoustic):

- hearing testing using speech with noise;
- hearing testing using tuning forks;
- subjective audiometry.

Objective:

- objective (computer) audiometry;
- acoustic reflexometry;
- tympanometry;

- otoacoustic emissions;
- unconditioned reflex reactions;
- conditioned reactions to sound.

With all subjective methods of hearing research, the subject himself evaluates whether he hears the sound or not and in some other way reports this to the specialist. With objective examination methods, the results obtained do not depend on the patient’s wishes; in most cases, they are recorded using special equipment.

Hearing was once at the forefront of technological innovation [4, 8, 13, 17, 22, 27, 32]. Current hearing devices use a microphone to pick up sound, which is amplified and filtered before being digitized for signal processing. The processing parameters are fixed after fitting by an audiologist and the processed digital signals are converted to either an analogue signal delivered to a speaker in a hearing aid (HA) or an electrical signal delivered to electrodes in a cochlear implant (CI).

The cochlear implant, which restores hearing through direct electrical stimulation of the auditory nerve, was a revolutionary advance and remains the most successful neural prosthetic in terms of both performance and penetration (Fig.6).

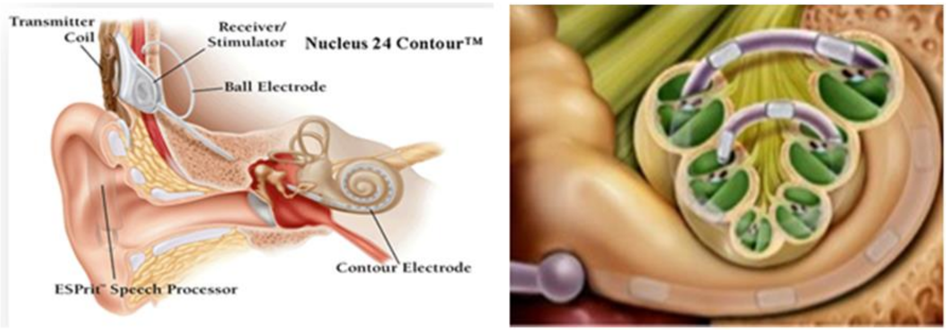

Fig.6. Cochlear implantation

Recent advances in AI have the potential to transform hearing. Machines have already achieved human-like performance in important hearing-related tasks such as automatic speech recognition (ASR) and natural language processing.

AI in hearing aids has the potential to significantly improve the listening experience for individuals with hearing loss. For hearing aids to be successful, they need to do a good job of adapting to the wearer's hearing needs, as well as sorting out challenges such as background noise.

In the digital hearing aids, AI helps the devices to function better. For instance, you are drinking coffee with a friend in a busy coffee shop, but you also like the music they play. Your hearing aids automatically adjust to only focusing on speech, but you'd also like to hear the music more as well.

In noisy environments, hearing aids can work very poorly because they are unable to separate speech sounds from others and instead amplify everything at once. Researchers using an artificial intelligence system were able to find a solution to this problem. The new AI system helps focus the device's attention on what's important to the user by analyzing their brain waves.

Your hearing aids have essentially made the decision for you and sacrificed one for the other. Speech is clear, but your spatial awareness and feeling a part of your surroundings have been disregarded.

In addition to improving the listening experience, AI can also be used to monitor and track the user's hearing health. This information can be used to optimize the hearing aid settings for the user or to alert the user or their healthcare provider if there are any changes in their hearing health.

AI can also be used to improve the usability and functionality of hearing aids [5, 6, 12, 14, 20, 21, 26, 32, 36]. For example, some hearing aids use AI to recognise and respond to voice commands, allowing users to easily control their hearing aids without the need for buttons or physical controls.

An AI technology that creates hearing programs developed on your typical soundscape with how often you manipulate the volume and settings in commonplace environments.

Typical environments such as the sounds of your commute, office space and favourite restaurant will be enriched automatically. Alternatively, you can keep it simple and take the reins by controlling your hearing aids yourself; it’s all down to what you want.

There are also the Oticon More hearing aids, which include Deep Neural Network technology - an AI system that mirrors the way your brain functions. The idea here is that instead of using a sound processor built upon theory and guesstimation - your hearing is enhanced in the most natural way [3, 11, 16, 23, 28, 31, 34]. The DNN is trained to understand and recognise all common sounds down to the finest detail and how they should be heard, as well as supporting your brain.

Today's WIDEX EVOKE hearing aids are equipped with automatic features that help you forget about your hearing aid and focus on hearing.

SOUNDSENSE LEARN is AI technology powered by machine learning algorithms that helps you tailor the sound of your hearing aid to the listening situation that matters to you by listening to sound profiles offered on your smartphone [3, 5, 10, 22, 24, 31, 36].

Hearing devices pick up the sound in the environment of the user, process it and deliver processed sound to the user by different means of stimulation, depending on the type of hearing loss:

-acoustic (hearing aids and hearables),

-electric (cochlear implants) or

-mechanic (bone-conduction devices or devices with direct stimulation of the temporal bone). For the most common case of mild or moderate sensorineural hearing loss, hearing aids are mainly placed behind the ear.

AI could also break the bounds of traditional fine-tuning methods.

Among the benefits of using the AI enabled hearing aid applications are:

1. Immediate Solutions: Users get immediate solutions to problems they face in various listening situations, at any time. This responsiveness goes beyond what is feasible with traditional fine-tuning, giving users a higher level of control and flexibility.
2. Continuous Improvement: The system utilizes machine learning to formulate solutions based on each user's unique needs. This allows for continuous improvement over time as the AI learns more about the user's preferences and usage patterns.
3. Transparent System: audioprosthetists gain access to real-time user preferences, enabling them to provide better counseling and more precise adjustments during follow-up visits. This seamless integration of technology and professional expertise enhances the overall service and care for the user.

Innovative new noise reduction features can assess and reduce incoming sounds, such as background noise and nearby conversations to help users hear better. For instance, wind noise reduction allows people with hearing aids to enjoy outdoor hobbies – including gardening, fishing, hiking, and running – without the wind impacting their ability to hear properly. The technology on modern hearing aids can detect wind blowing and automatically reduce the volume of that sound. As a result, the hearing aid user can focus on conversations, even in very busy settings with abundant background noise.

AI powered noise reduction systems used for dynamic listening environments and to analyze sounds in the environment and differentiate between speech and other noise.

These intelligent algorithms constantly adapt to changes in the audio environment, making real-time adjustments to suppress unwanted noise and improve speech clarity [2, 7, 9, 13, 17, 20, 26, 33].

Hearing aid manufacturers are collaborating with audiologists and smartphone manufacturers to develop hearing aids compatible with Apple and Android products.

These hearing aids connect wirelessly to smartphones and tablets without the need for a separate "hang-on" or "remote" accessory.

AI help to make audiological management. The goals of this way are:

-to assure access to sound adequate for auditory development

-programming or "mapping" of the cochlear implant system

-assessments at regular intervals to track auditory development

-age-appropriate techniques & materials.

First of all, we will understand that there are two main approaches and options for treating the hearing disorders: hearing aids and cochlear implantation (Fig.7).

Fig.7.Hearing aid and cochlear implant

How does a cochlear implant work?

Sound waves enter through the microphone. The sound processor converts the sound into a distinctive digital code.

The electrically coded signal is transmitted across the skin through the headpiece to the implant. The implant delivers the sound to the electrodes. The electrodes stimulate the hearing nerve. The hearing nerve sends the signal to the brain where it is perceived as sound (Fig.8).

Hearing Aid	Cochlear Implant
Acoustically amplify sound.	Convert sound into electrical signals.
Rely on the responsiveness of healthy inner ear sensory cells.	Bypass the inner ear sensory cells and stimulate the hearing nerve directly.

Fig.8. How does a Cochlear Implant differ from a Hearing Aid?

Cochlear implantation is no longer experimental. It is the treatment of choice for children and adults with severe-to-profound hearing loss. Significant gains in open-set speech recognition have been demonstrated by most of those who undergo implantation. Early implantation, whether in pre- or post-lingual patients, has shown to be effective at moving an otherwise marginalized segment of society into the mainstream. Implantation is cost-effective and results in high patient satisfaction. Although cochlear implants are still a rough and awkward imitation of our natural sense, they offer hope to thousands who must otherwise live in a silent world.

Currently we have possibility to use the new equipment for clinical examinations and intraoperative measurements (Fig.9,10).

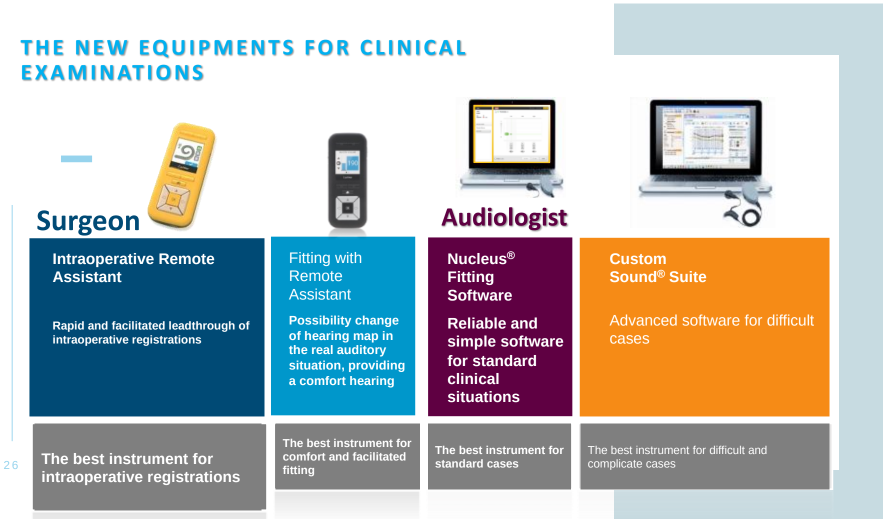

Fig.9. The new equipment for clinical examinations

The intraoperative measurement system CR120/220 provide:

- Auto NRT
- Impedance measurement
- Using sound processor
- Wireless
- Simple and easy operating by surgical staff.
- Minimises computer equipment required in the operating theatre

With the development of the state of the art in the field of technologies used for diagnostic purposes of various profiles, including testing the quality of hearing, speech recognition and audiometry, the need to automate all key functions that can be accessed by the end user without the need to resort to services of specialized specialists, as well as simplifying the obtaining of a primary picture of the condition of the hearing organs, which allows solving the problem of obtaining assistance to the population in regions where there is no opportunity to contact a specialized specialist as such.

Fig.10.The new intraoperative measurement system CR120/220

Luxury hearing aids now offer real-time language translation capabilities thanks to built-in artificial intelligence systems.

This feature allows users to receive translations of foreign languages directly into their ears, making it easier to communicate and understand conversations when traveling or communicating with people with different language backgrounds.

A prototype of a device has been created in Armenia that will help deaf and mute people study and work.

A special glove (Fig.11) reads sign language and translates it into regular language through a mobile application (a version for the Armenian language has already been prepared). In the new model, reading will be accelerated and will be carried out almost synchronously. The Armenian startup 5Yet has created a device that will help people with hearing and speech impairments to fully communicate with the outside world, study and work.

To do this, the development team created a glove with sensors that read words and phrases in sign language from the phalanges of the fingers and hand and simultaneously translate them into any of the languages (Armenian was included in the original model). The mobile application displays ready-made text on the screen. A prototype of the device was presented at the Sevan Startup Summit 2023 forum.

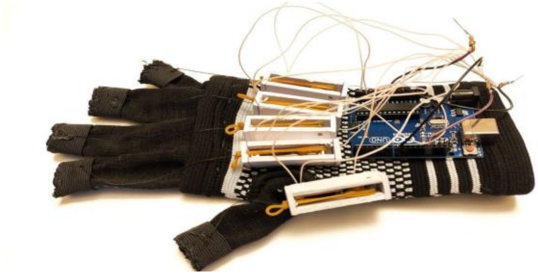

Fig.11. A special glove for reading sign language

Another new development from Vibrosonic is the so-called “acoustic lens”. It is installed directly on the eardrum, and its operation is based on piezoelectric microdynamics - Vibrosonic- Aktor (Fig.12). According to the company, it is the first and only hearing aid speaker of its kind that was developed using MCT (Micro System Technology) technology.

Fig.12. “Acoustic lens”-Vibrosonic-Aktor

Overall, one thing is already becoming clear now - AI in the future will play a leading role in the global development of science, technology, medicine, education, where it will become an indispensable assistant in all spheres of life for people of the future. The main thing for the people of the future to remember is that AI does not move from the local system with the performance of local tasks to the global level, where it can influence their lives and fertility.

AI has the potential to significantly improve the listening experience and hearing health of individuals with hearing loss. By adapting to the user's environment and needs in real-time, AI can help to optimise the performance of hearing aids and improve the overall quality of life for users.

Ultimately, the decision to use hearing devices with AI technology should be based on individual needs and preferences.

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Искусственный интеллект и нарушения слуха

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Искусственный интеллект (ИИ) сегодня используется во многих целях и присутствует практически в каждом доме, и мы постепенно становимся поколением автоматизированного ИИ.

Как отмечается в статье, ИИ в слуховых аппаратах может значительно улучшить качество прослушивания для людей с потерей слуха. Автоматизация слуховых аппаратов совершает скачок, и чтобы слуховые аппараты были успешными, они должны хорошо адаптироваться к потребностям слуха пользователя, а также решать такие проблемы, как фоновый шум.

Автоматизированные функции слуховых аппаратов действительно помогли владельцам получить доступ к лучшему звуку. Слуховые аппараты с возможностями ИИ могут анализировать и адаптироваться к среде прослушивания пользователя в режиме реального времени, автоматически регулируя громкость и частоту звука для оптимизации восприятия звука. Это может быть особенно полезно в шумной обстановке, где традиционные слуховые аппараты могут с трудом различать важные звуки и фоновый шум.

В некоторых слуховых аппаратах используются датчики для сбора данных о привычках пользователя в окружающей среде, которые могут быть проанализированы алгоритмами ИИ для выявления закономерностей и тенденций. Эту информацию можно использовать для оптимизации настроек слухового аппарата для пользователя или оповещения пользователя и его поставщика медицинских услуг о любых изменениях в состоянии его слуха.

Таким образом, слуховые аппараты с ИИ открывают путь к улучшению качества слуха и, возможно, к другим революционным прорывам, поскольку они перенимают процессы существующих потребительских технологий.

Несомненно, что в конечном счете, решение об использовании слухового аппарата с технологией искусственного интеллекта должно основываться на индивидуальных потребностях и предпочтениях.

Արհեստական բանականություն և լսողության խանգարումներ

Մ.Ա.Շուքուրյան, Խ.Մ.Դիար, Լ.Ա.Շուքուրյան, Ս.Վ.Լևին, Ա.Կ.Շուքուրյան

Արհեստական բանականությունը(ԱԲ) այսօր օգտագործվում է տարբեր նպատակներով և առկա է գրեթե յուրաքանչյուրի տանը, և մենք աստիճանաբար դառնում ենք ավտոմատացված ԱԲ-ի սերունդ:

Ինչպես նշվում է հոդվածում, ԱԲ-ն լսողական սարքերում կարող է զգալիորեն բարելավվել լսողության ընկալումը լսողության կորուստ ունեցող մարդկանց համար: Լսողական ապարատի ավտոմատացումը թռիչք է կատարում, և որպեսզի լսողական սարքերն արդյունավետ լինեն, դրանք պետք է լավ հարմարվեն կրողի լսողության կարիքներին, ինչպես նաև լուծեն այնպիսի խնդիրներ, ինչպիսին է ֆոնային աղմուկը:

Լսողական սարքերի ավտոմատացված գործառույթներն իսկապես օգնել են կրողներին ավելի լավ ձայն ընկալել: ԱԲ-ի հնարավորություններով լսողական սարքերը կարող են իրատեսական ժամանակում վերլուծել և հարմարվել օգտատիրոջ լսողական միջավայրին՝ ավտոմատ կարգավորելով ձայնը և հաճախականությունը՝ լսելու փորձն օպտիմալացնելու համար: Սա կարող է հատկապես օգտակար լինել աղմկոտ միջավայրերում, որտեղ ավանդական լսողական սարքերը կարող են դժվարությամբ տարբերել կարևոր ձայները ֆոնային աղմուկից:

ԱԲ-ն կարող է օգտագործվել նաև խոսքի ճանաչման և ըմբռնման բարելավման համար, հատկապես աղմկոտ միջավայրերում: Որոշ լսողական սարքեր օգտագործում են արհեստական ինտելեկտ՝ օգտատիրոջ սեփական ձայնը նույնացնելու և ուժեղացնելու համար, իսկ մյուսները կարող են օգտագործվել որպես մեքենայական ուսուցման ալգորիթմներ՝ ճանաչելու և առաջնահերթություն տալու կարևոր ձայների, ինչպիսիք են խոսակցությունները կամ ահազանգերը:

Որոշ լսողական սարքեր օգտագործում են սենսորներ՝ կրողի սովորությունների և շրջակա միջավայրի մասին տվյալներ հավաքելու համար, որոնք կարող են վերլուծել արհեստական ինտելեկտի ալգորիթմների միջոցով՝ օրինաչափություններն ու միտումները բացահայտելու համար: Այս տեղեկատվությունը կարող է օգտագործվել՝ օգտատիրոջ համար լսողական ապարատի կարգավորումներն օպտիմալացնելու կամ օգտագործողին և նրա առողջապահական ծառայություններ մատուցողին իրենց լսողության կարգավիճակի ցանկացած փոփոխության մասին զգուշացնելու համար:

Այսպիսով, ԱԲ-ով աշխատող լսողական սարքերը ճանապարհ են հարթում լսողության որակի բարելավման և հավանաբար այլ հեղափոխական առաջընթացի համար, երբ նրանք ընդունում են առկա սպառողական տեխնոլոգիայի գործընթացները:

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