Sohag University Sohag Medical Journal Faculty of Medicine

Hearing aid with artificial intelligence

Mohamed Abd Al-Ghaffar, Mostafa Ahmed Youssif , Maha Ahmad Ahmed, Gehad Fawzi

* Audiology Unit, Otorhinolaryngology Department, Faculty of Medicine, Sohag University, Egypt

Abstract:

Artificial intelligence (AI) has recently increased in its use.2017 represents the start of this new era for the hearing aid industry, artificial intelligence H.A. and it offers great promise in overcoming hearing challenges. In our opinion, artificial intelligence is the next revolution in hearing aids after the application of digital signal processing and wireless technology. With the use of artificial intelligence (AI), it will be easier for hearing-impaired persons to understand speech more clearly, especially in different environmental situations.

Artificial intelligence (AI), usually synonymous with machine learning, is the ability of computers to simulate human intelligence in problem-solving, logical reasoning, and managing complicated problems. Without being programmed, artificial intelligence can automatically learn from experience. So that it can recognize the wearer's listening environment and then adjust according to the acoustics of each environment. It offers an average 50% reduction in noisy environments, greatly decreasing listening eff ort, and improving speech clarity. So, it provides significant improvement in speech intelligibility in noisy environments.

Keywords: Artificial intelligent H.A, Widex evoke H.A, Livio AI H.A . Evolv AI H.A

DOI: 10.21608/SMJ.2023.185746.1363

Introduction

Patients with hearing loss face difficulties in their overall hearing abilities, such as decreased audibility, reduced dynamic range, and poor frequency and temporal resolution.(1) Also, they have a significant challenge in communication in difficult situations, like noisy and/or reverberant environments and despite advancements in digital signal processsing in hearing aid that tries to separate the primary signal from unwanted sounds, the person with hearing loss still has communication challenges.(2) Therefore, it is necessary to use new technology to deal with this issue, whether through wireless networking or the incorporation of AI into H.A.

What is artificial intelligence?

Artificial intelligence (AI), usually synonymous with machine learning, is the ability of computers to simulate human intelligence in problem-solving, logical reasoning, and managing complicated problems.(3) Artificial intelligence (AI) is a general term for a combination of deep learning and machine learning, which

includes algorithms for self-training, feature extraction, and outcome prediction AI is a technological breakthrough that has enhanced hearing capabilities and improved individuals' lifestyles.[4]

Applications of Artificial intelligence in hearing aid

1- Optimization of Hearing Aid Technology

Hearing devices with integrated machine learning can increase ease and hearing accuracy in real-world environments and reduce the need for repeated office visits. Additionally, with the rise of wearable technology, hearing aids with AI enable simple and dependable TV streaming directly from the hearing aid.[5]

2 Improvement of Speech Enhancement and Intelligibility

It has recently been proven that speech enhancement algorithms based on machine learning can significantly improve speech intelligibility in noisy and reverberant environments. This occurs by:

Acoustic Environmental Classification

AEC is the computational method for simulating the auditory system's ability to differentiate various sounds in the real-world listening situation.[6] Modern hearing aids use AEC to classify several types of listening situations, like quiet, speech, noise, and music, and to automatically enable sound management features such as directional microphones, noise reduction, and feedback control that are appropriate for those environments.[6] Any AEC system's accuracy is depending on the number of feature parameters, the sound classes, and the type of statistical model applied.

The classification accuracy of AEC systems has been enhanced using machine learning models trained on substantial, well-known datasets. In Starkey's Hearing Reality Sound AEC system, there are eight automatic sound classes: music, speech in quiet, speech in loud noise, speech in noise, machine, wind, noise, and quiet.[7]

It promotes speech understanding in noisy environments by making accurate adjustments in gain, compression, directionality, noise management, and other parameters appropriate for each distinct class.

Edge Mode

Edge Mode was created to overcome some of the drawbacks of AEC. By allowing the power of AI under the control of hearing aid users

Edge Mode is designed to be a simple user interface that allows a hearing aid wearer to initiate assistance in a challenging listening environment by double-tapping or pushing a button. the hearing aid takes an "acoustic snapshot" of the listening environment and maximizes speech intelligibility. Then change the parameters of eight proprietary classifications in different listening situations.[6]

Many users preferred Edge Mode over audiogram-based recommended hearing aid settings in communicating in noisy places, such as restaurants, transportation, and reverberant environments.[8]

1. individualization and customization of signal processing algorithms [5]

2. applications of machine learning in improving the efficiency and effectiveness of clinical tests:

psychophysical measurement of tinnitus is an example application of machine learning in audiological testing as it is time-consuming. Therefore, the perception process is modeled and depends on comparisons between the tinnitus and external sound, depending on the (latent) tinnitus features, such as pitch, and (known) physical stimulus properties, such as frequency. Once a psychophysical model of this kind is establi-

shed, it can be applied to create a statistically effective test strategy. These aim to conduct the fewest number of trials necessary to obtain reliable estimations of the psychophysical quantities of interest.[9]Moreover, testing methods that account for prior knowledge are more effective than alternatives that ignore prior knowledge.

Different models of A.I H. A

Widex evoke H.A: "SoundSense learn technology"

The first hearing aid manufacturer that applied real-time AI which applies hearing aid users with a better, more natural, and customized sound experience.[10]

Starkey AI H.A

With their Livio AI hearing aid, Starkey was the first to introduce artificial intelligence (AI) to the hearing aid market.

Evolv AI, based on Starkey Sound uses machine learning to automatically reduce background noise and improve speech audibility and intelligibility. These technologies work together to give users an effortless hearing experience.

This type of artificial intelligence is designed to mimic the neural processes of the brain and tries to react just like your brain would, without being previously taught how to do so.

It consists of a deep network that was trained on a huge, unique database of noisy speech signals, followed by additional optimization by a neural architecture search utilizing a deep learning model.[8]

Phonak AI HA

The AutoSense OSTM 5.0 in the Phonak AudéoTM Lumity with SmartSpeech Technology has been programmed using artificial intelligence-based machine learning to effectively recognize a sound environment.

Studies have also reported that participants who used hearing aids integrated with Phonak's StereoZoom technology had an 18% reduction in the listening effort required to understand speech in challenging and noisy Environments.[11]

Advantages of AI H.A

- Understand speech more clearly, especially in different environmental situations.[12]
- The user won't have to worry about manually adjusting or changing programs.
- Reduces the time in explaining complex instructions to users and leaves more time for counseling and managing clients' expectations.
- Make H.A a smarter, Multipurpose device.
- Increase satisfaction and H.A acceptance.

Other Applications of Artificial Intelligence in Otology

1.**Diagnosis and Management of Vestibular Disorders**

It develops assessment methods that can offer people with balance parameters with better vestibular outcomes through training with interactive vestibular rehabilitation programs.[13] With an overall sensitivity and specificity of 0.93, It also can identify postural sway patterns for postural phobic vertigo, unilateral vestibular neuritis, and anterior lobe Cerebellar atrophy in posturography.[14] So, Machine learning can improve the management of vestibular disorders.[5]

2. Prediction of Sensorineural Hearing Loss Outcomes

Recent studies had evaluated machine learning techniques in hearing loss prediction. [15] contrasted two different algorithms of AI: neural networks and logistic

regression in detecting otoacoustic emissions threshold. They found a higher sensitivity by using logistic regression than by utilizing a neural network. These outcomes contrasted with [16] who discovered Regression methods are less accurate than neural networks for predicting hearing loss in noise-exposed workers of a steel factory.

Most recently, different Groups have created predictive models that compare machine learning techniques and found consistent accuracy between different algorithms.[17] This is to be expected as, in general, no method is superior to another but needs to be optimized based on the size and quality of specific data collections.[5]

3.Interpretation of Auditory Brainstem Responses

Specific waveform properties that may b e challenging for humans to identify can-be detected by AI. Future applications of this technology might offer a more objective interpretation. Additionally, AI ma y be used to create automated ABR algor ithms for neonatal screening that are mor e effective than the currently available automated algorithms.[5]

4. Cochlear implants

Automated evoked potential measurement (Auto NRT, Auto ART), signal artifact filtering, postoperative performance, surgical anatomy site prediction, electrode placement, and improving speech perception in noise have all been performed with the use of machine learning .[12] AI has been enhanced to deliver quick and efficient outcomes in cochlear implant.[18]

5. Diagnostic Algorithms for Imaging Modalities and Image-Processing Technologies

Machine learning can identify patterns in imaging techniques of the cochlea for different uses. [19] created a convoluteional neural network utilizing learned features of Reissner's membrane on optical coherence tomography to classify endolymphatic hydrops. [15] used AI techniques in the automated diagnosis of otitis media using image-processing techniques. Also, AI was used in detection of tympanic membrane side and presence of a perforation.[17]

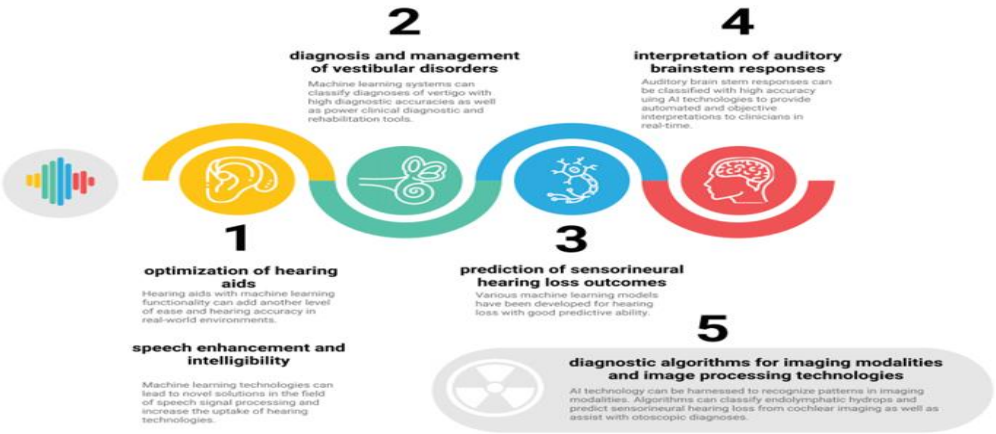

Diagram Summary of Articles With Machine-Learning Applications on otology[5]

References

1. **Atcherson, S. R**. Assistive Technology for Adults with Hearing Aids. Semin Hear 2022; 43, 79-84.

2. **Salehi, h., parsa, v. & folkeard, P**. Electroacoustic Assessment of Wireless Remote Microphone Systems. Audiology Research .2018; 8,204.

3. **Copeland, J**. Artificial intelligence: A philosophical introduction, John Wiley & Sons.2015, 81-84.

4. **Wolfgang, K.** Artificial intelligence, and machine learning: pushing new boundaries in hearing technology. The Hearing Journal.2019; 72, 26-27.

5. **You, E., Lin, V., Mijovic, T., Eskander, A. & Crowson, M. G.** Artificial intelligence applications in otology: A State-of-the-Art Review. Otolaryngol Head Neck Surg.2020; 163, 1123-1133.

6. **Fabry, D. A. & Tchorz, J**. Results from a new hearing aid using "acoustic scene analysis". The Hearing Journal. 2005; 58, 30–36.

7. **Diehl, P. U., Singer, Y., Zilly, H., Schönfeld, U., Meyer-Rachner, P., Berry, M., Sprekeler, H., Sprengel, E., Pudszuhn, A. & Hofmann, V. M**. Restoring speech intelligibility for hearing aid users with deep learning. arXiv preprint arXiv .2022;2206.11567.

8. **Harianawala J, M. M., Fabry D**. Intelligence_at_the_Edge_White_Paper https://starkeypro.com/pdfs/technical papers/Intelligence_at_the_Edge_White_ Paper.pdf .2020.

9. **Zhang, T., Mustiere, F. & Micheyl, C**. Intelligent hearing aids: The next revolution :Annu Int Conf IEEE Eng Med Biol Soc. 2016 ; 72-76.

10. **Widex evoke H.A.** The hearing review. Widex Incorporates AI into SoundSense Learn Oct 30, 2020 .retrieved from https://hearingreview.com/hearing-products/hearing-aids/ite/widex-incorporates-ai-into-soundsense-learn

11. **Appleton, J.**Autosense OS 4.0 .Significantly less listening effort and preferred for speech intelligibility.2020 . Phonak Field Study News retrieved from www.phonak.com/evidence, access ed August 2022

12. **Umashankar, A., MN, A. & C, P**. Applications of artificial intelligence in hearing aids and auditory implants: a short review. Journal of hearing science.2021; 11, 20-23.

13. **Yeh, S. C., Huang, M. C., Wang, P. C., Fang, T. Y., Su, M. C., Tsai, P. Y. & Rizzo, A**.. Machine learning-based assessment tool for imbalance and vestibular dysfunction with virtual reality rehabilitation system. Comput methods programs biomed.2014;116, 311-8.

14. **Krafczyk, S., Tietze, S., Swoboda, W., Valkovic, P. & Brandt, T**. Artificial neural network: a new diagnostic posturographic tool for disorders of stance. Clin Neurophysiol.2006 ;117, 1692-8.

15. **Ziavra, N., Kastanioudakis, I., Trikalinos, T. A., Skevas, A. & Ioannidis, J. P**. Diagnosis of sensorineural hearing loss with neural networks versus logistic regression modeling of distortion product otoacoustic emissions. Audiol Neurootol.2004;9, 81-7.

16. **Aliabadi, M., Farhadian, M. & Darvishi, E**. Prediction of hearing loss among the noise-exposed workers in a steel factory using artificial intelligence

approach. Int Arch Occup Environ Health.2015; 88, 779-87.

17. **Bing, D., Ying, J., Miao, J., Lan, L., Wang, D., Zhao, L., Yin, Z., Yu, L., Guan, J. & Wang, Q.** Predicting the hearing outcome in sudden sensorineural hearing loss via machine learning models. Clin Otolaryngol.2018; 43, 868-874.

18. **Crowson, M. G., Lin, V., Chen, J. M. & Chan, T. C. Y.** Machine learning and cochlear implantation-a structured review of opportunities and challenges. Otol Neurotol.2020; 41, e36-e45.

19. **De Waal, R., Hugo, R., Soer, M. & Kruger, J. J**.Predicting hearing loss from otoacoustic emissions using an artificial neural network. S Afr J Commun Disord. 2002;49, 28-39.