Leveraging Deep Neural Networks to Improve Noise Reduction in Edge AI

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Starkey

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INTRODUCTION

Machine learning techniques have been used in hearing aids to identify different types of acoustic environments, especially when speech is present. These algorithms are trained on an external computer, and a scaled down version implemented in the hearing aid limited only by processing capabilities and memory constraints. Deep Neural Networks (DNNs), a subset of machine learning, open the possibility of creating more sophisticated algorithms with better accuracy. DNNs try to mimic how the brain processes information by creating a mesh of nodes and layers that can decode information after it has been extensively trained. Many hearing aid features can benefit from DNN. Noise reduction is one of them.

Conventional noise reduction algorithms primarily rely on the modulation of sound. Speech exhibits distinctive temporal fluctuations, or modulations, which help differentiate it from various types of noise that typically display far fewer modulations. However, modulation-based features have difficulty distinguishing between speech and non-stationary noise types. These noises can easily be misclassified as speech, leading to errors in classification.

Edge AI builds on breakthroughs in DNN processing by incorporating a speech presence predictor with a proprietary sound management system that is better able to differentiate between speech and noise components, an important distinction when figuring out when to apply the appropriate noise reduction scheme.

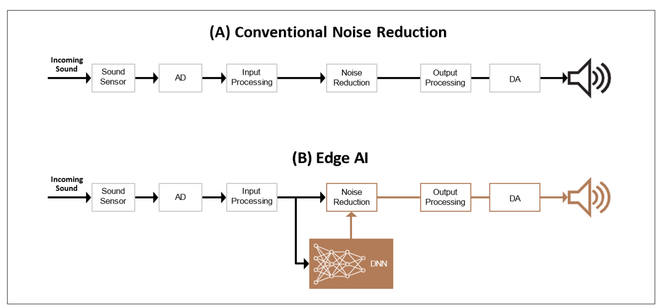


Figure 1. Schematic comparing (a) conventional noise reduction and (b) Edge AI where DNN is used to inform the noise reduction

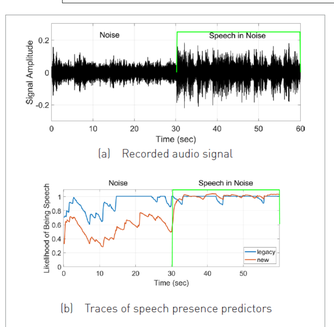


Figure 2. Example of the new speech presence predictor in Edge AI (red) against the legacy technology (blue). The noise environment has several people talking in the background inside a reverberant church at 65 dB SPL and 0 dB SNR. The target speech begins at 30 seconds.

METHODS & RESULTS

Laboratory Bench Measurements

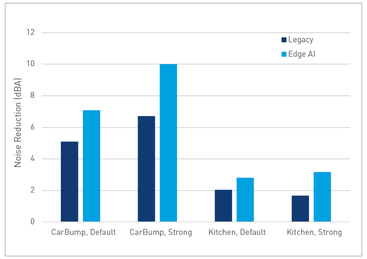


Figure 3. Noise reduction of the new Edge AI DNN-based algorithm versus the legacy modulation-based algorithm

A pair of Edge AI hearing aids, fitted with N3 audiograms[1], were worn by a KEMAR manikin. Recordings were made using both a DNN-based algorithm and a Legacy modulation-based algorithm, applying both the default and strong settings for each. Two sound samples were used: "Road Noise with Bumps" and "Kitchen Fan with Clanking Dishes."

Up to 2-3.5 dB more noise reduction was measured for the Edge AI DNN-based algorithm than the Legacy algorithm.

Paired Comparison Listening Evaluation

Purpose: To compare the Edge AI DNN-noise reduction algorithm to the legacy noise reduction algorithm

Participants: 14 experienced hearing aid users (6 males, 8 females)

Age: 52-85 years (mean = 71.6; SD = 9.3)

Hearing aid fitting: Participants were bilaterally fitted with Starkey hearing aids using e-STAT 2.0. Fittings were verified using real-ear measurements.

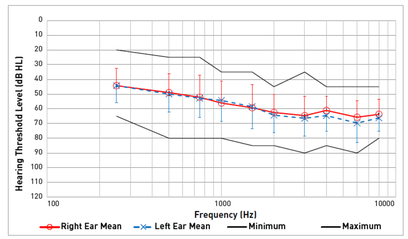


Figure 4. Average audiogram of the 14 participants.

Procedure:

Test stimuli:

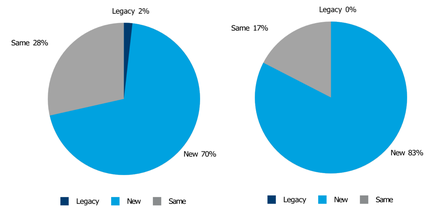
- Noise only: (1) Road noise; (2) Kitchen fan with clanking dishes; (3) Fan with transient noises
- Speech in noise: (1) Female talker in a bar noise (-5 dB SNR); (2) Female talker in a restaurant noise (-5 dB SNR); and (3) Male talker in a car noise (0 dB SNR);

The stimuli were first pre-recorded on a KEMAR mannequin positioned in the center of a circular array of 8 loudspeakers. The mannequin was wearing a pair of hearing aids fitted to the hearing loss of each participant as described above. Recordings were completed for both Edge AI (New DNN-based algorithm) and Legacy (modulation-based algorithm) hearing aids. The test stimuli were then presented in pairs 3 times each via headphones for a total of 27 pairwise comparisons (New vs. Legacy) per participant.

Questions for Paired Comparisons:

- Choose the signal that has the **least amount of noise** *(noise only stimuli)*
- Choose the signal that you would **prefer to listen to** *(speech in noise stimuli)*

METHODS & RESULTS



(a) Default – Level 3 *(b) Strong – Level 4*

Figure 5. Participant-preferred noise reduction approach in (a) default setting and (b) strong setting, from pairwise-comparison headphones listening test.

Noise Only

Participants judged Edge AI to provide greater noise reduction than Legacy hearing aids 70% of the time at the default Pro Fit setting (3) and 83% of the time in the strong setting (4)

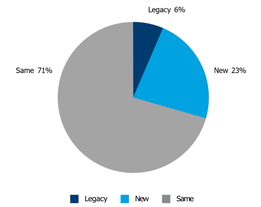


Figure 6. Participant preference for all speech-in-noise samples from pairwise-comparison headphones listening test for default setting

Speech in Noise

While there was not a strong preference for the majority (71%) of the comparisons , when there was a preference, Edge AI DNN-based noise reduction was preferred 3:1 over Legacy processing.

CONCLUSIONS

- The DNN-based noise reduction in Edge AI can better differentiate speech and non-stationary noise compared to the legacy noise reduction algorithm.
- Benchtop measurements show that the Edge AI DNN-based noise reduction algorithm can provide more gain reduction than the legacy approach, particularly when the competing background is speech or modulation based, such as the babble noise found commonly in restaurants, crowds, transportation, etc.
- The perceptual data show a strong preference for the Edge AI DNN-based noise reduction algorithm over the Legacy algorithm in common, everyday noise and speech-in-noise environments.

REFERENCES

[1]Bisgaard N, Vlaming MS, Dahlquist M. (2010). Standard audiograms for the IEC 60118-15 measurement procedure. *Trends Amplif, 14*(2):113-20.