Enabling Automatic In-Field Hearing Aid Optimization

Justin Jensen*, Dhruv Vyas†, Kowsar Hossain†, Harinath Garudadri~, Octav Chipara†, Yu-Hsiang Wu*

*Department of Communication Sciences & Disorders, The University of Iowa; †Department of Computer Science, The University of Iowa, ~Qualcomm Institute, University of California San Diego

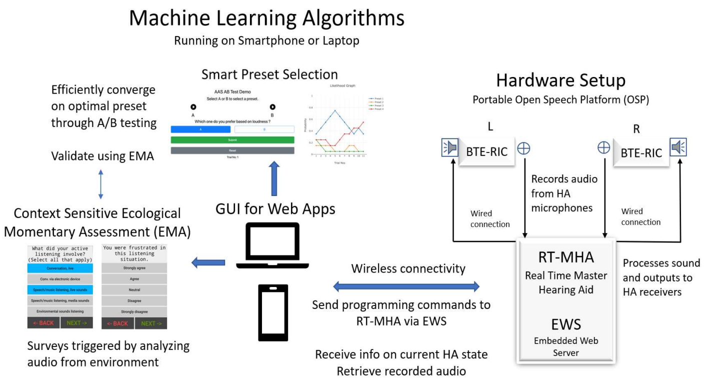
BACKGROUND

GOAL

- Develop machine learning algorithms that can control the hearing aid (HA) state in-situ and incorporate user feedback to converge on contextually optimal HA configurations.

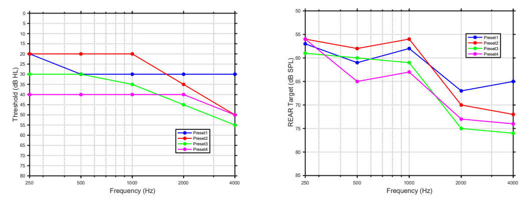
IMPLEMENTATION

- Integrate the wearable units of the Open Speech Platform (OSP) and the smart-phone based Ecological Momentary Assessments (EMA) system.
- Develop machine learning algorithms that incorporate time-aligned, real-time data about listening experience, listening context, and signal processing/HA state.
- The algorithms can make changes to the HA parameters in-situ and validate these changes via app-based user interaction.

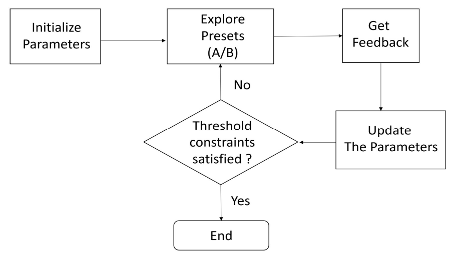


SMART PRESET SELECTION: A DEMO

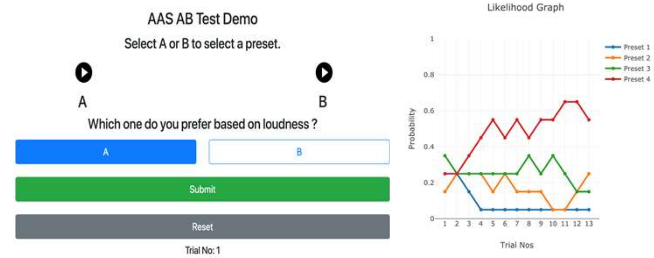
- Audiometric data from an epidemiological database was used to develop 4-gain frequency response presets that would fit 70% of older adults with mild-to-moderate hearing loss.
- The audiometric data and associated NAL-NL 2 targets for the 4 presets are shown below.
- See poster #71 for more details.



- We characterized the question of which preset is optimal for a given individual as a multi-armed bandit problem and developed an algorithm using an epsilon-Greedy approach.
- The algorithm seeks to balance efficiency in determining the best preset with sufficient exploration of all available options.



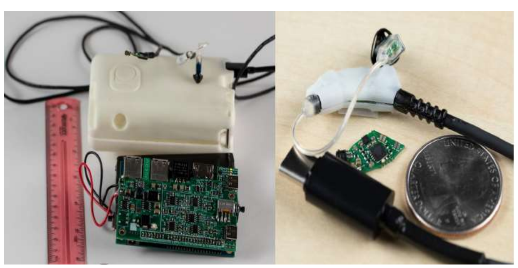
Preset Selection App Screenshots



- The user is asked a series of A vs. B preference questions across multiple sound quality domains, i.e. loudness, fulness, or tininess.
- When the user hits the "A" or "B" button, the HA configuration changes instantly to the associated frequency response.
- The user can listen to an audio file played through and processed by the HA's current configuration or listen to live amplified sound to make their preference selection.
- The algorithm collects user input and updates the probabilities of all presets about which the algorithm has new information, i.e. the user prefers the louder preset, therefore all other presets that are less loud have decreased probability.
- The algorithm determines which presets to present in the following trial based on updated probabilities from the current trial.
- When one preset reaches a predefined threshold probability, it is presented to the user as the optimal configuration.
- This A/B framework can be used either for initial HA fitting configuration or for real time fine tuning based on user interaction via EMA.

PORTABLE OPEN SPEECH PLATFORM

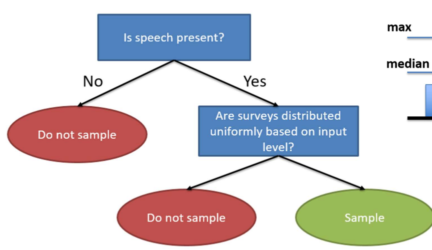
- Open-source software includes adjustable parameters for frequency response, compression, noise reduction, and feedback cancellation.
- Capable of 96 kHz, 24-bit audio processing at low latency.
- Custom BTE-RICs with wired connection to Real Time Master Hearing Aid.
- Configurable via web-based interface using JavaScript and HTML.



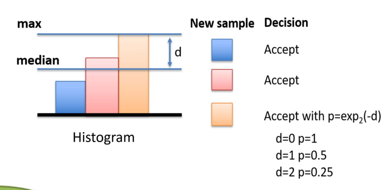
CONTEXT SENSITIVE ECOLOGICAL MOMENTARY ASSESSMENT

- Smartphone or web-app based user interaction that collects user feedback about listening environment, context, and listening effort.
- Surveys can be triggered by analyzing audio from the user's environment, i.e. is the user in the presence of speech in quiet, speech in noise, or music?
- Can be used as a validation measure for changes made by the real-time HA optimization algorithm.

Context Sensitive



Uniform Sampling



FUTURE DIRECTIONS

- Further develop the preset selection algorithm to be dynamic and able to handle variable numbers of presets or HA configurations, including compression parameters that significantly increase the search space.
- Expand presets to cover more individuals and configurations of hearing loss.
- Conduct field trials of environment-triggered EMA surveys to further the development of the real-time optimization algorithm.

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CONTACT

Contact Justin-Jensen@uiowa.edu for more information