CCi-MOBILE platform for cochlear implant and hearing-aid research

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Extended Abstract

Improvements in sound processing technology have played a critical role in the advancement of cochlear implant (CI) and hearing-aid (HA) technology. Since the inception of CIs and HAs, investigators have relied on research tools and interfaces to conduct perceptual studies. Research interfaces commonly provided by the manufacturers either have limited functionalities or are not suitable for conducting a broad range of experiments. Portability, wearability, and ease of programmability limits existing research interfaces to benchtop/laboratory use only. Real-world, long-term subject evaluations are needed to assess true potential of novel sound processing strategies.

Our center (CRSS-CILab) over past ten years has been involved in the development of portable research platforms/tools for speech and hearing research [1]. Our latest effort is to leverage computing capabilities of emerging smartphones and tablets for sound processing needs. The functional structure of the platform is shown in Fig. 1. The digital acoustic signal is sampled from Behind-the-Ear (BTE) units and transmitted to the computing platform via a USB-serial port of a custom-developed interface board. The computing platform processes the acoustic signal through a sound coding strategy and generates a set of stimulation data. This data is sent back to the interface board where it is simultaneously delivered to the RF transmission coils (electric stimulation) and hearing aid transducers (acoustic stimulation). In case of electric stimulation, the data is first encoded (using the transmission protocols of the CI device) in the FPGA, before streaming to the implant (see Fig. 1).

The platform can be used for both unilateral and "time-synchronized" bilateral stimulation. Time-synchronized bilateral stimulation means that biphasic pulses and acoustic signal on both left and right ears arrive at the exact same time. In addition, the platform can be configured to provide both electric and acoustic stimulation (EAS) concurrently. Acoustic stimulation can be delivered to ipsilateral as well as contralateral ears, thereby giving 4 channels of time-synchronized stimulation simultaneously in two modes. From operational stand-point, the platform can be used in both real-time and bench-top modes. The real-time mode works similar to a clinical body-worn processor to conduct experiments in free field using the BTE microphone. The bench-top mode, on the other hand, can stream pre-processed stimuli (e.g., audio files) from a desktop PC in laboratory environment. The bench-top mode can also be used to conduct psychoacoustics or psychophysics experiments.

One of the unique and powerful capabilities of the platform is the ability to use it as a real-time speech processor in MATLAB environment. Researchers have access to real-time microphone signals, implement custom algorithms, and stream stimuli for subjective evaluation in real-time from MATLAB. Furthermore, by using smartphones/tablets, there is an additional flexibility to develop and run custom applications (Apps) that are tuned to specific experiments. The touch-screen capability and graphical controls on the smartphone provide an interactive user-interface for modifying processing parameters on the go and enable user input in real-time.

The CCi-MOBILE platform was evaluated acutely with eight post-lingually deafened adult CI users. The assessment of speech recognition was accomplished with AzBio and IEEE sentences presented at different SNR levels as well as with CNC words/phonemes. Study participants were tested in free-field, both with their clinical processor and CCi-MOBILE. The results from acute evaluation indicate that on all measures of test material, CCi-MOBILE platform (μ=59.86±16.02) was not statistically different from each individual's clinical processors (μ=56.38±17.96). These results indicate that performance with the CCi-MOBILE is comparable to the clinical processor, and that it holds potential for conducting reliable speech assessments in future studies.

The CCi-MOBILE is one-of-a-kind research platform, and is orders of magnitude more flexible and computationally powerful than existing commercially available processors. It will aid in bridging scientific research with commercial applications. The research platform is intended to be an open-source contribution to the cochlear implant and hearing-aid field and will be distributed to the research community on a non-profit model.

References

[1] H. Ali, A. Lobo and P. Loizou, "Design and Evaluation of a PDA-based Research Platform for Cochlear Implants," IEEE Transactions on Biomedical Engineering , vol. 60, no. 11, pp. 3060-3073, 2013.

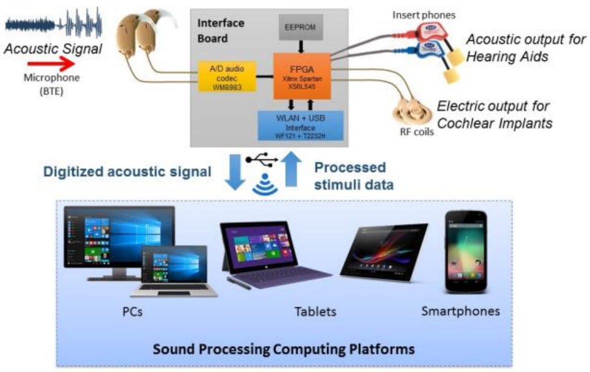

Fig. 1. High-level description of the CCi-MOBILE research platform.