Hands-On With CCi-MOBILE: A Cochlear Implant and Hearing-Aid Research Platform

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Virtual ARO 2021 Workshop

Cochlear Implant Processing Lab (CILab)
Center for Robust Speech Systems (CRSS)
The University of Texas at Dallas
https://crss.utdallas.edu/CILab/

February 19, 2021
1–2:30 PM (EST)

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Joint-collaboration between NYU (Dr. Mario Svirsky), UWM (Dr. Ruth Litovsky), and UTD (Dr. John Hansen)

Laboratory for Translational Audio Research (NYU), Binaural Hearing and Speech Lab (UWM), and Cochlear Implant Processing Laboratory (UTD)
Workshop Overview

1-1:30 PM (EST) – Technical Presentation/Overview
• CCi-MOBILE – Research Platform for Speech Scientists
• Research Capabilities

1:30-1:40 PM (EST) – CCi-MOBLE Video Spotlight Series
• Hardware Showcase
• Software Suite Walk-through
• Mobile (Android) Demo
• Subjective Testing & Safety

1:40-2:30 PM (EST) – Breakout Sessions for Q/A
1. General Breakout Room – Dr. John Hansen
   • How to obtain CCi-MOBILE, IRB/NIH Process, and other general questions
2. Software Breakout Room – Nursadul Mamun, Juliana N. Saba, Avamarie Brueggeman
   • Software-related questions, Android/Java-related questions, and conducting experiments
3. Hardware Breakout Room – Ria Ghosh, Hazem A.M. Younis, Ram C.M.C. Shekar
   • Hardware-related questions, hardware specifications, hardware testing paradigm, and cloud-based platform
CCi-MOBILE

CCi-MOBILE Research Platform

- Research interface for cochlear implants* and hearing-aids
- Configured for both in-laboratory, in-booth, and in-field testing
- Supports time synchronized acoustic and/or electric stimulation
- Plug-and-play system (portable, wearable)

* For implants manufactured by Cochlear Corp.

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**Diagram:**

- **Acoustic Signal**
  - BTE Microphones
  - RF coils
- **Acoustic Output for Hearing Aids**
  - Insert phones
- **Electric Output for Cochlear Implants**
Explore & Test

- **Signal processing solutions**, i.e., compression, noise-suppression, speech enhancement
- **Custom experimental designs** with human subjects, i.e., intelligibility in naturalistic environments, localization, modulation detection, etc.
- **Explore fitting parameters**, i.e., attack/release times, MCL/THR, frequency allocations, etc.

…and so much more
Data Processing

Working Sequence

1. **Input** – BTE (acoustic) samples at 16 kHz via stereo codec at 5Mbps
2. **Transmission** – Parallel computation at 8ms data packets
3. **Data Processing** – FPGA (CCi-MOBILE) receives EAS stimulation, encodes acoustic/electric stimuli
4. **Communication** – FPGA sends time synchronous data to CI/HA transducers
Hardware Design

- FPGA-based design, programmed in Verilog using Xilinx ISE software
- Real-time performance (10.4ms delay*) using incoming/outgoing data on a frame-by-frame basis
  * Does not include PC processing time
- Data synchronization managed using handshake design techniques
- Implant-specific stimuli generation (for CI24 implants)
- Sends individual pulse characteristics
CI Signal Processing

- Adapted from Nucleus MATLAB Toolbox into MATLAB App
- Default stimulation: Continuous Interleaved Sampling (CIS)
- Default sound coding strategy: Advanced Combination Encoding (ACE)
Custom CI Signal Processing

Control Individual Components

- Stimulation Rate (pps/ch)
- Pulse-width (PW)
- Number of Electrodes
- Channel Gains
- Sensitivity
- Stimulation Order
- Etc.

Custom SP Parameters

1. Signal Processing Parameters: Stimulation rate, pulse-width, # electrodes, etc.
2. User-Specific Parameters: channel/electrode level configuration, known as "MAP" (set by audiologist)
Ready-to-Use Applications

Easy-to-use, GUI-friendly, open-source programs written in MATLAB to help get researchers started

1. **Record/Visualize Audio** – AudioRecorder/AudioScope generates a time-waveform or real-time microphone input (BTE or HA)

2. **Direct Connect (CI-only)** – RealtimeStimulator implements signal processing routines to stimulate implants directly, without clinical processor

3. **Offline Experiments** – Various programs to stream individual audio files, process using custom strategies, and to set desired MAP/fitting parameters
In-Field Testing

Android App

- Real-time performance on Android smartphones and tablets
- Highly suitable for in-field or take-home trials
- Easily adjust signal processing/MAP parameters in real-time
- Quickly select/define pre-programmed environments
In-Field Testing

Evaluate algorithms outside the lab in everyday naturalistic environments
Currently developing a cloud-based platform to support multi-site remote experiments, data-sharing, and cochlear implant user outreach.

AWS services such as “Workspace” & “IoT Core” utilized as components of cloud-based platform.

Supports 3 subdivisions (cloud rooms):

- **CCi-Share**
  - Datalogging
  - Comparable to “google drive” functionality
  - Collaborative space shared among research institutions

- **CCi-Evaluate**
  - Remote Experiments
  - Longitudinal Testing
  - Auditory Training
  - Real-time signal processing

- **CCi-Connect**
  - Cochlear implant user portal
  - Website with available resources for existing and potential CI users and researchers
Clinical Processor vs. CCi-MOBILE

Compared speech intelligibility of CI users (N=8) using 3 sentence databases with various degrees of noise.

No significant different between clinical processor and research processor ($F[7,49]=4.882, p=0.069$)
Open source software, and Hardware available to the research community
35 New platforms recently completed
(Sub-committee from multiple institutions will review all requests and make recommendations)
Request CCi-MOBILE

How to Obtain CCi-MOBILE for your Institution

Applicants to disclose research interests, objectives of incorporating CCi-MOBILE to support hypotheses, and intended use

- **Memberships** – All CCi-MOBILE units are funded through membership options (full ownership, annual/monthly leases)

- **IRB** – Required at home-institution for use with human subjects
  - Sample IRBs can be provided upon request

- **Hardware Cost** – No-cost hardware, all funds are folded back to support units in the field (updates, repairs, etc.)

- **NIH Investigators** – Supplement requests to obtain CCi-MOBILE
  - Sample request letter can be provided upon request
Membership Tiers

Four Membership Options

1. **Platinum Plus** – Full ownership, two CCi-MOBILE platforms
   - Suggested for use through NIH supplement

2. **Platinum** – Full ownership, single CCi-MOBILE platform
   - Suggest for smaller research labs/organizations/institutions

3. **Gold** – Suited best for short-term research investigations

4. **Silver** – Great for graduate students or intern researchers

For more information:
https://crss.utdallas.edu/CILab/subscription.html
CCi-MOBILE Research Platform is meant for “non-clinical” experimental investigations

CCi-MOBILE does NOT fall under the scope of the FDA IDE

Your organization/institution must have IRB approval from your respective institution to conduct research with human subjects

FDA submission (Feb 2017) for FDA-IDE status resulted in the following response:

“…we have determined that your study does not fall within the scope of the IDE regulation, and an IDE application is not required to be submitted to FDA for your proposed study.” – FDA
CCi-MOBILE Adopters

**Platinum Plus Sites**
- New York University (New York, NY)
- University of Wisconsin – Madison (Madison, WI)
- New Jersey Institute of Technology (Newark, NJ)
- Cadwell Industries (Kennewick, WA)
- McMaster University (Hamilton, ON, Canada)
- Universidade Federal de Santa Cararna (Florianópolis, Santa Catarina, Brazil)
- South China University of Technology (Guangdong Sheng, China)

**Platinum/Gold/Silver Sites**
- Split University (Split, Croatia)
- Shenzhen University (Guangdong Sheng, China)
- Cochlear Corporation, LLC.
Publications

For more information on the hardware/software processing and verification:

DOI: 10.1109/BHI.2019.8834652
Publications

For more information on CCI-MOBILE, developmental design, history, hardware, system, etc.


CCi-MOBILE: A Portable Real Time Speech Processing Platform for Cochlear Implant and Hearing Aid Research

Ria Ghosh, Student Member, IEEE, Husnain Ali, Member, IEEE, John H.L. Hansen, IEEE Fellow, IEEE

Abstract—Hearing impairment is a pervasive problem which occurs due to the detrimental damage caused to the inner ear, processor. The electrode array consisting of 12-22 electrodes is surgically implanted in the cochlea (inner most part of the ear) to mimic the functionality of the healthy hair cells in normal
Publications

For more information on testing paradigm

DOI: 10.1121/10.0002989
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Spotlight Video Demos

**Software Spotlight**
- Applications/software suite demonstrations
- How to create custom GUI (AppDesigner)
- How to use/run MATLAB Scripts

**Mobile Spotlight**
- Demonstration of Android App in-field
- How to run Android App
- How to find open-source code

**Hardware Spotlight**
- Walk-through of FPGA design
- How CCi-MOBILE generates stimulation
- How data transmission is processed

**Experiment Spotlight**
- Overview of board verification
- Proposed infrastructure for Cloud setup
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Q/A Breakout Rooms

Questions about... CCi-MOBILE?
- Breakout Room #1
  - General questions
  - How to obtain CCi-MOBILE
  - IRB, FDA-IDE concerns
  - How to request supplement/draft IRB

Moderator: Dr. John Hansen

Questions about... running experiments/signal processing?
- Breakout Room #2
  - How to test custom processing strategies
  - How to evaluate custom MAP parameters
  - How to access/use the applications
  - How to run Java/MATLAB scripts

Moderators: Juli, Ava, & Mamun (Research Assistants)

Questions about... hardware? Safety?
- Breakout Room #3
  - How CCi-MOBILE was designed
  - How CCi-MOBILE transmits and sends data
  - Testing paradigm
  - Proposed infrastructure for Cloud setup

Moderators: Ram & Haz (Research Assistants)

Visit our website for documentation, demos, software, and updates
https://crss.utdallas.edu/CLab/