Mobile, Multi-Sensor, Real-Time Signal Processing Setup for Synchronous Recordings in Real-Life Situations

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Recording signals from multiple sensors synchronously in real-life environments is a challenging task. In this demonstration, we present a wearable multi-sensor real-time signal processing system for performing synchronous recordings in real-life situations. With this setup, we can concurrently record the multi-channel electroencephalography (EEG), the electrocardiogram (ECG), the breathing rate, the three-axis accelerometry and the binaural acoustic signals.

Our solution is best considered as an extension of the Portable Hearing Laboratory (PHL), a mobile, real-time signal processing platform for simulating and evaluating hearing aid functionality in laboratory and real-life settings. The PHL consists of a single-board computer extended with a multi-channel audio board, a battery and a set of behind-the-ear (BTE) hearing aid dummies featuring two microphones and a receiver on each side. The PHL sets up a wireless network to which several other sensor devices are connected to. The lab streaming layer (LSL) standard running on the PHL is utilized for the time-synchronous recording of the different sensor streams. Specifically, the LabRecorder command line interface is used to acquire the LSL streams, correct the time stamps and to save the corrected LSL streams in *.xdf format. Using a Smarting wireless amplifier (mBrainTrain), EEG signals can be added as a multi-channel LSL stream and may consist of cap or ear-EEG data. In our application, pre-recorded audio stories mixed with the real-life audio in real-time are presented to the listener via the BTEs and converted into LSL streams. This is achieved by making use of the real-time signal processing software Open Master Hearing Aid (openMHA) running on the PHL in combination with the Presentation application (Neurobehavioral Systems) running on a smartphone. For the ECG and accelerometer signals, we incorporate the Zephyr sensor, which is connected to the PHL via Bluetooth. A Python script running on the PHL converts the Bluetooth signals into LSL streams. In order to start, stop and monitor the recordings a web application was programmed using the NODE-RED dashboard, which also runs on the PHL.

Our setup facilitates data acquisition for a variety of studies looking into auditory attention decoding, listening effort, and fatigue monitoring in real-life environments.