Demo: Opportunistic Mobile Brain Research

Jó Ágila Bitsch Link, David Orlea, Roann Ramos, Klaus Wehrle*
COMSYS, RWTH Aachen University
Aachen, Germany
{jo.bitsch|david.orlea|klaus.wehrle}@rwth-aachen.de

ABSTRACT

The majority of research using brain imaging and EEG techniques is currently limited to clinical environments, restricting experiments to synthetic tasks in controlled conditions. Lifting these limitations brought about by this artificial set-up would allow us to perform neuropsychological assessments and research in mobile settings or at locations easier accessible to patients, possibly even in remote, hard to access areas.

We developed a tablet based mobile framework to present auditory and visual stimuli, capture wireless commercial EEG and screen interaction data, and analyze the recorded data for immediate evaluation, as well as share the data over internet or local opportunistic links.

To demonstrate the feasibility of our approach, we successfully replicated the experimental set-up and evaluation pipeline of two existing EEG studies on event-related potentials. This work therefore lays the foundation to further truly mobile brain research and health-care applications.

Categories and Subject Descriptors

C.2.1 [**Computer Communication Networks**]: Network Architecture and Design—*Store and forward networks*

General Terms

Design, Experimentation, Human Factors

Keywords

Mobile health; EEG; Opportunistic Communication

1. INTRODUCTION

Mobile information technology has fundamentally changed the way people interact with each other and their environment – without being bound to wires or fixed infrastructures.

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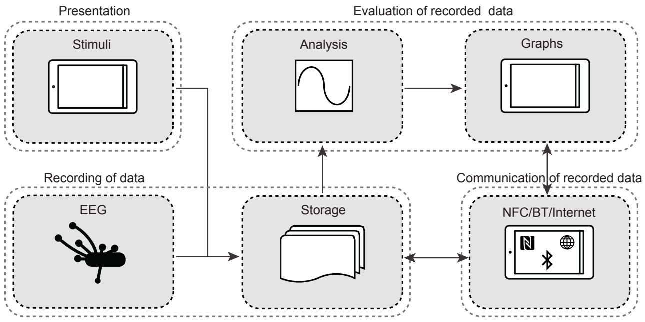

Figure 1: Overview of the framework's system architecture.

Our goal is to realize the potential for mobile technology to transform the way we do neuropsychological research and healthcare anytime and anywhere.

This paper proposes the further utility of wireless mobile (commercial) electroencephalography (EEG) in research and healthcare using mobile technology. A well-established tool in studying the neurofunctional correlates of cognitive processes, the EEG provides much-needed insight into the living human brain. In addition, it plays a role in diagnosis and health management. However, the use of existing research EEGs is restrictive. For instance, considering its bulk and size, experiments can be carried out only in controlled laboratory settings while participants' movements are restricted. This limits the contexts to be investigated and therefore the generalizability of results. It also poses issues for people with limited mobility and lack of access.

To maximize the EEG's utility, we combine a commercial EEG with mobile information and communication technology. We consider this as a new approach towards an enhanced understanding and better appreciation of the brain-body interaction in real-life, everyday scenarios. Mobile EEG in research will be a new approach to understand the brain's responses and dynamics in natural movements or behavior. The use of this device in neuroscience research opens broader possibilities outside a controlled laboratory environment and provides relative ease in data collection. This technology is also a viable adjunct to clinical decision-making, early screening, diagnosis, prognosis and monitoring. Additionally, its applicability extends to far-flung rural areas or in communities lacking in health-care providers.

2. ARCHITECTURE OVERVIEW

Our application [3] runs in a standard Android operating system on tablet computer connected to a commercial wireless EEG headset [1] using a small USB dongle. This

Figure 2: Experiment set-up with a Study Participant. Note, the equipment is small, mobile and easy to transport.

reduces efforts concerning the provisioning of hardware to a minimum and allows to focus on functionality and usability.

We use a component-oriented architecture design, logically clustering functionalities and separating different features from each other, thus making it possible to easily modify parts of the application and to extend the application with new functionalities.

We subdivide the application framework for the mobile EEG system into different logical components. As shown in Figure 1, it consists of four main parts:

- **Presentation of auditory/visual stimuli** A sequence of precisely-timed frequent (standard) and infrequent (deviant) stimuli is presented randomly either via tablet screen (visual) or headphones (auditory). Study Participants respond either by touching the screen each time a deviant stimulus appears or counting the number of deviant stimuli heard.
- **Recording of EEG/ERP data** Presentation and recording of data are synchronized. Sensor readings from the mobile commercial headset periodically transmit data packets with amplitudes of electrical potentials from all of its electrodes to the USB dongle attached to the tablet. Recording is limited to time-stamped EEG electrode readings and touch events.
- **Evaluation of recorded data** Our application enables for an automatic, on-device evaluation. Automatic analysis takes place in an evaluation pipeline (e.g., extraction and realignment of timestamps, filtering, calculation of average epochs). Results are then displayed as graphs.
- **Communication of recorded data** Data is shared between mobile devices as graphs. Recorded data can also be retrieved from storage.

The steps mentioned are utilized on a per experiment basis.

3. DEMO SETUP

To demonstrate our system, we bring several preconfigured calibrated mobile devices as well as a mobile commercial EEG headset to replicate an auditory study [2].

Additionally, it is possible for participants to use their own smartphones during the demo in the role of a remote expert evaluating the participant's data. The application will be available through the Android Play Store and distributed on site.

Workshop participants can try out several roles:

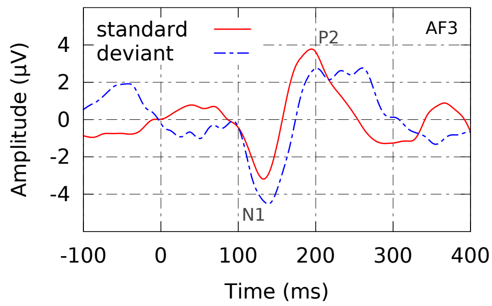

Figure 3: Sample wave form data from an EEG recording.

- **Study Participant:** The participant will wear a commercial EEG headset connected to a tablet computer, and be presented a series of stimuli, in particular, different sounds, cf. Figure 2.
- **Examiner:** Here, the participant sets up the preconfigured system and prepares the Study Participant for the activity. The system helps guide the Examiner through the necessary steps for successful data collection and forward the data opportunistically to expert evaluators.
- **Expert Evaluator:** The system derives different indicators, such as particular Event-related Potential wave forms, the brain activity in response to a particular stimulus, cf. Figure 3. As an Evaluator, the participant can observe these changes and share findings with other participants.

We will have data items prepared, so that workshop participants can perform these steps simultaneously. Each Study Participant will need approximately 5 to 10 min for preparation and a short demo experiment. Examiner or Expert Evaluator participants will take approximately 5 min. Local data exchange will be performed via NFC and Bluetooth.

4. CONCLUSIONS

Our system provides a mobile platform for EEG research and health-care assessment. The focus on local evaluation and opportunistic forwarding, while improving usability in well-connected areas, makes this technology available at all for hard to reach rural areas or communities lacking health-care providers.

5. REFERENCES

[1] Emotiv EEG. Online Resource. `http://emotiv.com/eeg/`, accessed 2014-03-12.

[2] Badcock, N. A., Mousikou, B., Mahajan, Y., de Lissa, P., Thie, J., and McArthur, G. Validation of the Emotiv EPOC EEG gaming system for measuring research quality auditory ERPs. *PeerJ 1:e38* (2013).

[3] Orlea, D. A framework for mobile brain research in the context of neuropsychological healthcare. Master's thesis, RWTH Aachen University, 2014.