Autonomy and Social Inclusion for the Severely Disabled: The BrainAble Prototype

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Abstract. Severely disabled individuals often suffer from high caregiver dependence and are at risk of social exclusion. The prototype developed in the EU Project BrainAble (www.brainable.org) offers access to common smart-home devices and popular Internet services, using electroencephalography (EEG) and non-EEG inputs. Here we describe our user-centered design approach and the software architecture of the system.

Keywords: Assistive Technology, Social Inclusion, Smart Home control, Ambient Intelligence, Non-invasive Brain-Computer Interfaces

1. Introduction

Individuals with severe functional disability often suffer from high caregiver dependence to perform basic tasks and are at risk of social exclusion. This is a result of their limited mobility and sometimes even limited ability to communicate. Existing assistive technology (AT) solutions are often not integrated in easy-to-use frameworks, lack compatibility with desired devices or popular internet services or require an AT expert to assemble and configure a heterogeneous setup of different components specifically for one user.

In a user-centered design approach, we created a fully integrated, context-aware [Navarro et al., 2011; Zander and Kothe, 2011; Scherer et al., 2012] framework that offers disabled users access to a large number of common devices and popular online services via a number of different input modalities, including electroencephalography (EEG) based brain-computer interfaces (BCIs). The system can also monitor the user's physiological signals and the environmental context. All signals are processed by an Ambient Intelligence system at the core of the system that assists the user wherever possible based on context and behavioral patterns.

2. Material and Methods

The system architecture consists of (1) the User Interface (UI), (2) the Ambient Intelligence, and (3) the Remote Systems. The UI supports two input menus, either of which can be used to access all functionality of the prototype: First, the Matrix Menu (Fig. 1, (A.1)) is similar to a P300 matrix interface. Second, the Hex-o-Select Menu (Fig. 1, (A.2)) is based on Hex-o-Spell [Blankertz et al., 2006]. Some of the supported input modalities seen in Fig. 1, (A.3) are specific to one menu type, others work with both. The specific combination of menu type and input modality can be selected easily and flexibly according to the ability, needs and preference of the disabled user.

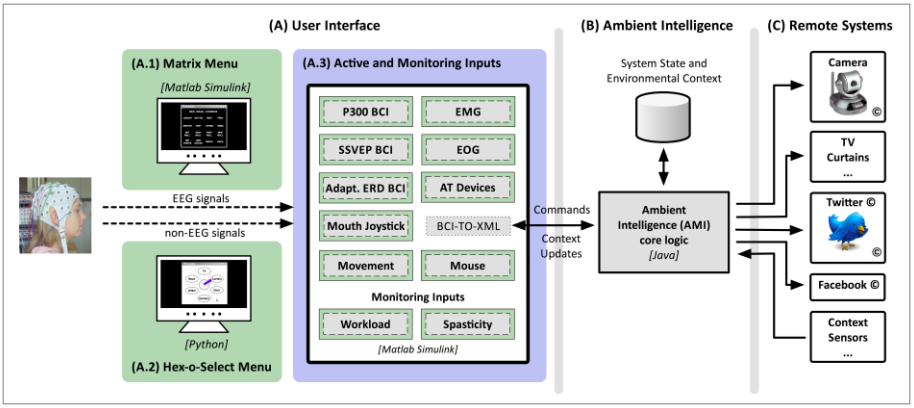

Figure 1. *Architecture Overview Diagram. Example of integrated web-camera top-right, D-Link © DCS-5220.*

As active EEG based input modalities the BrainAble prototype offers P300 [Ortner et al., 2011], steady-state visually evoked potentials (SSVEP, [Ortner et al., 2010]), and online co-adaptive event-related desynchronization (ERD, [Faller et al., 2012a]) based BCIs. As non-EEG based input modalities, movement tracking, electromyogram (EMG), electrooculogram (EOG), mouth joystick, and other AT devices are supported. The system can monitor cognitive workload based on EEG [Faller et al., 2013] and detect spasticity based on EMG. Some BCI inputs can be combined with other BCI or non-BCI inputs into Hybrid BCIs [Faller et al., 2012b; Allison et al., 2010].

The BCI-TO-XML module [Putz et al., 2011] facilitates bi-directional communication of user commands and context-updates between Ambient Intelligence (AMI) core logic and UI. The AMI communicates with smart home devices (e.g. TV, light, automatic doors, etc.) and Internet services (Facebook©, Twitter©) via the Universal Control Hub (UCH; ISO 24752; OpenURC Alliance, www.openurc.org). In addition the AMI collects information about user behavior and context to actively assist the user during his interaction [Navarro et al., 2011].

3. Results

In multiple iterations, we successfully tested modules and the whole BrainAble prototype with 100+ severely disabled users. We made improvements based on control performance measures as well as formal and informal feedback from users and caregivers. Some results are already published [Faller et al., 2012a; Ortner et al., 2011].

4. Discussion

The BrainAble prototype allows disabled users to control a large and expandable number of common smart-home devices and popular Internet services using a variety of EEG and non-EEG input modalities. A caregiver can easily try a number of input modalities for disabled individuals and leave them with a customized, most effective configuration. Some users will be able to use a standard AT Joystick, while others might require using P300 or even ERD based inputs. This work will continue within the FP7 EU Project BackHome (www.backhome-fp7.eu).

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