ROLE OF CONTEXTUAL FACTORS IN THE USABILITY OF ACCESS SOLUTIONS FOR PEOPLE WITH DISABILITIES

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ABSTRACT

An access solution consists of an access pathway, the channel that translates the functional intention of an individual with disability into a functional activity, and an access technology, which processes the physical or physiological data acquired through the access pathway. Recommendation of the appropriate access pathway depends on the nature and severity of the impairment, and the strength, reliability and endurance of client's potential access sites. An important factor affecting the usability of access solutions is the context in which the client exploits it. Context, or contextual factors as it is referred to by the World Health Organization's International Classification of Functioning, disability and Health (ICF), not only encompasses the client's personal features and characteristics, it also includes environmental factors such as the milieu and time of access solution usage. A drawback of access strategies developed to date is that they do not account for personal and environmental factors and thus their usability declines when applied in more than one environment or by different users. In this paper we highlight the need for designing context aware access strategies, and the ways consideration of contextual factors can enhance the usability of access solutions for the population with severe and multiple disabilities. We also discuss how monitoring particular contextual factors can lead to creation of new access solutions.

ACCESS SOLUTIONS FOR INDIVIDUALS WITH SEVERE AND MULTIPLE DISABILITIES

Individuals with severe and multiple disabilities often cannot employ conventional means of physical access, such as speech and gestures. They need an alternate conduit, known as access solution in the rehabilitation terminology, to interact with augmentative and alternative communication devices, environmental control units, and computers. A wide range of access solutions have been developed from simple mechanical switches to sophisticated physiological switches. Some examples are mechanical switches including hand switches, joysticks, foot switches, head switches, pressure switches, sip and puff (breath control), chin operated switches, eyelid operated switches, mouth switches or combinations of the above, voice recognition switches, electromyography (EMG), optical sensors, computer vision based switches, and brain-computer interfaces [1], [2].

IMPACT OF CONTEXTUAL FACTORS

According to the International Classification of Functioning, disability and Health (ICF), contextual factors, including personal and environmental factors, influence an individual's activity and participation [3]. Personal factors include age, sex, and indigenous status, personal resources (including physical and mental abilities), and personal perceptions [4]. Environmental factors represent an important new component of the ICF in recognition of their influence on functioning and disability. The ICF considers disability to result from the interaction between individuals and their environment rather than being a characteristic of the individual [5].

Assessment of the effect of contextual factors on the performance of access solution users has been usually based on the judgment of users' therapists or caregivers and thus rather subjective. In a recent study we proposed a quantitative method, derived from information theory, for measuring the impact of contextual factors on single switch access pathways [6].

CONTEXT AWARE ACCESS SOLUTION

Although the importance of contextual factors in the delivery of assistive technology [7], functional assessments [8], measurement of participation [5], [9], [10], technology assessment [2], and modeling disability [11] has been recognized in the literature, no context-aware intervention has been developed for individuals with disabilities. The access strategies developed so far do not account for personal and environmental factors and thus their practicality declines when used in more than one environment or by more than one user. With the purpose of enhancing the individual's performance in activity and participation levels, the usual trend has been either to change the individual's capacity (e.g. reducing the limitation due to speech disorder by repetitive exercises and therapy) or to modify the environment to fit the requirements of the individual (e.g. replacing stairs, obstacles or steep gradients with elevators, wide hallways, automatic doors and gentle ramps). However, this is not always feasible. Increasing a person's competence and confidence can be a very lengthy and difficult process. Modifying the person's environment can be an even harder –sometimes impossible task. A third approach, which has remained unexplored so far, is to design assistive interventions that sense and compensate for contextual factors, in other words, context-aware systems. The context-aware system will receive both personal and environmental contextual factors as explicit inputs and make use of them in interpreting the user's functional intention more effectively. Those factors may be dynamic (i.e. change with time and therefore need real time monitoring such as heart rate, skin conductance, level of background noise), or they may be static (i.e. permanent factors such as demographics, and user's characteristics). Figure 1(a) shows the system schematic of conventional access solutions for decoding functional intention, while figure 1(b) illustrates the system representation of the context-aware approach suggested in this paper.

The robustness of access solutions is critical to their acceptance and effectiveness. If an access solution fails to perform reliably in various occasions, it will lose the merit of functioning as a communication or access tool for the client with disability. One approach to confront the issue of robustness is through the consideration of environmental and personal contextual factors. Context aware systems can potentially sense and compensate for the negative effects of certain hindering contextual factors or exploit facilitating factors to improve the robustness of an access solution. For examples consider a voice switch. The usefulness of this access pathway drops with many people talking in the environment, where a client is trying to use the voice switch. In this case ambient auditory noise is a hindering contextual factor. If volume and frequency of ambient noise is monitored, involuntary voice switch activations due to ambient noise can be filtered out and the voice switch may perform robustly even in crowded environments.

CONTEXTUAL FACTORS AND DEVELOPMENT OF NEW ACCESS SOLUTIONS

We suggest that consideration of contextual factors may result in further positive impact on the lives of the population with severe and multiple disabilities by allowing for development of new access solutions. For that purpose, contextual factors may be exploited in the following ways:

<u>Developing user controlled access solutions (active access solutions)</u>

It has been shown that access solutions can be designed by training the clients to voluntarily control particular personal contextual factors [12]. We propose to call this type of access solution "active", as it can be initiated and controlled by the user. Brain signals and peripheral autonomic nervous system signals are examples of personal contextual factors that have been studied for developing user controlled access solutions. Technologies such as electroencephalography (EEG) and near infrared spectroscopy (NIRS) have been investigated to develop brain-computer interfaces (BCI) [13], [14]. Physiological signals including electrodermal activity (EDA), respiration amplitude, heart rate and skin temperature have also been investigated as active access pathways. It has been shown that humans can voluntarily generate low/high states in those physiological signals by performing mental activities such as arithmetic or music imagery [15].

<u>Developing emotion/preference detectors (passive access solutions)</u>

Even if the person with severe and multiple disabilities cannot volitionally control an access pathway, his/her physiological signals may be harnessed to decode his/her mood or emotion. We call this type of access solution "passive", as it is not voluntarily activated or controlled by the user. Building a classifier of unconscious reactions is one way of learning about the client's natural reactions to contextual stimuli. The effect of affective and startling stimuli on human physiological signals has been investigated for many years [16], [17], [18], [19]. It has been shown that physiological signals react to arousal and can be exploited as a way of monitoring human emotion [20], [21], [22], [23].

CONCLUSION

Access solutions are developed to help individuals with sever and multiple disabilities communicate or interact with their environment. These solutions are greatly affected by both the characteristics of the user and the setting where it is used. A vast number of parameters such as ambient noise level, ambient temperature, time of access solution usage, and presence of people may reduce the usability of access solutions. When assigning established access solutions to clients, user abilities and characteristics (personal contextual factors) is usually the main point

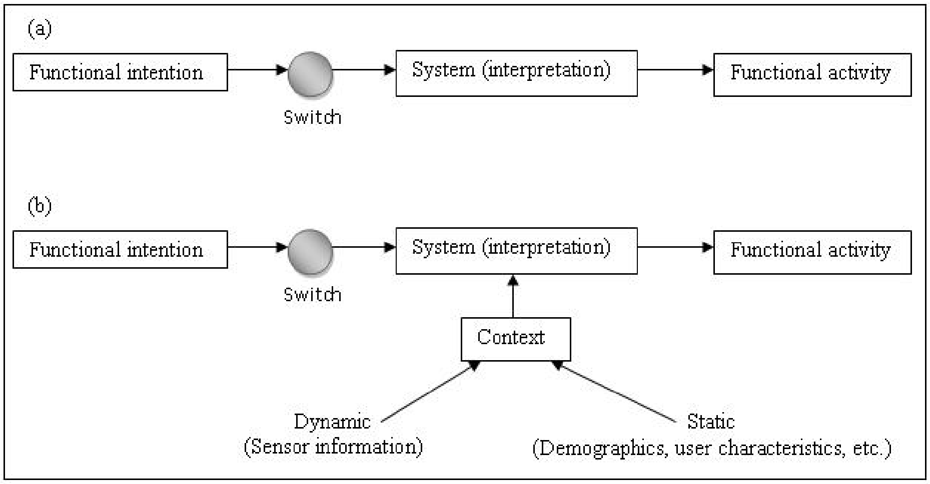

Figure 1: System representation of access solutions for decoding the functional intention of a user with disability; (a) conventional system, (b) proposed context-aware system.

of focus. In this paper we reasoned why it is also important to consider the effect of environmental contextual factors on the usability of access solutions. Also, we suggested ways that contextual factors can be exploited to design new active and passive access solutions for the population with severe and multiple disabilities.

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