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Human Computer Confluence Applied in Healthcare and Rehabilitation

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Abstract. Human computer confluence (HCC) is an ambitious research program studying how the emerging symbiotic relation between humans and computing devices can enable radically new forms of sensing, perception, interaction, and understanding. It is an interdisciplinary field, bringing together researches from horizons as various as pervasive computing, bio-signals processing, neuroscience, electronics, robotics, virtual & augmented reality, and provides an amazing potential for applications in medicine and rehabilitation.

Keywords. Perception, human body, cognitive neuroscience, embodiment, brain computer interface

Introduction

Human Computer Interface (HCI) research over three decades has shaped a wide spanning research area at the boundaries of computer science and behavioral science, with an impressive outreach to how humankind is experiencing information and communication technologies in literally every breath of an individuals life. The confluence of pervasive or ubiquitous computing and HCI through the Internet of Things, Smart Cities, AR and VR and mobile wearable devices is leading us to the disappearing interface.

Nowadays, technological improvements have changed the way that people communicate, sense and interact. Undoubtedly, these technological improvements have increased our capacities to understand the human brain and have provided new ways to envisage healthcare. The strong integration between humans and technology represents an incredible opportunity to investigate human behaviour and analyze all the potentialities and advantages when used in the field of healthcare and rehabilitation.

The horizontal character of HCC makes it a fascinating and fertile interdisciplinary field, with which new ways to improve the quality of life of the people can be envisaged, whether it is by providing new diagnostic tools or developing innovative therapeutic approaches, improving and accelerating the rehabilitation process of the patients. Under the umbrella of HCC there are several potentially interesting technologies for healthcare and rehabilitation.

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1. Brain Computer Interface & Computer Brain Interfaces

The field of Neuromodulation, including both neurofeedback and neuro-stimulation has seen a resurgence in the last 25 years or so. The Journal of Neurotherapy has been publishing mostly neurofeedback (NF) results since 1995. Much of this work has been based on Brain Computer Interfaces (BCI) studies carried out by both neuroscientists and HCI researchers trying to build new forms of communication for those that cannot use traditional channels. These insights have led to a better understanding of how NF can drive positive feedback loops with positive effects in the treatment of for example, ADHD and Autism.

More recent research (such as HIVE, http://hive-eu.org/) on using improved brain stimulation paradigms to explore fundamental neuroscience questions and applications, aims to design and test more powerful, controllable and safe non-invasive brain stimulation technologies. These technologies can be used for rehabilitation in stroke patients and have shown potential in the management of pain and depression.

In the next 50 years we will witness the coming of age of technologies for fluent brain-computer and computer-mediated brain-to-brain interaction. These systems will be *smart* and will adapt the NF protocol or stimulation to the needs of the individual based on real time decoding of brain state.

2. Mobile devices and the emergence of body computing

The explosive growth of networks and communications, and at the same time radical miniaturization of ICT electronics have reversed the principles of human computer interaction. One of the most advanced frontiers of this trend is the so-called “body computing”, which refers to wearable or implantable wireless devices that can transmit real-time data to physicians, patients or caregivers. More specifically, the vision of body computing is achieved through the combination of portable communication systems (i.e. smart-phones) and body-sensors technologies, which are small piece of little or non-invasive equipment that measure specific bio-physical parameters (for example, heart beat rate or body temperature).

As body sensors are becoming available at accessible price, the interest towards the development of personal healthcare applications and services that integrate these devices is increasing. The research community on body computing is also expanding rapidly, as indicated by the growing number of conferences focused on this topic. As concerns applications, examples of areas where body computing could be effectively used include (but are not limited to) chronic diseases monitoring, monitoring patient’s addiction recovery and long-term drug treatment, and daily assessment of generic health conditions of elderly patients. However, the successful development of body computing applications require not only cheap, reliable and non-invasive sensor technologies, but also appropriate data analysis approaches. Actually, the massive amounts of data collected via body sensors and stored in the databases must be integrated and processed in order to provide meaningful information about the patient’s health status. The development of appropriate data mining, machine learning and signal processing techniques, as well as the definition of sound patho-physiological models, is a significant open challenge.

Beyond medical applications, body computing could prove useful in other fields, such as in human-computer interaction. For example, researchers at VIBE’s

Computational User Experiences (CUE) group (http://research.microsoft.com/en-us/um/redmond/groups/cue/) are working on the idea of turning the body into the input device, in order to achieve the vision of "always-available computing". In one of their projects, Skinput (http://research.microsoft.com/en-us/um/redmond/groups/cue/skinput/), they are trying to develop a technology that appropriates the human body for acoustic transmission, allowing the skin to be used as an input surface.

In sum, body computing is an exciting field of research, which promises revolutionary applications in the fields of healthcare, personal wellness and beyond. However, the realization of this vision requires a careful analysis of the legal, ethical, societal, and privacy issues implicated by the use and manipulation of human data.

3. Virtual reality and body ownership

The neuroscience of body ownership has challenged the ideas about how humans interact with a virtual world, whether it is through a fully immersive display or a mobile display. The VERE project (Virtual Embodiment and Robotic re-Embodiment, http://www.vereproject.eu/), supported by the European Commission under the Future and Emerging Technologies program) in particular is studying the embodiment of people in surrogate bodies so that they have the illusion that the surrogate body is their own body – and that they can move and control it as if it were their own. Understanding and mastering embodiment in virtual reality would have implications in the context of rehabilitation settings.

How and whether the body is represented in a virtual environment have consequences that have been disregarded. Furthermore, the absence of body representation in a virtual environment have different implications according to the display setup used. For example, in a CAVE, the user is not dissociated from his/her actual body. But when using a head-mounted display, the user is completely detached from his/her body and the absence of visual representation of the body might have advantages but also drawbacks.

Virtual reality has long been neglecting body image and body schema topics, in spite of the pioneering work of Riva and colleagues who started to use virtual reality to improve body image in patients with eating disorders or obesity [1]. Paradoxically, what becomes of the body of a user immersed in a virtual world has been an inexistent topic until the neuroscience of body ownership made its coming out in the middle of the first decade of the XXIst century (see for example [2] for a feature article reviewing several of the recent illusions from Dr. Henrik Ehrsson lab). Today, virtual reality is one the favorite tools of neuroscientists studying body ownership, and the results of their study contribute a very important knowledge to the HCC community.

4. Acknowledgement

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