Wearable Sensors and BCI for Home Care, communication and automation control

Giuseppe Andreoni¹, Fiammetta Costa¹, Maximiliano Romero¹, Paolo Perego¹, Luca Piccini¹

1) Dipartimento INDACO, Politecnico di Milano

Abstract— This work presents the ongoing research in the field of integrated multidisciplinary research on wearable systems for healthcare monitoring and advanced aids for personal communication and home automation control based on BCI systems. Biomedical engineers and designers cooperated to overcome technological user acceptance which is one of the most challenging issue to the real usability of these new services. Current state of the art support both multiparametric wearable monitoring to support Home Care services and EEG based BCI systems for communication and control of some devices and home systems through the integration in the domotic platform of a commercial system. Actual results are promising and already support several experimentation.

I. INTRODUCTION

The “Grey Booming” phenomenon is one of the major issues indicated by the European Union to be faced as soon as possible. The assistance and health-care providing of such an “older” society means higher costs for national health systems. Telemedicine and home-care has been suggested as the main countermeasure for the reduction of the overall costs while maintaining high quality of care, to provide an easy access to care for citizens from any place, at any time. This situation will also shift the focus of healthcare from treatment to prevention and early diagnosis through wellness programs.

The necessity to increase the potential impact of home-care solutions is a complex and multi-facet problem, where coexists different technological issues among biosignals monitoring, data communications and preliminary automated signal analysis able to cover such an important share of population. The need to accomplish those challenges motivated the research and development in the field of Wearable Health Systems (WHS). WHS are integrated systems on body-worn platforms or devices interfaced with “biomedical clothes”, offering continuous health status monitoring though non-invasive biomedical, biochemical and physical measurments (Andreoni, 2008). Under these perspectives, WHS are expected to have a significant impact on the efficacy and quality of care, as well as on the citizens’ quality of life (Lymberis and Gatzoulis, 2006; Perego et al., 2008).

In the same field Brain Computer Interface (BCI) systems directly interface the cerebral activities with a personal computer that nowadays represents a powerful medium for productivity, entertainment, worldwide communication and also remote control. This technology could be used in order to restore lost body functions and it could represent a great improvement to the quality of life of severely disabled people (Piccini et al., 2010). In fact, though strongly promoted and encouraged by military and entertainment research, its primal and main application is undoubtedly assistive technology for people affected by severe motor disabilities. In recent years, the research in the BCI field has grown rapidly, showing renewed interest and demonstrating how this communication system is feasible. After communication, Home control is one of the first needs expressed by disabled people.

Home automation (or Domotics) is a field of building automation aiming at the development of specific technical solutions for private homes and dedicated to the application of technologies for the comfort and security of its residents. Many technological field are involved in the realization of a home automation system ranging from electronics and computer science, to communication networks and the internet. From the technological research point of view, the main focus is the creation of a smart system able to efficiently control and integrate all the typical home installations (Andreoni, 2009).

II. METHODS

A. Wearable Health Systems

In the Sensorwear project we contributed to develop a complete home monitoring service during the spontaneous activity of the subjects: this paradigm is known as “unobtrusive measure”. The main objective of the project is the creation of a Body Sensor Network (BSN) for health state monitoring through the recording, processing and transmission of the biosignals and the useful parameters obtained from to them [5]. The signals identified for the specific purpose of the telecardiology application are:
- Three ECG leads;
- Body movement;
- Respiratory frequency;
- Cardiac output monitoring.

The sensorized T-shirt was designed to optimize the industrial process necessary for the integration of sensors and for the best positioning for the ECG and ICG signals. In addition, the unobtrusive measure requires a design of garments which must be able reduce the effects of movements, without impacting the comfort. Also usability issues significantly drive the Interface development.
Fig. 1. An example of a sensorized t-shirt and a wearable polygraph for ECG, respiration and movement monitoring.

Fig. 2. The ergonomic study for user interface and device shape for wearability; these aspects are crucial for usability and compliance by patients.

B. BCI Systems

BCI++ is a framework dedicated to the development and fast prototyping of Brain-Computer Interface systems, pc-driven protocols for a variety of bio-signal acquisition paradigms and BCI-based applications. It guarantees ease of use, high flexibility and powerful solutions for the development of complex paradigms and immersive protocols oriented both to the in-lab research and to end-user application.

A specific software module was also implemented in order to provide an application layer with an home automation system. The module is specifically developed for MyHome® system (BTicino spa) that offers a simple low cost gateway and a communication protocol (OpenWebNet® - www.myopen-bticino.it) which can easily used to interface a personal computer with the home automation system. This gateway, with specific interfaces, can be also used to control different home automation systems.

III. RESULTS

A. Wearable Health Systems in Home Care

Multiparametric Wearable monitoring demonstrated reliable and capable for long term follow up. The HW architecture was optimized for wearable applications and patented by Politecnico di Milano. Now a spin-off of this University is commercializing handheld holter polygraph. Several application up to now were tested: from neonatal pre-term newborns monitoring to elderly people follow up at home, up to sportsmen during exercise. But home care applications were the most interesting to support the EU vision and enhancing the quality of life of subjects.

Fig. 4. The Phedra polygraph by SXT – Sistemi per Telemedicina s.r.l.; it is an handheld device for the continuous monitoring of ECG, Cardiac output, respiration, pulse-oximetry, temperature and movements.
B. BCI Systems applied to Home Automation

A SSVEP based BCI system was used to drive the home automation panel. The operating protocol consisted of the following sessions:

(i) Screening Session: to identify the most suitable stimulation frequencies for the subject.
(ii) Training Session: to configure and train the processing and identification chain parameters.
(iii) Testing Session: to validate and confirm the configuration parameters.

All the described sessions were guided by means of a specific graphic user interface developed using the AEnima module which also managed the stimulation device (Parini et al. 2009).

The system was tested by 20 voluntaries (healthy and disabled) between 22 and 50 years old. 16 out of 20 subjects were able to use the software application at the first time.

Fig. 5 An example of biosignals recording (ECG, respiration and 3D accelerations whose specific patterns allow for the identification of specific activities from) obtained through a sensorized tshirt and a wearable device.

Fig. 6. The SSVEP BCI system set-up: the four LED stimulators are placed on the sides of the display in front of the subject like the arrows (UP, DOWN, LEFT, RIGHT) for cursor movement. The patient is wearing a cuff supporting the electrodes for EEG recording; on the right side there is the Electro-Encephalo-Graph using a Bluetooth connection with the PC.

IV. CONCLUSION

Quality of Life of elderly and disabled people could significantly be improved by new technologies in the Ambient Intelligence framework. UE Commission identified the "Ambient Assisted Living" (AAL) as one of the most strategic issue in research and development. This programme is intended to address the needs of the ageing population, to reduce innovation barriers of forthcoming promising markets, but also to lower future social security costs. AAL aims - by the use of intelligent products and the provision of remote services including care services – at extending the time older people can live in their home environment by increasing their autonomy and assisting them in carrying out activities of daily living. These research examples wanted to move on in this direction.

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REFERENCES