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SMART ELECTRODE FOR A WIRELESS SENSOR NETWORK FOR HEALTH MONITORING

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KEYWORDS

Wireless Sensor Networks, Wearable Health Monitoring, Ambient Assisted Living.

ABSTRACT

Wearable and wireless systems for health monitoring are currently a very active research topic and hold promise of improving the quality of healthcare. This work has the goal of developing a smart electrode system, composed by a dry and flexible electrode material, attached to an intelligent electronic core. The smart electrodes should be able to autonomously create a wireless sensor network for monitoring the health condition of their user, in a wearable fashion. The concept of the smart electrode and a first prototype are presented.

INTRODUCTION

At the present moment, healthcare services and resources are enduring a tendency for increasing demand and for the rise of global healthcare costs (Hao and Foster 2008). This is essentially caused by the unprecedented ageing of the world population (United Nations 2009) and consequent increase in the incidence of chronic disease and physical disability.

To deal with these circumstances, efforts are being made on the development of novel and more efficient means for monitoring the health condition of patients, focusing on proactive wellness management and early disease detection instead of reactive treatment of disease (Milenković et al. 2006), with the goal of increasing the quality and efficiency of healthcare. This is made possible by the recent developments in different technologies such as sensors, wireless communications and materials, which led to the emerging of new fields of application such as Wearable Health Monitoring Systems (WHMS) (Pantepoulos and Bourbakis 2010) and Ambient Assisted Living (Steg 2006).

The development and widespread availability of WHMS is helpful to both patients and caregivers. Patients are no longer required to stay at, or to frequently visit caregivers to have their health condition observed and can thus remain in their familiar environment. Therefore, patients are allowed to be active, improving their quality of life and independence while leading a healthier lifestyle. Correspondingly, caregivers obtain new and more effective means for patient observation, which allow continuous and remote monitoring, contributing for the detection of early signs of disease and influencing further decisions and the effectiveness of treatment, preventing the occurrence of severe health complications. This is particularly suitable for the treatment of patients at risk, e.g., those suffering from chronic diseases or undergoing rehabilitation.

Even though WHMS promise great benefit, their realization is a challenging task since limiting user and application requirements must be taken into account when designing the system. Failure to satisfy these requirements may impede the acceptance of these systems by caregivers and patients. Among these requirements are: unobtrusiveness (small size, light-weight and noninvasiveness), wireless communication (for remote monitoring and mobility), low power consumption (to enable long-term monitoring) and ease of operation.

The goal of this work is to develop a “smart electrode”, which allows the creation of a wearable system for health monitoring, through combination of different smart electrodes in a wireless sensor network. Further details are given in the next section.

OBJECTIVES

This project consists on the development of a smart electrode, composed by a dry and flexible electrode material (Hoffmann and Ruff, 2007) and an electronic core, which contains low power electronics for signal acquisition and wireless communication, allowing the creation of a self-organizable wireless sensor network for acquisition and monitoring of physiological signals related to the user’s health condition, namely the electrocardiogram (ECG). The smart electrodes should also feature small dimensions and autonomous energy supply for wearability or possibility of integration with textiles. Since each smart electrode is autonomous and has its own power supply, a common reference signal cannot be shared within the wireless network of smart electrodes, e.g., when measuring an electrocardiogram according to the conventional 12-lead system.

Therefore, in the later stages of the project, methods for synthesis of physiological signals from individual local measurements will be studied, in order to obtain physiological signals of clinical use from the combination of the signals obtained by each smart electrode in the wireless network.

PROTOTYPE

The first prototype of the smart electrode was built as a wearable module for health monitoring and it is shown in Figures 1 and 2 (Figueiredo et al. 2010).

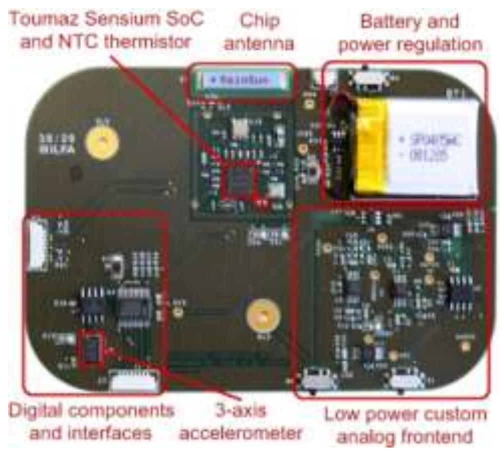

Figure 1: Top view of the first smart electrode prototype

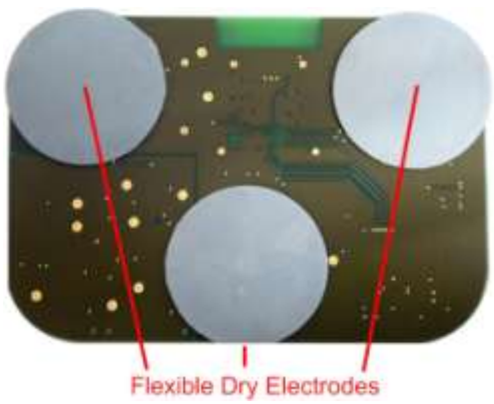

Figure 2: Bottom view of the first smart electrode prototype

The prototype of the smart electrode was designed to meet the aforementioned user and application requirements, featuring: wearability by the assembly on a small size circuit board, use of flexible dry electrodes and complete absence of connecting wires; continuous monitoring of single-lead electrocardiogram, activity and local temperature; wireless communication using a proprietary solution operating at 868 MHz, with a 50 kbps data rate, and possibility of combination of up to 8 smart electrodes in a star-shaped wireless sensor network; and low power consumption (over 90 hours of continuous operation).

CONCLUSION

The concept of a smart electrode was presented, which envisions the development of wireless sensor network for health monitoring composed of smart electrodes that would ultimately allow complete absence of connecting wires (reference signals, power, etc.), and therefore provide comfortable use on a wearable system.

Future work will involve further miniaturization of the first prototype and the research of methods and algorithms for the synthesis of a conventional 12-lead ECG from the individual measurements of each smart electrode on the network.

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