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SMART ELECTRODE FOR A HEALTH-MONITORING WIRELESS SENSOR NETWORK

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Wireless Sensor Networks, Wearable Systems, Health Monitoring, 12-lead ECG Synthesis.

ABSTRACT

Wearable health-monitoring systems are currently a very active research and development topic, and they are being held as a promising solution to tackle the increasing demand for healthcare services, by improving their quality and reducing their global costs. The aim of the present work concerns the development of a wearable health-monitoring system based on a wireless sensor network of smart electrodes. The smart electrodes are composed by a dry and flexible electrode material, attached to an electronic core which provides sensing, processing and wireless communication capabilities. The system was designed to meet user and application requirements, such as unobtrusiveness, low power consumption and user-friendliness.

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, with the goal of increasing the quality and efficiency of healthcare. This is made possible by the recent advances and increasing miniaturization in different technologies such as sensors and wireless communications, 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 restrictive and often conflicting 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 simplicity of operation.

SYSTEM DESIGN

The first prototype of smart electrode is shown in Figure 1 (Figueiredo et al. 2010) and its main specifications and features are summarized in Table 1.

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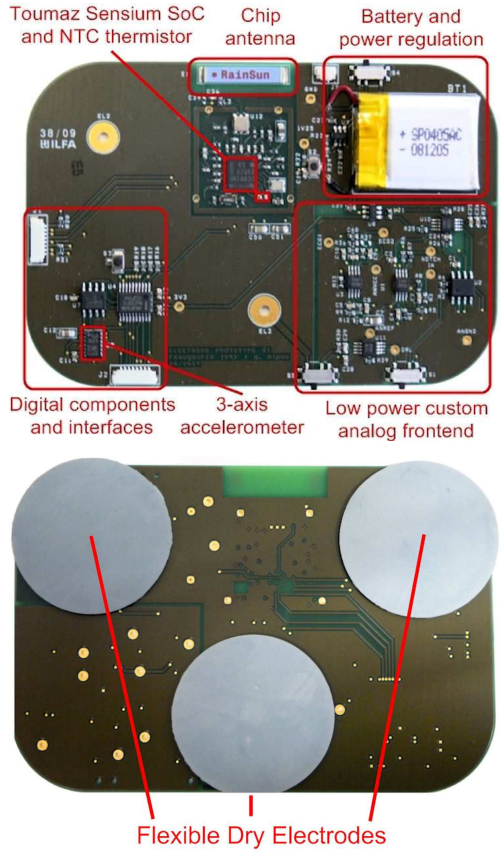

Figure 1: Top and bottom views of the smart electrode prototype

Table 1: Summary of the specifications and features of the smart electrode prototype

ECG lead monitoring	Gain	500
	Resolution	11 bits
	Sampling rate (max.)	256 samples/s
Triaxial accelerometer monitoring	Range	± 2g or ± 8g
	Resolution	8 bits
	Sampling rate (max.)	400 samples/s
Temperature monitoring (local)	Range	20 to 40 ºC
	Resolution	11 bits
	Sampling rate (max.)	256 samples/s
Wireless link	Operation Frequency	868 MHz
	Data rate	50 kbps
	Max. number of nodes combined in a WSN	8 (100 samples/s) 4 (256 samples/s)
Power consumption	Supply voltage	3,3 V
	Average current consumption	0,98 to 1,43 mA (accelerometer off or on)

CONCLUSION

The concept of a wearable health-monitoring system based on a wireless sensor network of smart electrodes was presented, along with an implemented prototype. The system is intended to be used in two scenarios: to monitor a single ECG lead of up to eight patients in the same ward of a hospital or assisted living facility, or to synthesize the standard 12-lead ECG of a patient, from the lead signals obtained from three smart electrodes, placed at specific locations and orientations on the patient's chest. Future work will involve the evaluation of the system's performance and of the accuracy of the 12-lead ECG synthesis, in the latter described scenario.

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CELSO P. FIGUEIREDO received his M.Sc. degree in Biomedical Engineering - Medical Electronics in 2007, from the University of Minho, Portugal. Since 2008, he is working towards the Ph.D. degree in Biomedical Engineering at the University of Minho. Between 2008 and 2010, he conducted his PhD work plan in collaboration with the Fraunhofer Institute for Biomedical Engineering, St. Ingbert, Germany. Since 2008, he has been a student member of the IEEE Engineering in Medicine and Biology Society.