Chapter 3
Smart Clothing for Health Care

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ABSTRACT

The use of wearable technologies in medicine and health care has become of important in order to considerably improve benefits for patients and health service providers. Within telemedicine, biomedical clothing plays a crucial role. The main technology advances and the research of the Textile and Paper Materials Research Unit (UMTP) and of the Assisted Living Computing and Telecommunications Laboratory (ALLab) teams, in the area, will be addressed. Issues that remain unsolved will be presented. The chapter presents an overview of the key concepts for telemedicine and the role of textile electrodes and their integration in smart clothing. The development of software algorithms that specifically handle signals that are collected using biomedical clothing, integrating resiliency and a proper set of alarms, is presented and discussed in the context of classical biomedical signal processing. Finally, biomedical clothing design will be discussed in social, psychological, and esthetical contexts.

INTRODUCTION

Telemedicine is not a new concept. In fact, the first telemedicine experiments took place around the mid 20th century (Grigsby & Sanders, 1998), and its development is tightly connected to the development of the telecommunications networks, and more recently, to the development of the Internet.

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More recently, the concept of telemedicine is no longer viewed as simply the act of providing medical acts to a distant patient, and thus involving a doctor or a physician on one side of the communication network and on the other side, a patient or a person who requires medical assistance. Telemedicine is now perceived more widely as the act of providing health care by means of a telecommunication network, possibly using specialized devices such as sensors or actuators,

maybe not even requiring the physical presence of a physician or a health care practitioner.

This chapter provides a focused review of the state of the art on the issue of clothing that integrates ECG sensors, and discusses some of the developments made on these areas by the research groups at UMTP / University of Beira Interior and from the Assisted Living Computing and Telecommunications Laboratory from the *Instituto de Telecomunicações* (Assisted Living Computing and Telecommunications Laboratory, 2010).

After this initial section where the motivation for this subject has been presented, a Background section presents some of the most relevant research and projects in this area. The following section contains an overview of the concept for telemedicine. A section describing the motivation for the approach of smart clothing to a class of circulatory system diseases follows. Sections describing the construction and the evaluation of textile electrodes, and its integration in smart clothes precede a section where an argument for the need of new resilient and adaptative algorithms is discussed. Issues related to the design of biomedical clothing as an argument for user adoption are presented. Finally, future trends are suggested and conclusions are drawn.

BACKGROUND

Since the year 2000, the European Union invested over 500M€ (De Lombaerde & Van Langenhouve, 2011) in Research and Development (R&D) projects, on intelligent clothing or smart garments, due to its strategic importance for potential savings in the health care national systems and in the improvement of the quality of life for the society. In Europe, in particular, the increasingly large segment of elderly population demands for wearable technologies in Medicine and Health Care. Several European Projects, involving Industrials and Research Centres were financed (*e.g.* http://www.clevertex.net, http://www.proetex.org, http://www.systex.org, http://www.mobiserv.eu, http://www.psycheproject.org, http://veritas-project.eu). From EU funded projects such as MyHeart (Harris & Habetha, 2007), the main achievements consist of knitted T-shirts, and of seamless and textile electrodes to monitor in real-time Electrocardiograms (ECG) using a 5-lead configuration (Paradiso, Loriga, & Taccini, 2005). The T-shirts also integrate textile sensors to monitor pulmonary and abdominal ventilation and body movement. Muscle activity monitoring has also been demonstrated. Nowadays, many spin-off companies from universities have been formed, *e.g.* in Italy (http://www.smartex.it), in Finland (http://www.meagemg.com), in the United Kingdom (http://smartlifetech.com), and in Portugal (http://www.biodevices.pt).

Nevertheless, while wearable technologies are becoming a mainstream commodity for sports (consider the commercial products from Polar or from Adidas, such as the bra and the wrist strap), longer time is still to come for clothing that monitors the vital signals in health care. Research and development in the area have not stopped to increase, and nowadays there are trials being done in many European hospitals to improve the efficiency of the solutions, the comfort of patients and the trust of health care providers.

To acquire know-how in these emerging technologies is important. Not only because of the challenges that still have to be overcome, but also mostly because of the expected impact these technologies will have in a near future for increasingly ageing populations in Europe, in the United States and in some countries from Asia and the Oceania. Among the issues that remain to be solved, the following are being addressed by the UMTP research group: overall reliability for signals captured while walking, standing or sleeping; signal isolation, to allow as little interference from artifacts and cross-talk from other signals being monitored; clothing architecture and design, to allow its adoption from users and to make it as comfortable as possible, while also to make it appealing to use and to maintain.