NEW METHOD TO ATTACH WEARABLE ELECTRONICS TO CLOTHS

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Abstract: *The integration of electronic devices and sensors into textiles has many different potential applications. Textile fabrics, from clothing to upholstery and home textiles, are an integral part of daily life and the ability to combine electronics into textiles means that a huge range of valuable data can be collected and used by the wearer to monitor their health, performance and wellbeing, among other uses. One of the most pressing challenges is that of interconnecting electronic components via the textile fibres in a robust and reliable way. Another aspect to be studied is the ability for the electronics to be connected and disconnected when necessary; for example, when charging the batteries or washing the garment. It is this aspect that has been considered by this development to facilitate ease-of-use among the older people. In addition, the complete package must be comfortable enough not to restrict movement, and must be unobtrusive so as to avoid any embarrassment to the wearer. The present paper presents a new solution for the connection of electronic measuring and monitoring devices to textile sensors to monitor variables such as movement, temperature, heart rate and breathing.*

Key words: *intelligent textiles, wearable sensors, knitted electrod, conductive yarn, smart textile*

1. INTRODUCTION

The demographic change leads to larger percentages of older people in society. Within the next 20 years, the amount of people over 75 will raise significantly in Europe. According to the third EU Demography Report, the life expectancy has also been increasing in an almost continuous and uniform trend at the rate of 2-3 months every year, and is the main driver behind the population ageing. The Digital Agenda for Europe reinforces solutions for Ambient Assisted Living to improve the quality of life of the older people and strengthen the competitiveness of European industry through the use of ICT. It also seeks to employ these innovative solutions to lengthen the time that an older person can remain independent and live in their own home.

The present development has been made in the frame of the Project ALFRED: Personal Interactive Assistant for Independent Living and Active Ageing. ALFRED's objective is to develop a mobile, personalized assistant for older people, which helps them to stay independent, to coordinate with carers and to foster their social inclusion. ALFRED is specifically dedicated towards older people and is fully focused around their needs. ALFRED will realize a mobile, personalized butler, created using cutting edge technologies such as advanced speech interaction, making it possible to talk directly to him. ALFRED will thus be very easy to use and will provide context-sensitive services related to social inclusion, care, physical exercise and cognitive games.

Part of the project is focused in integrate body sensors contributing in a more effective and personalized care process. This has been done by integrating wearable sensors and permiting that data can be accessible from everywhere by trusted carers and family members. All this data will be personalized according to the needs of end users and health status using a web portal. During the project the design of a wearable device has started including different sensors like heart rate, breathe rate, temperature and movement, according to the requirements previously defined. All these sensors have been integrated into an underwear t-shirt using smart textiles. The requirements of low energy consumption and comfort have been considered in order to facilitate easy handling for older users.

2. DEVELOPMENT

2.1 Scope

The current project developed a t-shirt incorporating movement, temperature, heart rate and breathing rate sensors and designed a simple connectivity system so that the older wearer could operate it without problems. The authors have developed prototypes during recent years using different connection systems to combat the problem posed by conventional soldered connections breaking too easily with use or failing in other ways [1, 2]. In this development several technologies have been used in order to obtain a new method to attach electronic devices and wearable sensors to smart textiles.

2.2 Sensors

Heart and breathing rate monitors were connected using two electrodes made from a fabric incorporating pads made with conducting yarns. During development, different solutions to the problem of how to apply the technology to the garment were researched including embroidery using conducting yarns and serigraphy to print circuits into the fabric with conductive inks, but the selected solution improves the elasticity of the fabric, making it more comfortable and easy to use [3, 4, 5]. For this a seamless textile has been manufactured including sensors using a combination of conductive and non conductive treads.

Different locations of the sensors were also studied to achieve the most accurate measurements and results [6]. Another complex, but important aspect to resolve was that of achieving a design which does not apply excessive pressure on the wearer but allows reliable readings to be taken. The problem was approached by different authors to show variations that produce these aspects [7, 8]. The developed fabric offers be breathable improving comfort. At the same time it provides elasticity to fit sensors in contact to the body without being unconfortable.

Fig. 1: *T-shirt with sensors.*

2.3 Attachment method

In order to facilitate the attachment of the electronics to the fabric and make all the necessary connections, it was decided to design a comfortable and easy-to-use capsule/holder to accept the device and allow easy contact with the sensors. The holder design was undertaken using 3D design software and the prototype was constructed on a 3D printer using flexible filament.

The flexible design of the holder means that the electronic device can be easily removed for charging and/or when the garment needs to be washed, in addition to acting as a protective cover for the device and the connectors to prevent damage during use.

Fig. 2: *Attachment solution for sensor connection.*

2.4 Electronics

A prototype device, built around a Texas Instruments CC2540 microchip with Bluetooth low-energy support was designed to collect signals from the various sensors, which sends the readings to a mobile device. A 32 Mbit memory is incorporated to provide backup in the case of lost reception and temporary storage.

During development, different IIR and FIR filters were installed for the different channels to filter noise and improve reading accuracy [4, 9]. The firmware has been optimized to minimize the number of operations; this permits autonomy of 100h.

Fig. 3: *Electronic unit.*

3. RESULTS AND CONCLUSIONS

The electrodes designed for the project perform well and the system provides excellent flexibility for integration into clothing, as well as being comfortable and not interfering with the ease with which the garment is put on and taken off.

Readings taken through the device/garment interface are accurate and no excessive signal noise is generated. In addition, the support is easy to use and requires no additional wires or clips.

Current energy consumption figures for the device have demonstrated that more compact models can be designed which can incorporate sensors within a single unit. The use of Bluetooth LE communication means that there is constant communication between the device and a Smartphone.

4. ACKNOWLEDGEMENTS

The work presented was supported by the EU project ALFRED approved under Grant Agreement 611218, in the frame of the EU program FP7-ICT-2013 call 10.

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