Cool Sensors for a Freer Lifestyle

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***Abstract*— This work will demonstrate the importance of enabling fabrics and garments to interact with wearers and users in ways which they consider normal and everyday. The technology discussed embodies a variety of data capture using multi-functional sensors which are part of the garment rather and an addition to a garment. The systems are designed for application in a variety of areas, for a full age range of users and with properties which require little or no special care.**

I. Introduction

Until recently, most wearable technologies manifested themselves in laboratories or as clothes that were specially made and bore little resemblance to garments which users would regard as normal. The nature of the functionality – normally Heart Rate (HR), Skin Temperature (Temp), Respiration (Resp) – was collected by adding sensors to a substrate garment in the general vicinity of where the bio-electrical signal could be best collected, e.g. HR was located under the breast on the front of the chest and usually in two places – one either side of the sternum.

A number of systems have evolved over recent years (primarily since 1999 but more specifically from 2002/3) and they have manifested themselves in a collection of devices variously known as Numetrex, LifeShirt, LifeVest, HealthVest and others from companies situated in the United Kingdom, United States, Netherlands, Italy, Germany, New Zealand and the Far East.

The value of this work is depends on the patents that have been registered in many domains and most importantly in the fields of fabrics, textiles and materials. Without core patents in these sectors, the electronics – much of which improves the quality of the outputs from the collecting sensors – are of minimal intrinsic value as much of the hardware and electronics, as well as some of the software derivations are off-the-shelf technology. The 'application twist' is the way these technologies are applied to the garments and the interpretation and potential value of the data outcomes.

II. The SmartLife® Approach

As a company, SmartLife® secured its core technology from the University of Manchester in the UK. It used this as the basis for the development of its business, itself having a purpose to lead the field in the research, development and commercialisation of flexible fabric sensor systems for the improvement of lifestyle. The model creates a new freedom for those people who suffer from a range of personal conditions from cardio, respiratory, general health and well-being, through to applications such as personal performance (sport), safety (hazardous situations), automotive, location, entertainment and military. There are 23 recognised ECG related conditions diagnosis of a number of which might well be enhanced through persistent and consistent monitoring. The knowledge emanating from such monitoring is likely to have significant impact on the future understanding and treatment of many conditions, particularly when the monitoring covers the 'normal' lifestyle of the wearer hence avoiding occasional snapshot and artificial environment tests paradigms.

III. Scalability

SmartLife recognises the importance of being able to tailor the system to the application and, furthermore, tailor the system to the individual thereby ensuring that in medical situations, wearers are monitored against their own personal bio-rhythms and not against a generic group. The paradigm shift therefore is for clinicians and medics, who work with this group of people, to move from snapshot, expensive, time-consuming and restrictive monitoring to inexpensive, unrestricted and home-based monitoring on a round the clock basis if required. The results become personalised to the patient in comparison with his norms and even personalised in terms of how the information is both presented and analysed should that be required.

Of equal importance is the necessity to manufacture and produce SmartLife garments on equipment which is in commercial use throughout the world, using manufacturing techniques which required only the SmartLife programs, the quality assurance framework accompanying this type of garment manufacture, and the data familiarisation especially as it is a medical device Class 2a.

IV. THE WEARER EXPERIENCE

The crucial point, as cited in the introduction is that successful deployment of these and similar products and medical devices depends absolutely on the acceptability of the product or device in practical use. In other words, the user must find it easy to use, comfortable, unintrusive, invisible and so on. One clear solution is to make the device an integral part of something that the patient routinely and habitually employs anyway. The obvious choice is to replace a standard piece of clothing with a special version. Providing that the use of the monitoring garment presents little more challenge than the normal one, the patient has no excuse not to use the monitoring version. Moreover, being a garment the wearer can subject it to normal garment care procedures and hence maintain its performance without recourse to professional or expert help.

But normal garments come in sizes to suit body shapes and a monitoring garment must also accommodate a wide range of body shapes and sizes. In the SmartLife case, the size scaling is simple – along the lines of Small, Medium, Large – with few additional variants. This flexibility of approach is possible because the sensors are automatically positioned on the wearer's body in the correct place. Therefore the customer proposition is: one simple on/off device; no skin or gel preparation; ‘24/7’ real time monitoring; and data collection from ECG, heart rate, EMG, respiratory rate and respiratory tidal flow.

V. THE TECHNOLOGY, ELECTRONICS AND USER INTERFACE

The technology was developed to meet a variety of requirements. They included; Simultaneous multiple parameter monitoring; signal capture, selection, analysis and data transmission; option for local or remote interpretation of signal; single or multiple subjects. Furthermore the signals had to be of comparable quality and reliability to those collected from conventional, clinical equipment such as that found in hospitals, health centres and emergency services centres.

SmartLife uses the garment simply as a data collection device. As such, the nature of the garment system allows the manufacture of a variety of next to skin garments, programmed to collect a variety of signals for a variety of applications. There is nothing restricting the system from being deployed only as a torso garment, the SmartLife garment system is ideal in that it is multi-functional. The signals travel from the sensors along integral conductive pathways whether they be ECG, HR, EMG or respiratory and it is these characteristics that appear in the patents which protect the SmartLife garment system.

In the current demonstration version, the signals are captured and fed to the worn electronics which then relay them via Bluetooth to, for example, a PC. The signal processing is undertaken on the PC, mobile phone or PDA. Wearers can use existing telecommunications networks, again avoiding proprietary platforms and ensure costs of use are kept to a minimum. A local alert can be fitted to the electronics audibly and visibly to alert the wearer to a change in the captured signals as pre-selected for them. The graphical user interface (GUi) demonstrated below appears on the user's PC / mobile phone, or home screen in the case of an integrated home monitoring system being installed. The GUi can also be tailored by the wearer to prioritise the display of the data and to aid reading and recognition for those visually impaired.

Fig. 1 SmartLife® Graphical User Interface

Currently the power for the worn electronics is rechargeable and situated on-board. Alternative and future ultra-low power and green options are already feeding into future developments.

VI. SMARTLIFE COLLABORATION

The SmartLife system embraces the strengths of various collaborators who are involved in the delivery of the data to clinicians and monitoring services, and they equally enhance and benefit from adoption of the system. SmartLife is currently engaged with a number of global corporates to deliver this solution. This approach assures SmartLife licensees and customers gain confidence in the infrastructure plus, the delivery of the data is formatted into existing analytical and diagnostic technology for immediate, easy and tailored use.

SmartLife is a member of the *Continua* organisation and there is a widening and global emphasis on the need for collaborative innovation – particularly in the context of open interoperability of networks. These networks support the vast range of body-worn monitors and remote healthcare management devices that are expected to play a future role in substantially reducing pressure on hospital resources. This theme was echoed by the operator of the largest non-profit healthcare organisation in the USA, Kaiser Permanente. They see the key to success as ‘standards’ for interoperability – reducing costs and enabling faster development. The European Centre for Connected Health is a recent development based in Northern Ireland and expected to play a major global role in providing a real-world test and development platform for all participants – bringing together technological, networking, healthcare and public policy perspectives.

Other collaborators important to SmartLife are its business partners. SmartLife licensees determine the retail price and end-user operating costs of the garments and a number of scenarios, not detailed in this paper or the presentation, can be explored in appropriate circumstances ‘off-line’.

VII. TRIALS

SmartLife did not attempt to replicate a 12 lead ECG initially and sought a 3 lead ECG. Comparison between the quality with conventional Ag/ AgCl sensors and the results of garment system tests are shown below. These tests were undertaken on SmartLife team people at Manchester Royal Infirmary in the UK (MRI), between May 2007 and March 2008. Standard ECG data methodology and equipment has been compared against the SmartLife system in the following instances: Comparison of the responses from standard Silver/Silver Chloride (Ag/AgCl) electrodes and yarn electrodes using hospital monitoring equipment.

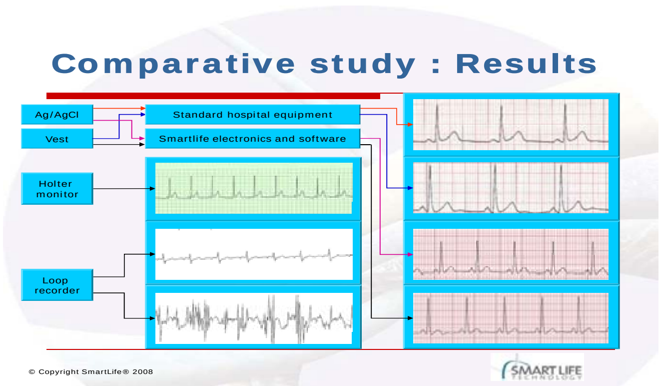

Fig. 2 Comparison of the results of a loop recorder, Holter monitor and SmartLife HealthVest®

VIII. DELIVERY

The SmartLife model is to engage with parties who have aspirations for or actual deployment of applications using intelligent garment technology where there is a desire to tailor the system for a specific application and to secure the necessary regulatory compliance associated with that application. This in turn offers the partners with whom SmartLife works to explore additional sensing capabilities for the garment system such as location, motion, temperature and other targeted features. The SmartLife electronics are built with multi-functionality within the architecture.

There is a myriad of applications each with their own requirements and varying data collection needs in differing operating scenarios. The monitoring requirement many be continuous or episodic and this too is part of the flexibility of the SmartLife garment system.

IX. CONCLUSION

The SmartLife garment system may appear to be similar to the products of a number of projects from across the world in that it attempts to use clothing as the foundation for monitoring of vital functions. However, the SmartLife garment system brings critical advantages by adding knitted structures to otherwise familiar garments. Apart from addressing the issue of unit cost, it substantially increases the probability of enthusiastic adoption by its target user populations. And such a gain must bring benefits in improved health and well being.

ACKNOWLEDGEMENTS

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