Modification of Microclimate Monitoring Jacket

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Abstract **– The article describes the improved version of a jacket with some modifications for advancement of jacket design and comfort conditions. The arrangement of electronic elements is optimized, placing two largest blocks of system in the pockets on sleeves. POF display is replaced with the flexible textile LED matrix display for more effective signalizing. Design of electronic elements is also optimized – individual circuit boards are designed for power supply system, logic and control system.**

Keywords – microclimate, smart clothing, comfort, children

I. Introduction

Clothing is an important and special part of our environment as it is personal, comfortable, close to the body and used almost anywhere and anytime. Nowadays, clothing has more functions than just climate protection and appearance [1]. Smart and interactive clothing is a novel industrial area, which gives clothing additional functional properties. Such innovative garments are used in different areas – sports, medicine, entertainment, etc. The system of smart or interactive clothing often functions with integrated electronics and, as a result, garment can respond in an adaptive way to external stimuli, process them and produce new signals [2] such as light, sound, vibration, etc.

Wearable electronics usually denotes a functioning device that always is attached to the clothing, and it is comfortable, easy-care and easy to use. In other words, it is garment with integrated electronics that does not disturb the wearer of the apparel [1]. Therefore, while developing smart clothing it is important to consider design and arrangement of electronic elements in order to get functional, comfortable and ergonomic layout of electronic components in the smart garment.

During the previous research, the child's jacket with embedded electronics and integrated plastic optical fibre (POF) fabric has been developed that reacts to microclimate changes with the help of integrated electronics. The system is programmed for specific temperature and humidity thresholds. If the thresholds are surpassed, the garment signalizes about it with the help of visual output interfaces – the POF display lights up. The prototype has been described in detail in the previous paper [3]. The jacket is especially suitable for very active and restless children – it is possible to control the child’s perspiration and temperature. The jacket protects children on dark roads, as well.

This article focuses on the improved version of the jacket with some modifications.

II. Improvement of the Jacket Design and Comfort Conditions

The modified jacket reacts to changes of microclimate under the garment and signals about the temperature and humidity level in two ways – with the help of the light emitting diode (LED) display that is integrated in the front of the jacket, and with help of the liquid crystal display (LCD) that is integrated in the mother’s purse.

As the first imperfection of the jacket prototype, the distribution of electronic elements can be mentioned that does not fully confirm to ergonomic principles both due to system placement and size of elements. In a modified prototype, electronic elements are placed in the areas, where there is less influence of inner and outer strain on the clothing and body (based on the analysis of studies [4; 5]). Two largest blocks of electronic system are placed in the pockets on the sleeve in the area between the shoulder and elbow. Partially, connections are done using conductive threads, thereby reducing rigidness of the system. In separate parts of the jacket textile communication layers or bands are provided, where conductive seam connections are sewn.

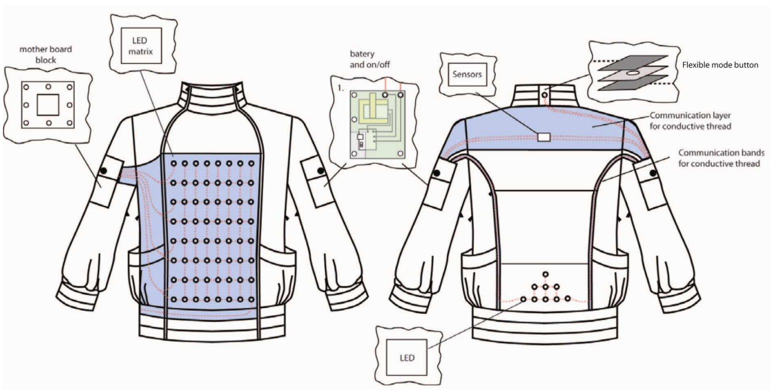


Fig.1. Schematic illustration of the jacket modified version

In the previous prototype, the plastic optical fibre (POF) fabric was used as the jacket display that was illuminated with LED, thereby signalizing about changes in the microclimate under the garment. Since all area of fabric is lighted up with one LED, light brightness is rather pale in daylight and well visible just in semidarkness or dark conditions. To make signalizing more effective in a new prototype, the POF display has been replaced with the flexible textile LED matrix display. It is brighter and it is possible to add some interactive functions to the jacket (different graphic image representation).

In addition to the LED display, there are light-reflecting insets provided in different parts of the jacket – on the sleeve cuffs, jacket hemline yoke, collar and pockets. It gives additional safety if the jacket system is turned off.

III. Textile Material Selection for the Jacket

Designing smart textile garments with the integrated electronic systems requires that the electronic components are isolated or at least partially isolated. Contact of electronic components with the environmental agents (such as humidity) is not desirable both for data detection accuracy and system protection. Using waterproof fabric, it is possible to provide protection from adverse weather conditions both to the human body and electronic system. However, it reduces hygienic requirements of garment because waterproof fabric prevents sweat circulation from the body to the environment, thus making discomfort in undergarment ambience. In this case, it would be useful to use the waterproof/breathable material as the base fabric – it would work as a protective shell for electronics, protecting the system components from undesirable contact with the external environment moisture (rain, snow), as well as ensuring hygienic conditions for the human body. For these purposes, the membrane fabric is used.

While designing functional clothing, it is important to apply the appropriate production technology so that the garment could fulfil its aim and functions. Garment detail joining conditions and methods should be taken into consideration, as well as the way of attaching accessories and furniture to the garment.

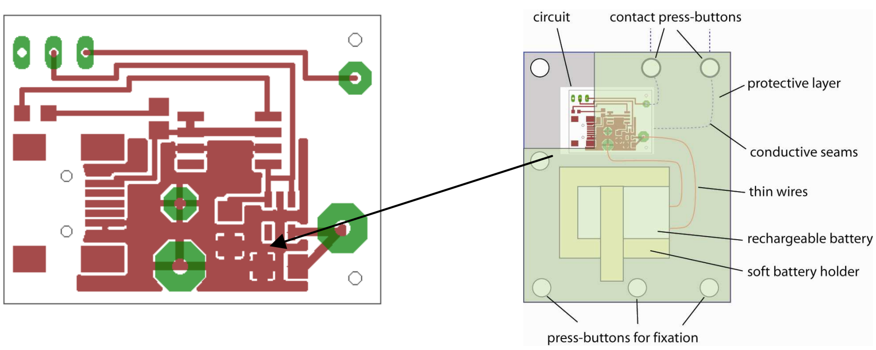
One of membrane fabric part joining technologies is welding, which provides perfect water impermeability in garment detail joining places. Using lock stitch sewing machine technology, seams must be isolated with a seam sealing tape [6]. To provide complete isolation from water, often it is required to have, for example, water resistant zippers in front of the jacket or on pocket openings. Another way how to ensure protection from water in the pocket opening is to make a pocket flap.

Analysing smart garment as a multi-layer system, it is important to take into consideration the compliance of other garment layers to the total clothing objective. Basic material has to confirm with lining and accessories, as well as appropriate processing technologies should be chosen. As for the smart jacket design, the membrane fabric is provided, which is water impermeable from outside and vapour (sweat) permeable from inside. Lining material should confirm to the system as well; breathable lining material should be chosen. It is appropriate to use lining material that confirms to the first layer of 3-layer system [7], i.e., material that absorbs sweat and eliminates moisture. This layer should provide the key element of wicking to remove moisture away from the skin surface caused by perspiration. Synthetic materials (for example, polyester or/and polypropylene) are good for this purpose as rather than holding water like cotton, they move moisture away from the skin [8].

To provide better sweat vapour conducting it is advisable to sew in lining insets from lightweight net fabric for ventilation in intensive sweating zones [9]. For the smart garment that monitors temperature and humidity, in places where sensors are located, net fabric is sewn in the lining layer for better microclimate data detection.

IV. Electronic Components and System for Microclimate Monitoring Jacket

In order to optimise weight distribution and decrease risk of injuries, the electronic system is divided into two main functional parts and placed on both sleeves. One part contains the battery and all the parts are needed to feed the



a. b.

Fig.2. Reattachable electronic block placed in the pocket of jacket sleeve: a – PCB; b – PCB attached in a pocket

system and charging the battery. It also contains the main switch for turning the system on/off and a standard mini-USB socket for charging the battery from a +5V source. The board is dimensioned so that it can be placed alongside the battery, and space for additional mechanical protection (embroidered 3D spongy traces) is provided. The conductive traces for connecting this power supply module to the textile structures are embroidered, and the plate is then sewn to these embroidered traces. PCB size is 30x23mm and it is shown in Fig. 2; the PCB design is shown in Fig.2.a, and the pocket block with the attached PCB is illustrated in Fig.2.b.

On the other hand, all the logic and control elements are placed in the pocket on another sleeve. The board contains a programmable microcontroller, wireless communication module and additional elements needed to control circuitry. The board has contact pads, which can be sewn to textile structures in order to provide a PCB-textile connection interface.

Other elements include a temperature sensor, placed in the back, which senses the temperature inside the jacket, and two LED panels in the front and the back of the jacket, which can be used both for microclimate monitoring and for safety/decorative purposes.

Mode switching is provided by an embroidered touch sensitive switch placed in the collar – it can be used to switch operational modes of the jacket (stand-by mode, monitoring mode, safety illumination mode).

V. Designing of PCB

Several attempts have been made to produce the PCBs for the improved jacket version. The system has been divided into two boards for ergonomic purposes. This has allowed power supply electronics and the battery itself to reside on one side and the logic part – on the other. Besides, it has balanced the load exerted by the weight of electronic components on the jacket. Another improvement –optimization of the routing of power traces between various components of the system.

First of all, heat transfer method has been applied to a flexible PCB substrate, which turned out to be unsuccessful because of the inherent low precision of the method and small trace sizes of the PCB. Afterwards, the most common optical method has been used, yielding much more satisfactory result. First, a pattern has ben made on a transparent foil, used to block UV light during exposure of a PCB substrate with photosensitive coating.

Sprayable photoresist has been used first, which has been rather hard to handle, because it has been difficult to ensure an even layer on a flexible PCB substrate. Film-like photoresist coatings and pre-coated substrates have yielded much better results, since the coating has been even. It has ensured better development after exposure and even etching of the board. Some of the results are provided in Figures 3, 4 and 5.

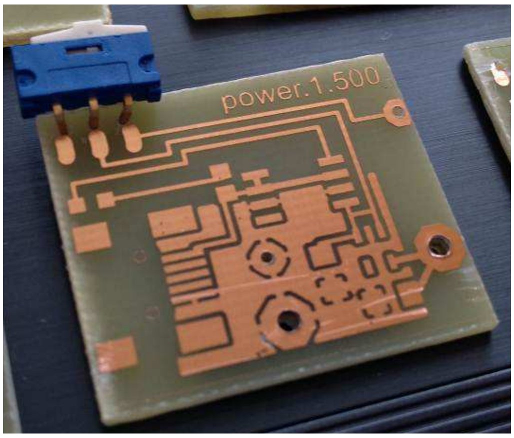


Fig. 3. Power supply PCB

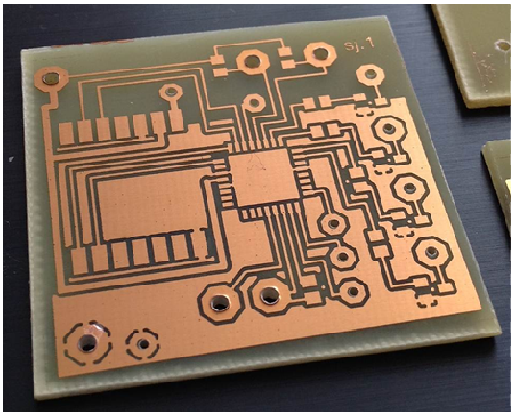


Fig. 4. Jacket logic unit PCB

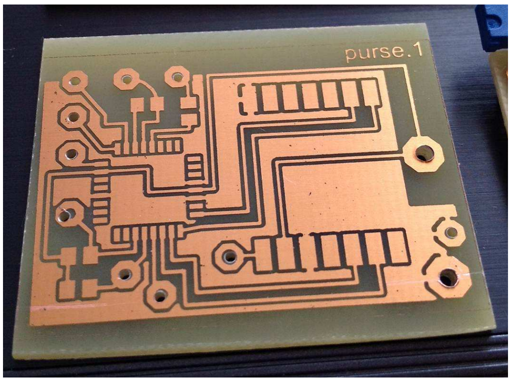


Fig. 5. Purse logic unit PCB

VI. Conclusions

When designing smart garments, it is important to ensure operating efficiency of the system, as well as comfort while wearing. Both suitability of the jacket basic fabric and specific properties of garment construction for comfortable fit have been considered in the description of the modified jacket prototype. Jacket electronic system has been improved – it has been reduced in size and divided into several modules in order to balance weight distribution. It is important to test a new system in real operating conditions; special attention should be paid to conductive thread seam contacts and their behaviour over time and under influence of different conditions. Isolation of contacts is one of the topics for the future study, as well.

VII. Summary

Smart and interactive clothing provides additional functional properties, which can be used in different areas – sports, medicine, entertainment, etc. Smart or interactive clothing often functions with integrated electronics, and, as a result, garment can respond in an adaptive way to external stimuli, process them and produce new signals such as light, sound, vibration, etc.

This article describes the improved version of jacket with some modifications for advancement of the jacket design and comfort conditions. The arrangement of electronic components is optimized, considering inner and outer strain zones for clothing and body. Two largest blocks of electronic system are placed in the pockets on both sleeves. Some connections are made using conductive threads, thereby reducing rigidness of the electronic system. In separate parts of jacket textile communication layers or bands are provided, where conductive seam connections are sewn.

To make signalizing with the light output interface more effective, the POF display is replaced with flexible textile LED matrix display. It is brighter and it makes it possible to add some interactive functions to the jacket (different graphic image representation). Small LED display is located in the back of the jacket, as well.

It is appropriate to use membrane fabric as basic textile material for the jacket – it is waterproof/breathable material, so it would work as a protective shell for electronics, as well as it ensures hygienic conditions for the human body.

Design of electronic components is optimized as well – individual circuit boards are designed for power supply module and for logic and control system.

Acknowledgment

This research has been supported by the European Social Fund within the project “Establishment of interdisciplinary research groups for new functional properties of smart textiles development and integrating in innovative products”, No. 2009/0198/1DP/1.1.1.2.0./09/APIA/VIAA/148.

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References

[1] X. Tao (ed.). Wearable Electronics and Photonics. Woodhead publishing, 2005.

[2] G.Cho (ed.). Smart Clothing: Technology and Applications. Taylor and Francis Group, LLC, 2010

[3] I. Parkova, A. Vališevskis, I. Ziemele, A. Viļumsone. Integration of optical fibers into textile products. Journal “Advanced Materials Research, 2011, Vol. 222, p 162-165.

[4] Aizsargapģērbs motobraucējiem profesionāļiem — Jakas, bikses un viengabala vai dalītie uzvalki — 1.daļa: Vispārīgās prasības. Standarts LVS EN 13595-1 : 2002

[5] R. M. Laing, J. Webster. Stitches and seams. Manchester: The Textile Institute, 1992. 96 p.

[6] J. Prabir. Assembling technologies for functional garments – an overview. Indian Journal of Fibre & textile research. Vol. 36, December 11. [Tiešsaite]. Pieejams: http://nopr.niscair.res.in/bitstream/123456789/13232/1/IJFTR%2036%284%29%20380-387.pdf

[7] The 3 Layer Clothing System [Tiešsaite]. Pieejams: http://www.baselayer.co.uk/introduction-to-layering.php

[8] Gear Guide: Outdoor Clothing Layers. [Tiešsaite]. Pieejams: http://www.headtothehills.co.uk/articles/90-gear-guide-outdoor-clothing.html

[9] A. Das, R. Alagirusamy. Science in clothing comfort. Woodhead Publ., Cambridge, 2010, 250 pp

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Inese Parkova, Aleksandrs Vališevskis, Ausma Viļumsone. Mikroklimatu uzraugošās jakas modifikācija.
Viedais un interaktīvais apģērbs piedod apģērbam papildus funkcionālās īpašības, ko var izmantot dažādās jomās – sporta, medicīnas, izklaides u.c. nozarēs. Bieži vien viedais vai interaktīvais apģērbs funkcionē ar iestrādātās elektronikas palīdzību, kā rezultātā apģērbs adaptīvi reaģē uz ārējiem stimuliem, apstrādā tos un izvada kā jaunus signālus.
Rakstā tiek aprakstītas mikroklimatu uzraugošās jakas modifikācijas prototipa dizaina un komfortu nosacījumu uzlabošanai. Optimizēts elektronikas daļas izvietojums, ņemot vērā ārējās un iekšējās spriedzes iedarbību uz apģērbu un ķermeni. Sistēmas divi lielākie bloki izvietoti kabatās uz piedurknes. Daļa savienojumu izpildīti ar elektrovadošajiem pavedieniem, tādejādi samazinot sistēmas stīvumu. Atsevišķās jakas daļās paredzētas tekstila starpkārtas vai joslas, uz kurām nošūti elektrovadošo diegu savienojumi.
Lai padarītu jakas displeju spilgtāku un efektīgāku signalizatoru, optisko šķiedru displejs aizstāts ar tekstila gaismu izstarojošo diožu (LED) matrices displeju. Neliels LED displejs atrodas arī mugurdaļā.
Kā tekstila pamatmateriālu ir lietderīgi izmantot membrāndrānu - ūdeni necaurlaidīgu / gaisa caurlaidīgu materiālu, kas kalpo gan kā aizsargājošs karkass elektronikai, kas pasargā sistēmas elementus no nevēlamā kontakta ar ārējiem vides mitruma apstākļiem (lietus, sniegs), kā arī nodrošinā higiēniskus apstākļus cilvēka ķermenim.
Optimizēts arī elektronikas daļas dizains – projektētas individuālas plates barošanas mezglam un loģikas mezglam. Veikti eksperimenti plašu kodināšanā, izmantojot dažādas metodes un materiālus.

Инесе Паркова, Александр Валишевский, Аусма Вилюмсоне. **Модификация куртки, регулирующей микроклимат**.
Умная и интерактивная одежда имеет дополнительные функциональные свойства, которые делают ее подходящей для разных областей - спорт, медицина, развлечения и т.д. Умная или интерактивная одежда часто работает со встроенной электроникой, и как следствие, одежда может адаптивно реагировать на внешние стимулы, обрабатывать их и выводить как новый сигнал.
В статье рассматривается улучшенный вариант куртки с некоторыми модификациями для улучшения дизайна прототипа и условий комфорта. Размещение электронной части оптимизировано с учетом внутреннего и внешнего напряжения на одежду и тело. Два крупнейших блока системы помещены в карманы на обоих рукавах.
Частично соединения выполнены с использованием электропроводящих нитей, тем самым снижая жесткость системы. В отдельных частях прототипа предусмотрены текстильные прослойки или полосы для контактных швов из электропроводных нитей. Для более эффективного отображения дисплей из оптических волокон (POF) заменен эластичным текстильным светодиодным (LED) матричным дисплеем. Он ярче, и это дает возможность добавять прототипу некоторые интерактивные функции (различные графические изображения). Небольшой светодиодный дисплей также расположен в задней части прототипа.
Целесообразно использовать мембрановые ткани как основной текстильный материал для прототипа - это водонепроницаемый / паропроницаемый материал, поэтому он будет функционировать в качестве защитной оболочки для защиты компонентов электронной системы от нежелательного контакта с влагой окружающей среды (дождь, снег), а также он обеспечивает гигиенические условия для организма. Оптимизировано также проектирование электронной части - для модуля питания и модуля логики и системы управления предназначены отдельные индивидуально разработаные платы.