

A USER CENTERED DESIGN METHODOLOGY FOR FUNCTIONAL AND SMART GARMENTS

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ABSTRACT

Bioswim[®] is a multidisciplinary project that is developing a wireless full-body monitored swimsuit with the aim of increasing swimmer performance. The different points of view of the multiple working groups brought to the project a different vision that expanded the primary aim of the project to a universal level where the application of the instrumented suit for other objectives could be a real fact.

Given that most research user-centred methodologies, although straying from the user needs, are in the end actually focused on the final design product, a different approach to the problem had to be found by the working group: to have the user's input as a significant and central part of the project. Within the project, a new methodology - the User Centered Layered Methodology (UCLM), was designed, implemented and tested.

KEYWORDS: *Design Methodology, Functional Garment Design, Rehabilitation, Swimming, Smart Clothes.*

1. INTRODUCTION

Design is a multifaceted discipline that agglutinates knowledge from different scientific areas and combines it by the user and consumer's point of view. The possibility of inclusion of the widest possible community into a design project is a greater accomplishment for the designer as well as being a basic and very important principle of inclusive design.

In sports and in rehabilitation, the capability to gather realtime information on body limits is a fundamental tool that allows achieving better and credible results that are fundamental to planning subject training, with a specific benefit on body movement performance, specially if recovering from injuries suffered in accidents, to improve strength for elderly people or as a therapy for neurology disease. The permanent updated monitoring of biomedical and biomechanical variables enables the trainer to explore all body potential being aware of the limits of the final user, avoiding injury and excessive movements.

The use of a specific methodology in order to achieve the best result in terms of object study and maximize the overall satisfaction of the final users require the application of a specific methodology that have to be adapted to the unambiguous user requirements. The method applied to the project has to be developed inside the research group to assure a real user's centred methodology.

2. RESEARCH GOALS

The work described in this paper is part of a project that intends to provide an extensive set of tools for swimming performance evaluation and optimization, involving several biometric signals and biomechanical parameters, with the purpose not only of improving the athlete's performance, but also for rehabilitation.

However, other applications from different scientific areas are readily derived from the developed product and could be applied with different results. Non-professional sports, rehabilitation, injury recovery, physiotherapy, older people movement and muscle enhancement are some of the possible targets of the sensorised bodysuit.

3. STATE OF THE ART

The design of garments that for some reason could be defined as smart garments or a technical garment specially devoted to a specific use or for a specific environment, has to take into account a proper design methodology often adapted on a case by case basis. The process involves the definition of a series of parameters and requirements specifically centred on the task the garment will be used to carry out and focused on the needs of the final user, ensuring an adequate performance during a specific period of time.

In functional and smart garment design, as can be considered the bodysuit produced along the project development, even if all the aspects of product design are present and taken into consideration, the proportion of the technical requirements and functional aspects of the garments are considerably superior and significant than the remaining ones.

Different approaches to functional and smart garments have been used in the last years. The defined "critical path" proposed by Jane McCann (McCann 2005) is a path that considers to operate the appropriate technology in order to give response to the users' needs, but the focus on end users in terms of co-design and user cooperation is less significant. The end user is not an actor in the development process. The new methodology proposed here is exactly the opposite: the end user takes part of the research group and participates in the different stages of the project development. On the other hand, the theoretical formulation described in Ariyatun's work (Ariyatun 2005), proposes the following core issue trilogy: 1. user requirements, 2. electronics and 3. clothing. The analysis puts more focus on the methodology system than on the user.

A layering system methodology in terms of garment usage and not as a conceptual methodology was mentioned by McCann (McCann 2005c) as a method used to identify the needs of the end users since the post-war to the present days.

METHODOLOGY

Since the beginning, the adoption of existing design methodologies specifically elaborated for the design of functional and smart garments were followed, being a valuable starting point, but requiring further development.

In fact, at that moment, the working group realized that the methodology needed to be developed from the users' point of view concept, but also taking into account action and reactions of the user to the product during the design development progress. To do that, the user has to be the central part of the entire process, acting and interacting with the object and with the research group. The duality form/function continues to be the basis for the project methodology development and a technical and theoretical horizontal relationship was created between the different items of this duality. Without spreading cultural and aesthetics needs from desired functions of the body and the users' activity, the renewed vision of the working group was that of dividing the garment into different (conceptual, not physical) layers, starting from the body towards the outside.

The present methodology, for smart and performance wear, is based on a new conceptual layered system - the UCLM. The aim of the UCLM methodology is to take into account the different levels of the user's needs whilst helping to organize and plan the different tasks of the working group, in order to achieve the best result for the final user, no matter the kind of user, and always in a user centred perspective.

Level one, and the most basic, considers the textile substrate used to make the suit in terms of textile material and its properties; level two considers the way the bodysuit will be made, making considerations about the form and the way the textile compresses the inner body and structures the body mass and the muscle position during training and exercise; level three considers the application level of sensors and external links to the bodysuit to be implemented and included for body parameter supervision; level four considers the construction and inclusion of the smart system to the bodysuit; level five considers the technique and method used for garment design and construction.



Figure 1: Conceptual Model for User Centered Layered Methodology (UCLM)

The User Centred Layered Methodology (UCLM, figure 1) has been designed in order to satisfy the needs of the final user and at the same time to plan and organize the working group developing methodology. The methodology takes into account the main characteristics of smart clothes and performance and considers them as a different and separated conceptual levels in order to be managed in an organize manner during the entire design, development and prototyping phase project.

The conceptual levels proposed in this paper may or may not correspond to physical levels. The methodology can be adapted to different kinds of projects and different project complexity. The different conceptual levels proposed by the UCLM Methodology will be always considered during the design project, no matter the intensity and difficulty of the presence of each physical level in the final product or its relation with the final user.

Level 1_ Textile Substrate: The “Comfort” parameter is a central item on user garment evaluation and be it physical or/and psychological comfort, it is constantly absent from the functional and smart design methodologies, and undoubtedly very important on user choice and performance.

Level 2_ Suit Body Fit: This level could be used for a simple body textile covering garment layer where compression is not important or as a very body structuring instrument were body compression in necessary. Body compression has a direct influence on body muscular performance and fatigue recovery.

Level 3_ Definitive Textile Sensors Integration: The research team had to deep integrate sensors into textile substrate and not to apply them as a supplement or/and accessory. Conductive yarns have been used to produce textile sensors, with a special adherence to the skin and reduced impedance.

Level 4_ The “Smart” System: A “smart” system is applied to the bodysuit for a specific biomedical and biomechanical data gathering and analysis. Textile and conventional sensors are part of the smart system and applied directly into the fabric knit substrate after its production.

Level 5_ Suit Construction: The suit construction is a central point of the garment design. From its shape to the way it is assembled, every specific detail has to be taken into consideration and evaluation.

4. STATE OF DEVELOPMENT AND DISCUSSION

The bodysuit prototype is still in a changing and improvement phase. Previous not completed prototypes have been made to test different items on different layers of the suit. Each part composing the body suit have been tested separately by the working group with the end users, adapted and modified before integration to other parts.

On level 1 the achievements on textile substrate were tested with the end users, in different phases, with different materials and with different structures.

Placed on level 2, body compression is closely related to textile substrate properties and construction as well as the end users’ needs and physical properties. Tests demonstrated that swimsuit compression is a mix of textile fibre characteristics, combined with weft knit structure, yarn tension and knit loop length.

On conceptual level 3, textile sensors have been included in the textile substrate very efficiently. Inserted inside the knit substrate as a jacquard design the textile sensors demonstrated to work very well both in dry as well as in wet conditions. Non-textile sensors, such as a thermistor for tympanic temperature measurement, Force Sensitive Resistor Films for palm pressure measurement, piezoelectric film for breast movement detection and accelerometers are integrated into the bodysuit by specifically designed support.

Level 4 was assigned to the smart system that will connect together the sensors. The system is arranged as a network of independent sensor nodes, communicating wirelessly to a central controller that transmits the data to the central processing station implemented on a PC. The whole system has to be waterproof.

The synthesis of all levels will be made at level 5 which will interact with all the others, being responsible for the garment assembly. Textile substrate and fibre use, knit structure and sensor application, as well as body muscle compression and modification, smart system application and insulation will be just some of the aspects that directly interfere with garment construction and its design.

The successfully implemented User Centered Layered Methodology (UCLM) revealed all its potential during the project development and assured a specific and objective development of all phases of the project, facilitating the communication between the multidisciplinary research group, ideas exchange and new solutions approaches, always focusing into a User Centered Layered Methodology.

5. CONCLUSION

The tested methodology used during the project development revealed itself very useful and important, giving good results in terms of workgroup methodology and end user product results. The need to test every component of the bodysuit at each time was successfully adopted and the natural option of a real inclusion of the end users into the project gives the best results. The layered methodology developed by the working group having the end user as a central item during all the research phases and taking into account physical and psychological comfort revealed itself a valuable tool that improved results from the beginning, giving to the work team special motivation and specially was responsible for a growing self security and well being of the end users. The working group has learned a lot from the project in terms of group integration and collaborative design. However a better textile substrate integration was desired. A growing series of ideas and possibilities are being taken into account for later development.

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