3D CAD METHOD FOR SMART GARMENTS FIT PREDICTION

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ABSTRACT

In the scope of textile products categorized as "smart wearables," the perfect fit to the user's body is of central importance. The adjustment provides means for the full operation of the electronic system integrated with clothing. The main objective of this paper is to present the methodological path that constituted the redesign of the flat patterns of a smart t-shirt for vital monitoring, by comparing the process and benefits between a traditional method and 3d-2d Cad process to build the basic pattern blocks.

Key Words: flattening, cartesian, garment design, sensors, smart wearable.

1. INTRODUCTION

The fit is considered an objective element among the issues that guide the development of clothing products [1], [2]. Its performance conditions, the relationship between clothing and the anatomy of the user's body, as well as the ergonomic efficiency of the system: product/user/activity [3], [4]. In the scope of textile products categorized as "smart wearables", the perfect fit to the user's body is of central importance [5]. The correct position of the sensors, at specific points along the user's body, is fundamental for the monitorization process to be performed as expected [6]. Thus, the good fit provides means for the full operation of the electronic system integrated with clothing.

Flat pattern design by the cartesian method is the technique most commonly used in the industry. It is characterized by the translation of body volumes and fashion design into two-dimensional drawings [1], [2], [7]. It is performed through geometrical methodological procedures and guided by tables of anatomical measurements [1], [2], [7]. Although it is related to precision, the flat pattern design is subject to distortions, impacting the desired aesthetics and functional effects [8].

The use of technological tools, such as three-dimensional digitization promoted by 3D body scanners and virtual prototyping enabled by 3D CAD software, support advances in efficiency and effectiveness in the development and validation of clothing projects [3], [8], [9]. These tools are a complementary alternative to traditional pattern design methodologies, by adding new possibilities.

Therefore, the primary objective of this paper is to present the methodological path that constituted the redesign of the flat patterns of a smart t-shirt for vital monitoring. This is an initial step for design of smart wearables. The new design had as guidelines the expansion of efficiency in fit and ergonomic-functional capacity of clothing, as well as the improvement of contact and stabilization of the shirt on the users body. It aims to create a better performance environment for electronic monitoring.

2. METHODS

The research procedure of this study was within the exploratory field of qualitative character. The techniques adopted were a direct documentary research with a bibliographical survey, and an experimental research, with direct documentation of the data obtained from the development of basic pattern design blocks through two different methodologies. The first was the Cartesian method to knitted fabric, providing flat patterns through bidimensional drawings. The second was the flattening method, that made the flat pattern by 3D extraction from the 3D virtual body surface. This study aims to compare these work procedures. Furthermore, it aims to compare the fit and performance of each prototype, in an individual context, while complying with a more ergonomic and stable clothing on the user body.

3. RESULTS AND DISCUSSION

In order to achieve the best fit, stability, and comfort of smart clothes for vital monitoring, it is necessary to consider the anthropometric characteristics and body shapes in the static and dynamics positions [10].

The use of 3D scanners and computer applications allow obtaining a very accurate 3D body model in static and dynamic postures [11]. An essential advantage of this technology is the possibility of analyzing the shape and determining the dimensions of lengths, girths and body volumes [8].

The investigation was divided in two steps to compare the efficiency between both methods. The first step was the construction of flat patterns of the long-sleeved raglan-style, in which observations about the process were pointed out. The second step was the virtual prototypes try-on tests, considering fit, textile contact, and the t-shirt stability on the body model.

3.1. Flat patterns drawing

3.1.1 Cartesian Method

The flat pattern 01 was done by the cartesian diagram process that translates the real measurements of the body in two dimensional drawings. The final drawings considered the fabric elasticity. The design of the flat patterns is not difficult; however, it requires high abstraction capacity concerning volumes and looseness requirements for a good ergonomic result. Figure 1 shows the final drawings.

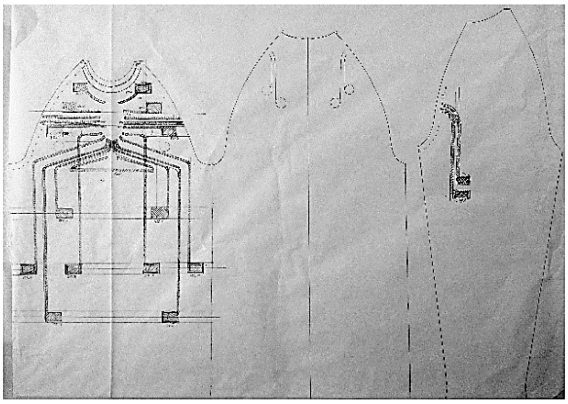


Figure 1. Cartesian method – Pattern 01

3.1.2 Flattening method

Pattern 02 was developed using the flattening method available in 2d-3d Cad software, *Clo 3d*. This method is entirely digital. The tool principle states that “a flattenable mesh surface is a polygonal mesh surface that can be unfolded into a planar patch without stretching any polygon” [12].

The software allows the study of patterns directly on digital scanned models or customizable avatars. This study used the customizable avatars due to the ease of adjustment in dynamic postures. The construction of the t-shirt pattersn by the flattening method was done with the delimitation of lines directly over the body model. These lines represent the edges of the flat patterns, and them, the 3d surface is converted into 2d. This process was repeated in two different body postures. We have examined the differences in the areas of individual patterns. However, we have found differences in the armpit pattern areas. The results served as a reference for the design of the definitive blocks. The coefficient of elasticity was applied in the final version of the flat patterns. Figure 1 shows the process.

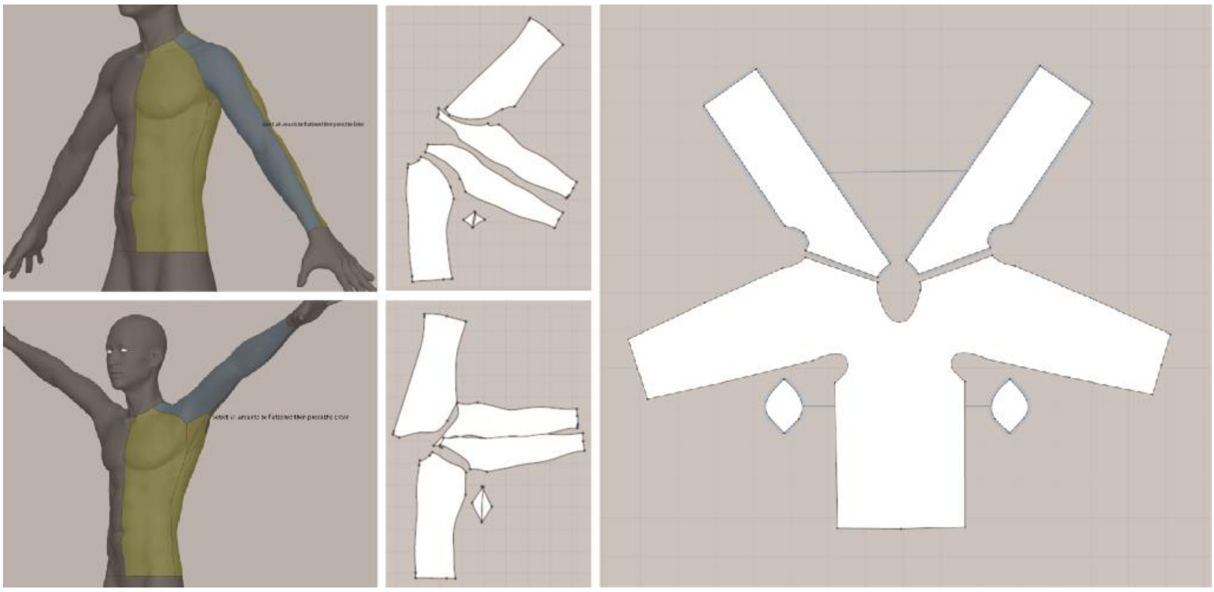


Figure 2. Flattening method process – pattern 02

3.2 Try-on test

The 3D Cad software enables the try-on prototype tests in dynamic postures. The available avatar was customized according to the user’s body measurements, and three body positions were programmed. Being: Position 01 - body at rest; Position 02 - arms open; Position 03 - right arm raised keeping the left arm open. Additionally, knit data was used to parameterize the virtual fabric. Table 1 shows the body positions used.

The test subjected the prototypes to the three positions, and then, returned to position 01. Table 2 shows the comparison of prototypes before and after the body movements.

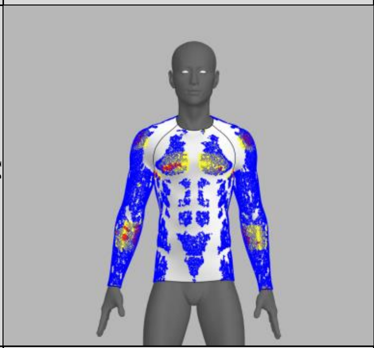
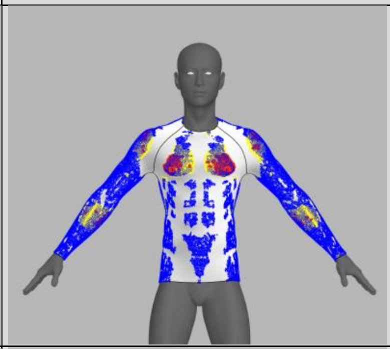
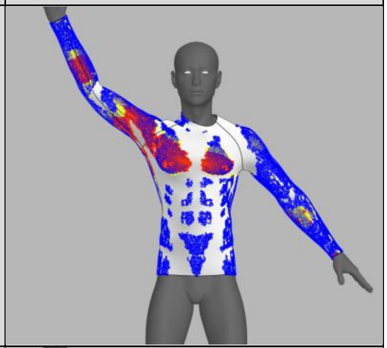
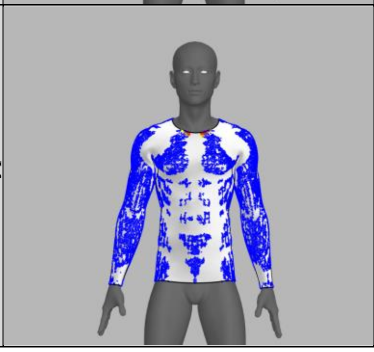
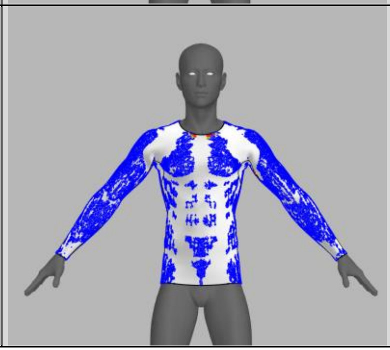
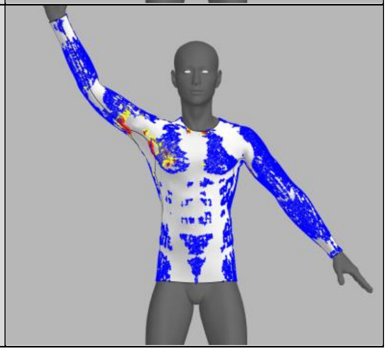
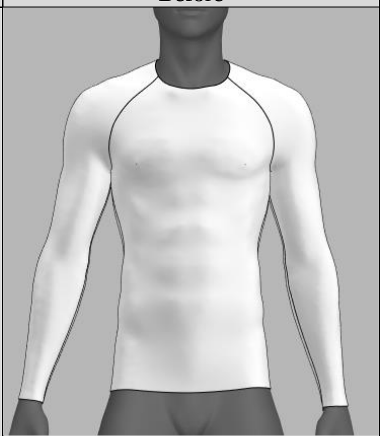
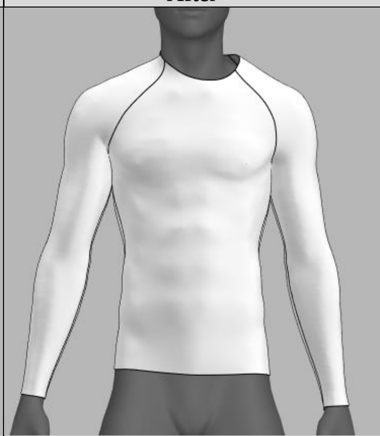
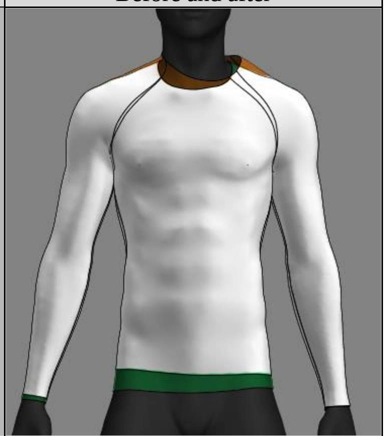
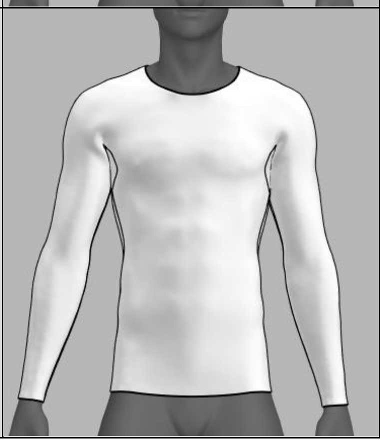
T	Position 01	Position 02	Position 03
Prototype 01			
Prototype 02			

Table 2. Comparison of prototypes before and after the body movements

	Before	After	Before and after
Pattern 01			
Pattern 02			

In pattern 01, there were problems in the sizing of the chest, adjustment in the sleeves and lack of looseness in the cell for movement of arms. It was not possible to predict the mistakes in the two-dimensional drawings; they were only identified during the prototype’s assembly.

Also in pattern 01, when we compare fit, before and after the body movements, it is possible to notice the displacement of the t-shirt bar, indicating the low stability of the t-shirt to the body movements.

In pattern 02, the pattern design process allowed the analysis and corrections of mistakes and potentialities during pattern development, because the software provides a fit evaluation in real time. The use of this process requires prior knowledge of the software operation, which can be difficult initially. Though, this process made it possible to analyze combined patterns without the need for proportional calculations or manipulation as in the Cartesian method. Figure 2 shows both real prototypes.

	
Real prototype 01	Real prototype 02

Figure 2. Real prototype 01, and 02.

The process used was positive, as it presented better results when compared to the previous traditional design process. As well, it favored the vision of new approaches to solving problems related to fit.

4. CONCLUSIONS

This study compared the performance of two prototypes for a smart t-shirt for vital monitoring. Two different methods to design the patterns were used. The first one created by the cartesian method of developing flat patterns for knitted fabrics. The second based on the flattening of body volumes surfaces in different body positions. It was used the flatten tool of *Clo 3D* software, which translated the 3D human body model surface into 2D patterns pieces. The purpose of this study was to compare the methods concerning efficiency in fit, stability, and contact of the fabric to the user's body.

The two methods resulted in prototypes of different designs. Virtual assays tested the prototypes in three body postures, comparing the behavior of each prototype.

The cartesian method resulted in a design with dimensional errors in the armhole, collar, and sleeves. This method also presented stability issues. The t-shirt displaced with body movements, which can compromise the sensors positions.

The flattening method allowed the broad understanding of the ergonomic needs of the project. It worked as a starting point for the creation of tight-fit clothing, which is necessary to achieve high demand functionality and precision. The extraction of the flat patterns in dynamic postures helped to understand the looseness requirement (ease values) for the user's movement. This process has resulted in a more stable prototype to the body, even in motion.

Finally, the flattening method presented positive results to develop ergonomic tight clothing and a high potential to build bases of smart wearable textile products.

Acknowledgement

This work is financed by Project “Deus ex Machina”, NORTE-01-0145-FEDER-000026, funded by CCDRN, through Sistema de Apoio à Investigação Cientifica e Tecnológica (Projetos Estruturados I&D&I) of Programa Operacional Regional do Norte, from Portugal 2020.

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