IMPLEMENTATION OF 3D CAD PROGRAMS IN THE GARMENT CONSTRUCTION FOR WHEELCHAIR USERS

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Abstract: *Designing clothes for wheelchair users demands special pattern construction requirements in accordance with their body shape in the sitting position. The main objective of this research consists in implementing 3D CAD technologies in designing trousers for this group of people. In order to do so 3D scanning is used for better understanding the shape and dimensions of the body of a paraplegic person. The animation of a kinematic body model was studied also in order to obtain information about the body shape in certain movements or positions including the sitting one. Further, 3D-to-2D and 2D-to-3D prototyping was used to create a trouser model that can fit to the shape and dimensions of a wheelchair user. 3D virtual simulation was applied to test the applicability of the pattern modifications and a trouser prototype was designed for a wheelchair user.*

Keywords: *wheelchair users, trousers, 3D CAD technologies, 3D-to-2D, 2D-to-3D, 3D virtual simulation.*

Introduction

Over time, the clothing industry has switched from conventional pattern making on paper to the CAD pattern making. The clothing computer design systems can include three integrated parts: 2D pattern design, 3D garment construction and virtual try-on for clothing simulation [1]. With the development of 3D CAD technologies, the idea of designing a garment directly on a 3D body model came as an innovative solution for garment construction for people with certain disabilities.

Paraplegia results from a spinal cord injury (SCI) [2], and it refers to an impairment or loss of motor and/or sensory function in thoracic (T2-T12), lumbar (L1-L5), or sacral (S1-S5) segments of the spinal cord [3]. Wheelchair users represent 1% of European population, nearly eight million people [4]. Regarding the clothing products, disabilities often lead to special functional requirements, which increase the necessity of physical and psychological comfort. One of the most important aspects of comfort for wheelchair users regarding clothing, is the garment fitting. Because of the sitting position, wheelchair users frequently have problems with the garments designed for the lower part of the body. This research is addressed to the 3D development of trousers adapted to the sitting position.

To understand better the shape and dimensions of the body were analysed first all the scanning procedures for the sitting position. For taking body measurements, the scanning method supposes maintaining the person in a fixed position for a short time. It allows taking plan or spatial images of the body in order to be further dimensionally analysed. The collected data can be integrated into a CAD system and the information can be used further in: garment production; designing ergonomic places for workplaces or cars; designing sport products or different devices for disabled people; avatar designing for computer games or virtual garment fitting. The aim of the study was to develop an improved scanning method that could help in obtaining better scan data in the sitting posture for the lower part of the body, gathering more information from the buttocks and pelvis area.

The garment industry is based on 2D patterns for product manufacturing but more recently the 3D design started to get more attention. The process starts with the development of clothing on a 3D body model followed by the flattening procedure of the 3D garment into 2D pattern pieces. 3D garment construction can be used as well for tight-fitting [5] and for loose-fitting garments [6]. With reference to the needs and demands of paraplegic people regarding clothing, 3D body animation, 3D garment construction and simulation programs were used to design a pair of trousers adapted to the sitting position. The 3D body animation was done in order to obtain different positions for the lower part of the body with different bending degrees that can be used in the virtual garment construction. With the purpose of finding an improved solution for the pattern modification, necessary to be applied for obtaining a good fitting of the trousers on the body in a sitting posture, a 3D-to-2D technique was used. The 3D-to-2D technique involves the construction of the garment directly on a virtual body model in the 3D environment and then the 2D pattern pieces are generated by flattening the created regions. The 2D flattened regions were analysed and a basic trouser was modified following the 3D model modifications. 2D-to-3D virtual prototyping involves the 3D simulation of 2D designed patterns. In this

manner, the modified basic trouser in the conventional way was further imported in a 3D simulation program to check the fitting on the body.

1. Experimental

All investigations were carried out at TU Dresden, Institute of Textile Machinery and High Performance Material Technology (ITM), Germany. The 3D scanning procedure was made on three participants, two healthy females, age 25 and 62 and one paraplegic male, age 54. Healthy people were used in the first stages of the study in order to establish the scanning procedure for the sitting position, and to select devices that could help in the scanning process (Figure 1); this was not possible with paraplegic subjects. For the scanning procedure there were used the handheld MHT scanner form *Artec*, and the body scanner zSnapper cart from *Vialux*. The editing of the mesh surfaces of the obtained scanned data was made in Geomagic Studio program from *3D Systems*. After the establishment of the scanning procedure, the scanning of the wheelchair user was possible next (Figure 2). The obtained 3D body model of the scanned wheelchair user (Figure 3) was later analysed in the trouser construction process.

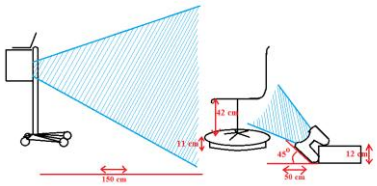

Figure 1: Scheme for scanner positioning in the scanning procedure

Figure 2: Scanning procedure for a wheelchair user

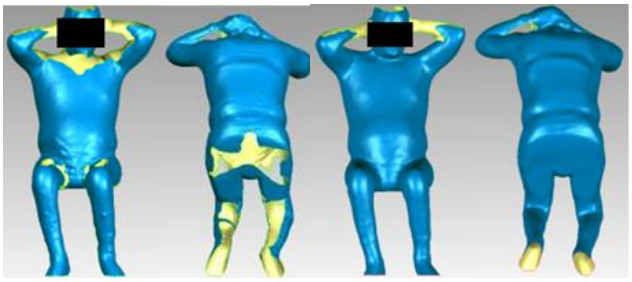

Figure 3: Obtained virtual body model before and after mesh processing

The majority of the CAD systems are using virtual body models with a standard body posture for the pattern design and fit simulation. That is why it was necessary, for the construction of trousers for wheelchair users, to obtain a virtual body model that can adopt different body postures. The virtual body model was obtained in 3dsMAX program (Figure 4) by merging a female scan data size 42 together with a kinematic template [7]. The 3D body animation of the designed kinematic model was done in order to obtain several postures with different bending angles for the lower part of the body (Figure 5). These postures were used further for the 3D design of a tight-fitting trouser using Design Concept from *Lectra*. Analysing the obtained patterns, the posture with a bending degree of 130° in the trunk and knee area was chosen for the final trouser construction (Figure 6). The patterns were flattened and analysed further in the 3D design process (Figure 7).

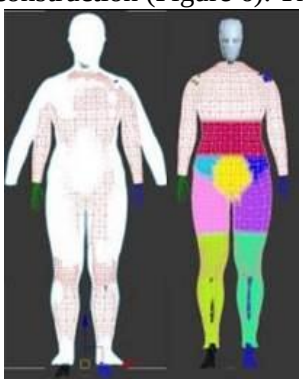

Figure 4: Obtained kinematic body model from a female scan data and template

Figure 5: Obtained positions by animating the kinematicbody model

Figure 6: 3D thight-fitting trouser model

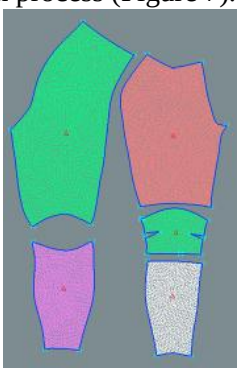

Figure 7: 2D Flattened patterns

The virtual fit simulation was done using ModarisV8R1 program, for the obtained 2D patterns from the 3D-to-2D methodology (Figure 8). Analysing the functional traits of the obtained 2D patterns (Figure 7) for

the bent posture and the result from the virtual simulation, there can be seen that the trousers for this specific posture need a bigger back crotch length to cover properly the back side. In front, the crotch length needs to be shortened to offer a proper fitting for the waist line. The fabric from the back knee area needs to be reduced to avoid the excess of folds that could bother the skin. Also the fabric for the front knee needs more allowance to offer a good comfort in the sitting posture. A 2D basic trouser model was designed following the pattern construction specifications of size 42 women trouser and the fit simulation was done on the same bended position (Figure 9).

Figure 8: Virtual fit simulation of the obtained patterns for the tight-fitting trousers from 3D-to-2D technique

Figure 9: Virtual fit simulation of the basic trouser model

According to the results obtained from the fit simulation, it has been concluded that the basic patterns must be modified in the back area by extending the crotch. The length of the front crotch must be shortened for a proper comfort for the wearer. The problem with the folds from the back knee has to be also solved. The patterns were further modified following the changes from the flattened patterns of the 3D trouser model (Figure 10). To verify the correctness of the modified trouser model it was necessary to make also a virtual fit simulation (Figure 11). Analysing the obtained fit result it can be seen that the new trouser model has now a good fitting for the waist area. The back side is covered and the front waist line has a good position to offer comfort for the bent body position. The small fold that appears in the back waistline can be adjusted with an elastic waist band that, in the simulation process, was not designed. The modification of the pattern in the back knee area reduced the number of fabric folds.

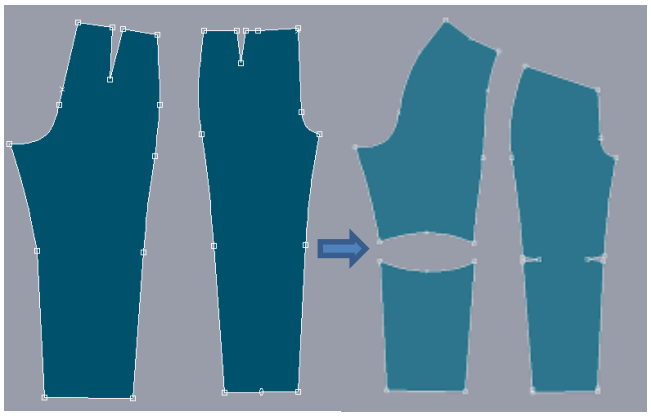

Figure 10: Modification for the basic trouser model

Figure 11: Fit simulation of the modified basic trouser

The final step was to take a basic trouser model for men and to apply the pattern modifications which were made in the case of the women trousers (Figure 12). By comparing the obtained body measurements for the wheelchair user from the scan data for the hip area with the size chart Size Germany of the dimensional specifications for clothing designed for men, a basic trouser model size 52 was created and further modified so that the prototype can be tried-on by the wheelchair-user (Figure 13). After making the necessary

measurements on the body of the wheelchair user, it was concluded that the knee line has to be lowered with 3 cm for a better fitting on the body.

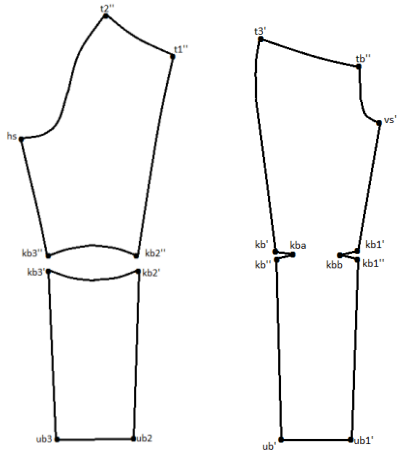

Figure 12: Modified patterns for the men trouser model

Figure 13: Wheelchair-user wearing modified jeans model size 52

Results and conclusions

The main purpose in analysing the 3D design method was to implement the efficiency of 3D CAD programs for the development of functional trousers for wheelchair-users. The 3D-to-2D method proved to be successful in obtaining important information about the dimensional changes a pair of trousers for sitting position should have. Designing the 3D tight-fitting trouser model gave the opportunity to analyse the modifications necessary for the patterns of the basic loose-fitting trouser model. After the modifications of the patterns for the basic trousers, the virtual fit simulation demonstrated that the applied changes improved the fitting of the trousers on the bent posture. With the positive results from the virtual fitting of the modified basic trouser for women, it was necessary further to create a prototype that can be tried by a wheelchair-user. The modifications applied on the trouser model for women proved to be relevant for the men trouser also, with just some small personal notifications from the wheelchair-user, regarding his personal body traits. Evaluating the fitting results from both trouser models, it can be concluded that the pattern modification method is valid to obtain functional trousers for paraplegic people. A further research can be conducted to establish a standard pattern design method to create functional trousers for this group of people, for different body types and sizes.

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