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Abstract

The goal of the study is to expand the new 3D garment creation method which has been developed by our team to cover other morphological targets. This creation process, applied until now to typical human body, shapes can be also used in the case of the atypical posture of the human being. The purpose of this study was to obtain 2D patterns of disabled people, especially for people afflicted with severe scoliosis. In our paper we introduced the pathology of this disease as well as the strong influence of this disability on the garment creation process. We present the method which has been used to capture the 3D shape of the body. Two methods of 3D pattern making are proposed. The first method, using virtual try-on, is an empirical method which uses the knowledge and know-how of pattern makers. The second method is a more rigorous one that shows the feasibility of creating a tailored garment directly on a 3D body shape. This method takes into account the 3D evolution of the body as well as the comfort and well-being of the customer, managed by the values of 3D ease allowance. Finally the result shows that the two methods can be used in different garment industries.

Key words: disabled people, atypical body, garment modelling, 3D virtual garment prototyping, virtual try-on.

system for persons with physical disabilities. These garments should meet the specific demands and functions imposed by the previous needs of persons with physical disabilities (from the ergonomic, biophysical, psychic, aesthetical, comfort/convenient point of view, and from other necessities related to illness or other conditions). The physical disabilities the most difficult to manage in the apparel industry are the severe cases of scoliosis.

Scoliosis is a three-dimensional deformation (in the three planes of space) of all or part of the spine (cervical, thoracic or lumbar) causing twisting of one or more

vertebrae on themselves and causing a distortion of the thorax, abdomen and paravertebral areas (close to the vertebrae) [3].

This deformation is noticeable by clinical examinations from radiographic images made in the frontal and sagittal plane. **Figures 1.a & 1.b** show the evolution of the scoliosis in the sagittal plane, the alignment of the 7th cervical, and the 5th lumbar and femoral head characterizing normal status (**Figure 1.b**). **Figure 1.c** shows the same case of scoliosis in the frontal plane [4].

Introduction

The consequence of an impairment for disabled people may be physical, mental and emotional, intellectual, sensory (vision, hearing, gustatory, olfactory, balance disorder), pervasive developmental disorders, or some combination of these [1, 2]. A disability may be present from birth, or occur during a person's lifetime following accident or disease. The medical community considers that the disability origin can be hereditary (genetically transmitted), congenital (caused by a mother's infection or other disease during pregnancy, embryonic or fetal developmental irregularities, or by injury during or soon after birth), acquired (caused by illness or injury), or of unknown origin. In the case of physical or sensory disabled people, they often need assistance with mobility and generally use devices such as wheelchairs, canes, crutches or artificial limbs to obtain mobility.

Our research project aims at developing a new personalised garment design

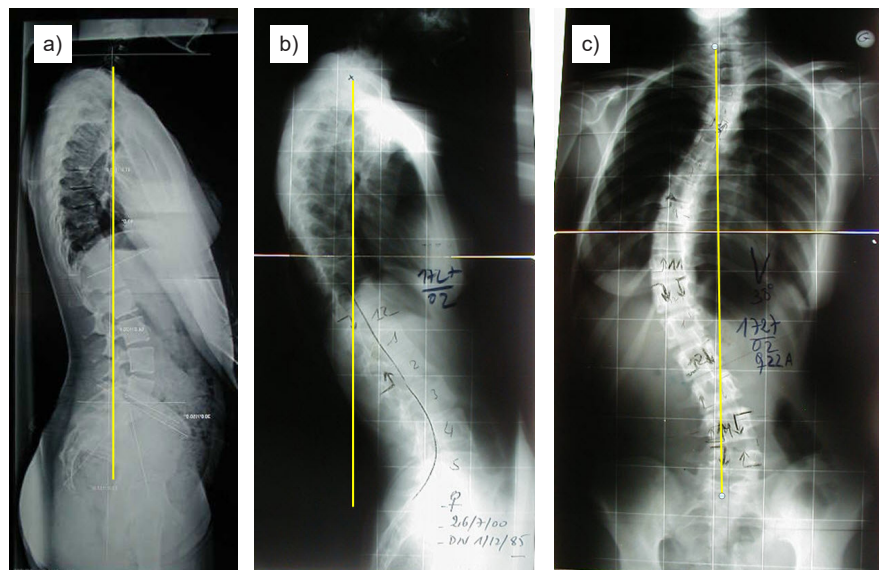


Figure 1. Examples of radiographic images of scoliosis in the sagittal (a, b) and frontal (c) plane.

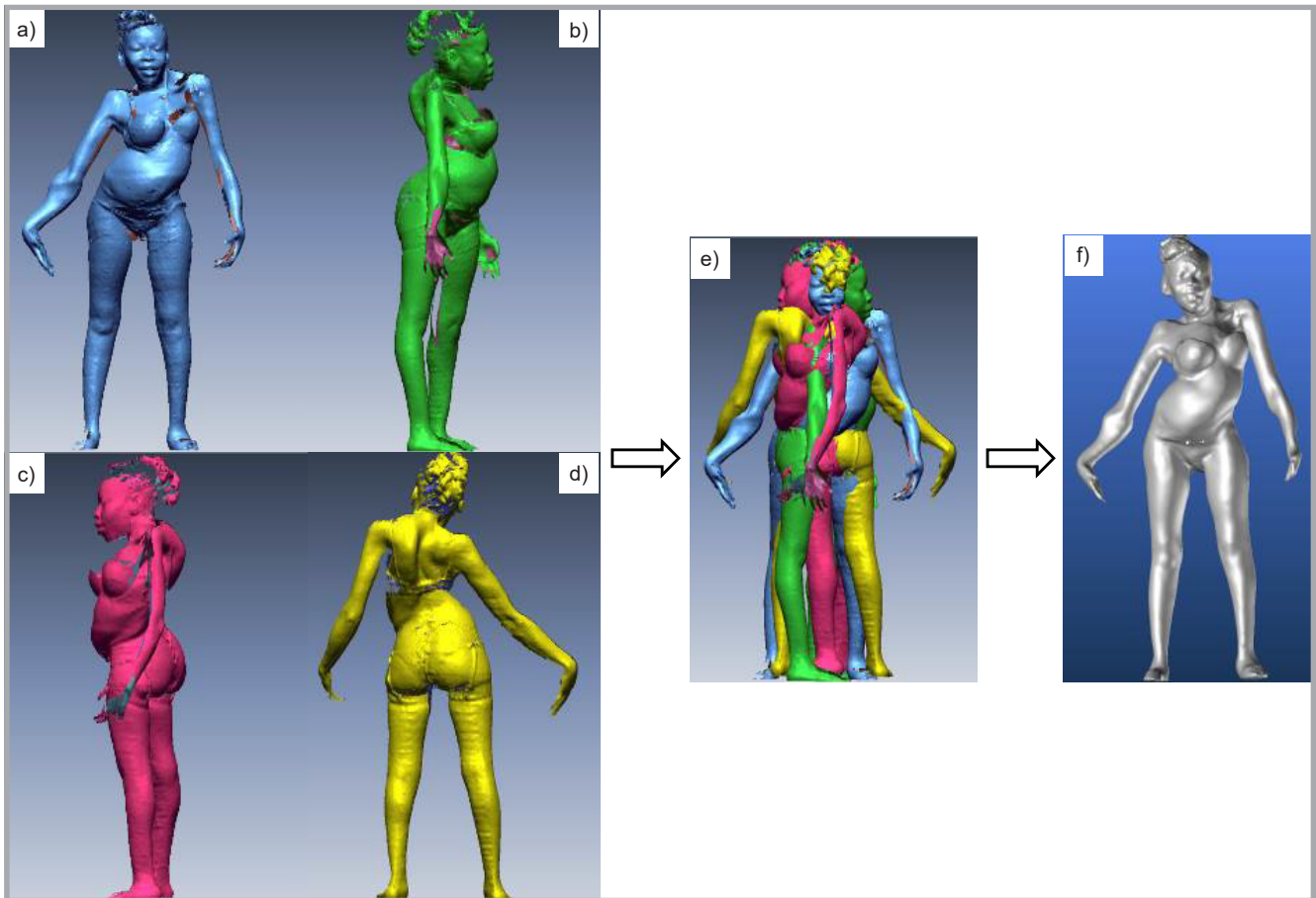


Figure 2. Procedure to measure atypical body by using 3D body scanner(a, b, c, d) and Rapidform software (e, f).

These data modify the garment creation process completely, which so far has been in 2D. 2D pattern making has been developed for traditional shapes, not for a body with a lot of deformations. The anthropometric references are completely different. Also new digital 3D technologies are a unique way to customize a garment for morphologies with physical disabilities.

■ 3D measurements

In the case of atypical shapes, the measuring of the human body in a 3D space is very complex [5]. Many places can be hidden because the standard posture cannot be respected. To remedy this problem, we have realized a procedure containing several steps. Firstly various bodies were scanned with a 3D laser scanner in different shots with the same posture of the person (*Figure 2.a, 2.b, 2.c, 2.d*). Then, using Rapid form software, we were able to realign the different shapes (*Figure 2.e*), rotate them in order to merge them and to obtain one scanned body (*Figure 2.f*).

Direct measurement from traditional software is impossible because the automatic methods have many difficulties in detecting anthropometric landmarks. Consequently this measurement has to be done manually, as in our case. However, using DC3D software we measured it directly on the 3D shape of the body. Moreover we received the results of measurements more precisely using an appropriate feature implemented in the software chosen than in the traditional tape-measurement process, where body dimension identification can be done erroneously.

This first method using virtual try-on is an empirical one which uses the knowledge and know-how of pattern makers [6]. The advantage of 3D virtual try-on is that the adjustment of the garment can be performed in 2D and that the result of the try-on on the body can be seen directly in a 3D space very quickly. But to start the creation process, it is very important to know the size of the customer and, in this precise case, the concept of size is not very appropriate.

Also this method starts with the virtual try-on of different sizes of standard basic

patterns close to that of the customer in order to know the most appropriate sizes for a digital moulding of the garment of the size chosen.

Figure 3 shows that the most close-fitting garment is given by the size 40, whilst the ease allowance value is too small for size 38. The look of the garment shows that in some places there are a lot of folds, whereas in others the fabric is tensed. For example, the value of ease allowance for the chest takes a compression ratio of 288.41 for size 40 and 295.39 for size 38. Another example takes into account the problem of garment balance, meaning the lack of following the body's shapes by the garment in that the bottom lines do not follow an horizontal line. It seems that is not comfortable to wear it as well. In the design of the garment we need to focus on the aspects that are the most important: proper fit, comfort, as well as the best solution of material in the function of changes to the patterns imposed.

The work consists of analysing step by step the different places of the garment during virtual try-on in order to modify the 2D patterns as in the function and

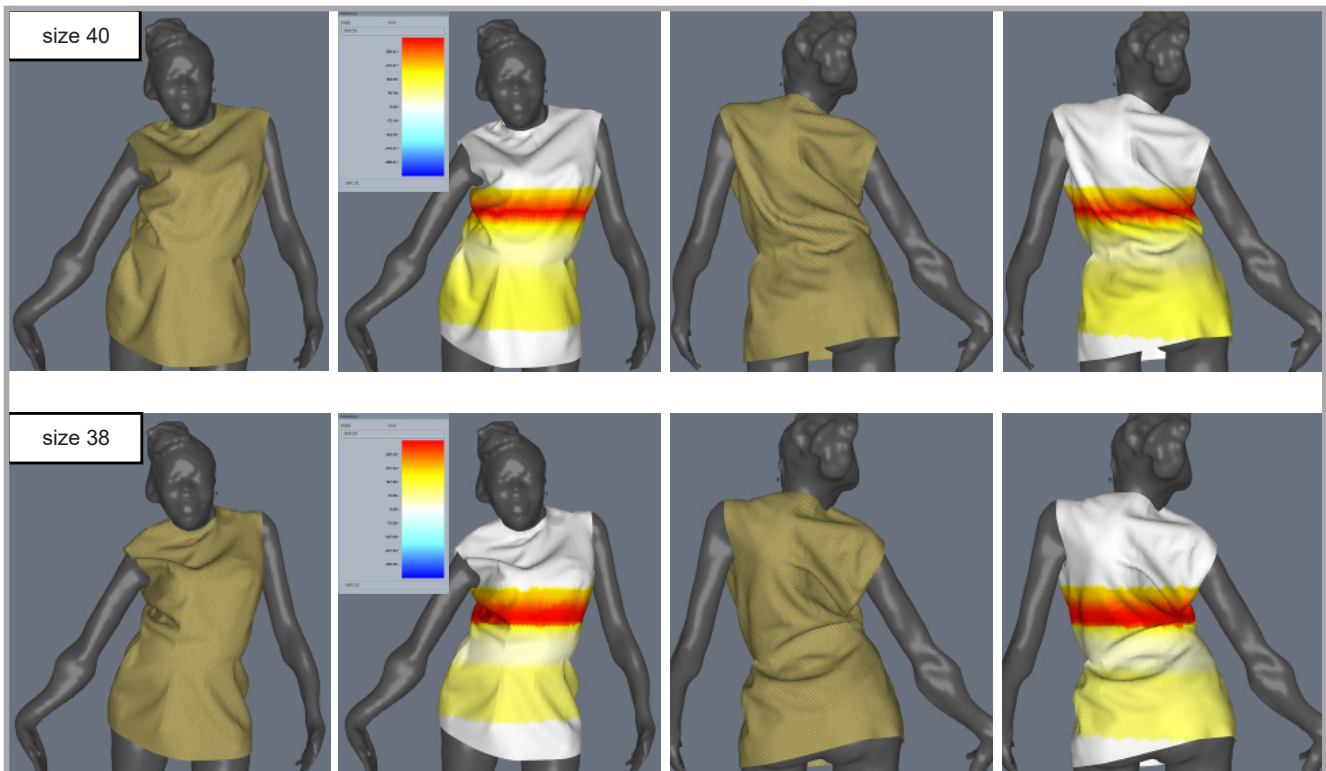


Figure 3. Different basic patterns tested for 38 and 40 size.

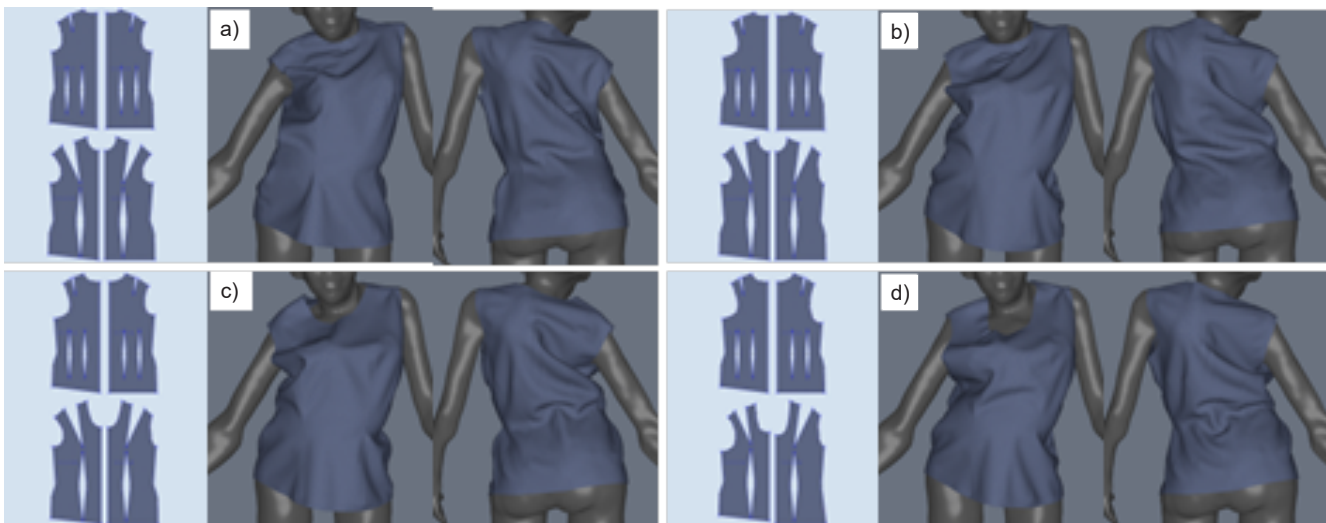


Figure 4. Pattern alteration proces with modifications of front bottom right side (a), armhole (b), neck (c) and front right side (d).

feeling of the pattern makers [7]. Firstly we decided to alter the shape of the patterns in order to follow the body much better (Figure 4). The goal of these first steps are to:

- adjust the bottom right side, realised in the bad direction (Figure 4.a),
- prolong the left armhole line to reduce the shoulder length (Figure 4.b),
- prolong the neck line to give more freedom to move the shoulders (Figure 4.c),
- reduce the right side by moving the shoulder line, armhole line and right

front side, move the armhole line and side line of the right back, prolong the neckline in order to enable the patterns to follow this inclined morphology (Figure 4.d).

Then we needed to identify zones where the garment fit seems to be not aesthetic (a lot of folds focusing attention on the problematic areas and bringing the contradictory effect as an improvement in the beauty of the silhouette). In the next step we need to resolve how to modify darts and decide how many of them we will

need (Figure 5). In this case, the new steps are:

- increase the gap of the two right back darts, and reduce the side dart to remove the excess material in the back (Figure 5.a),
- re-increase the gap of the right back darts and increase the gap of the shoulder dart of the right back to give a better overall position of the garment (Figure 5.b),
- readjust the gap of the right back darts and side dart to add a new dart in the middle back, and prolong the right

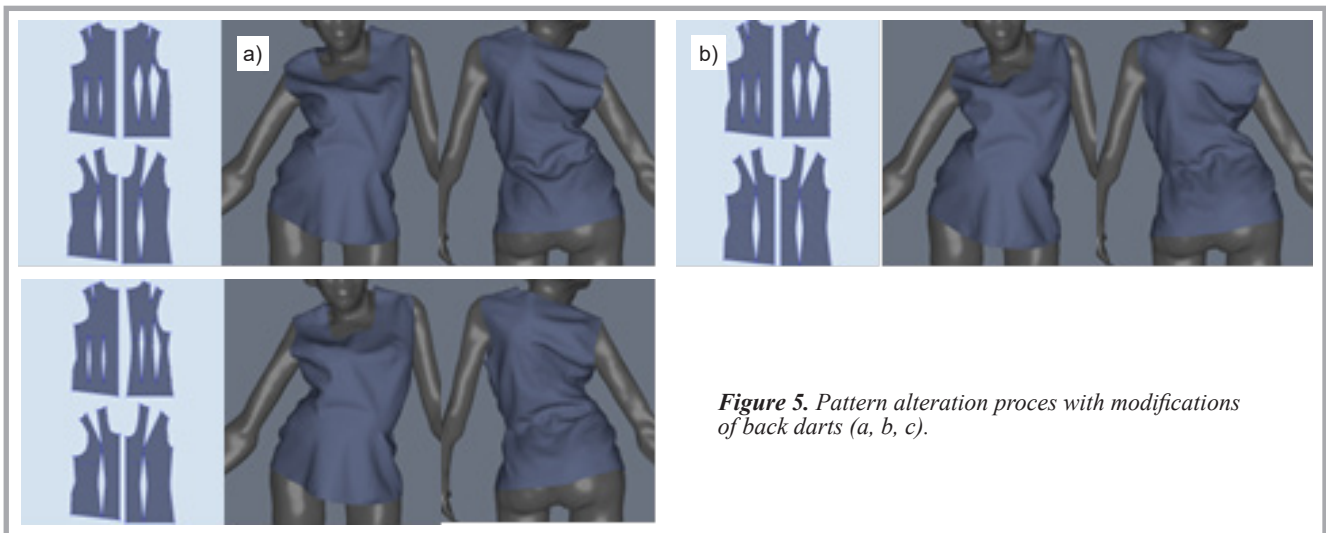


Figure 5. Pattern alteration proces with modifications of back darts (a, b, c).



Figure 6. Pattern alteration proces with modifications of darts (a) and side lines (b).

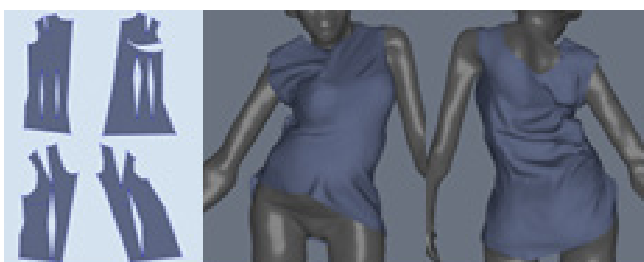


Figure 7. Pattern alteration proces with modifications of front.



Figure 9. Final result of pattern alteration proces and garment simulation.

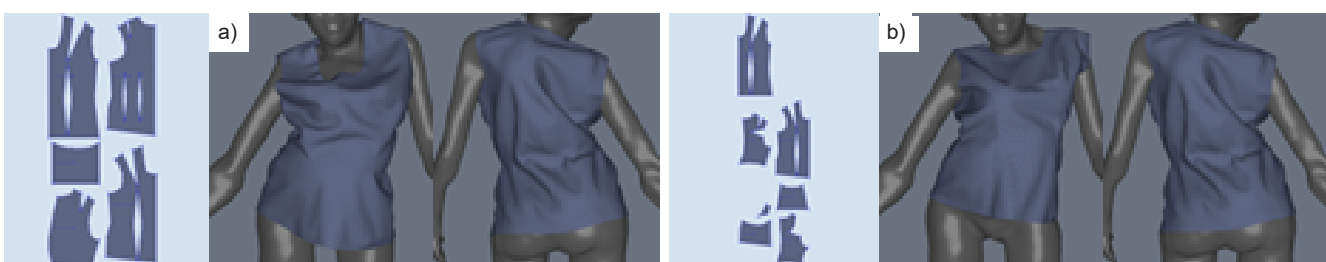


Figure 8. Pattern alteration proces with modifications of right back (a) and left back (b).

armhole line in order to follow a little more this inclined morphology (**Figure 5.c**)

After that we decided to verify if it's possible to manage the 3D evolution of the garment by the inclination of the patterns. Two tests were realized:

- rotate the left front and adjust the gap of the right back dart and side dart (**Figure 6.a**),
- rotate the right back and expand the bottom line, re-rotate the left front more pronouncedly (**Figure 6.b**).

Moreover we decided to follow mannequin body line in this direction. This

allows to realign the garment to the morphology, and to have a tight garment at the chest we need to:

- adjust the middle front on the right front and to integrate of a new dart in the armhole that should manage the excess material of the right back (**Figure 7**)

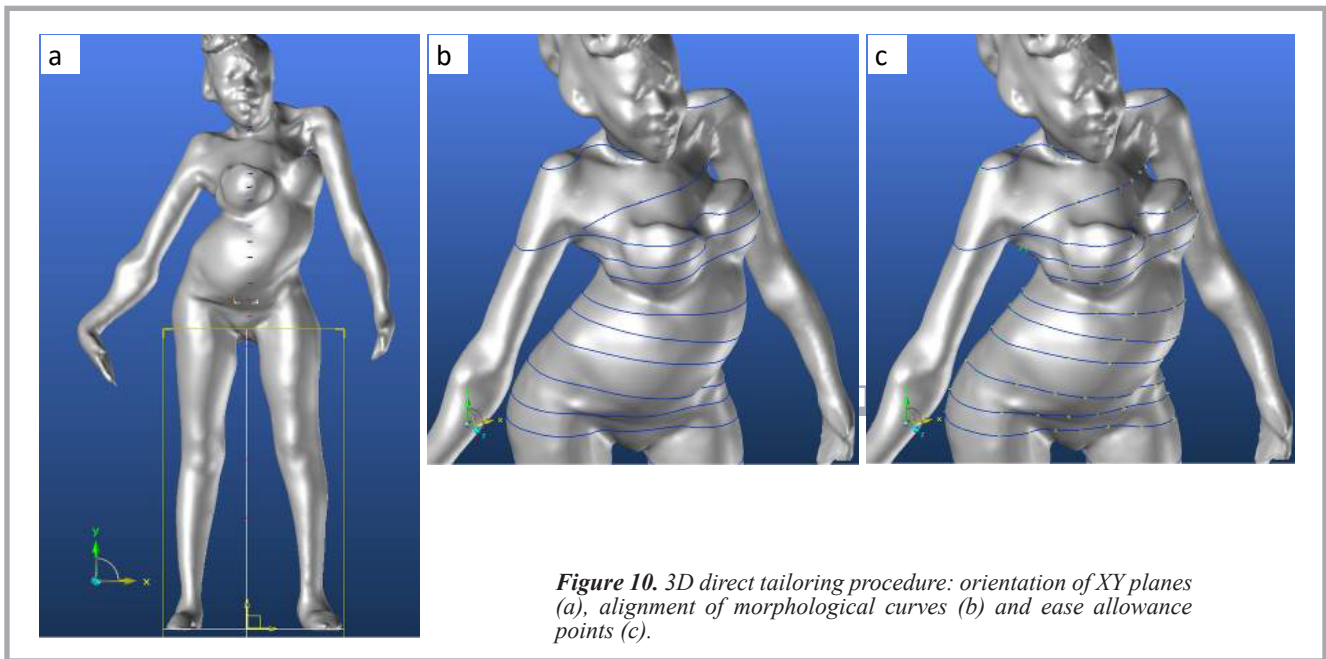


Figure 10. 3D direct tailoring procedure: orientation of XY planes (a), alignment of morphological curves (b) and ease allowance points (c).

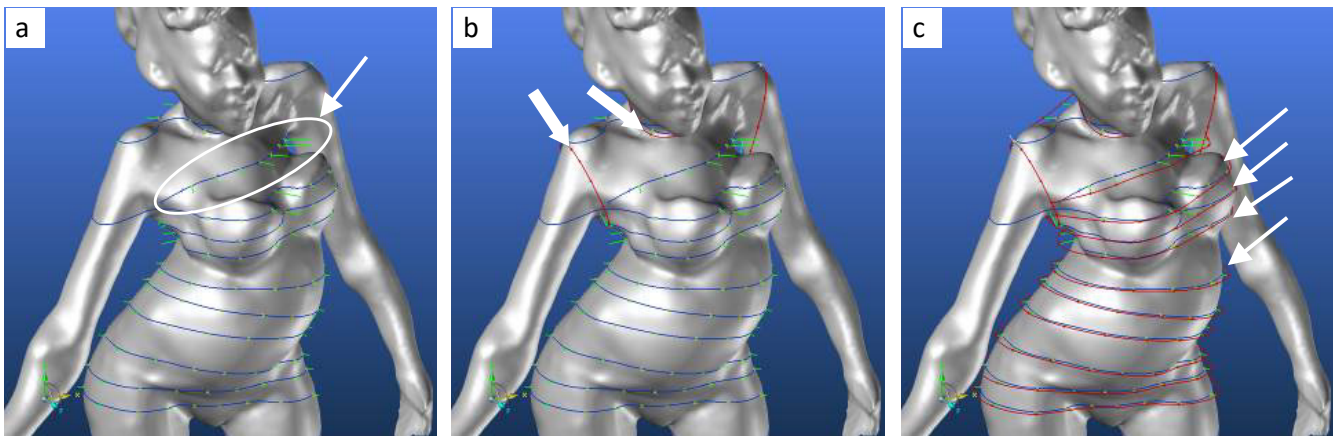


Figure 11. 3D direct tailoring procedure: ease allowance values (a), neck and armhole curves (b), curves of garment patterns in horizontal direction (c)

However, after many tests, we noted that the back patterns of the garment are difficult to mould in a proper, aesthetic way. It should be born in mind that the role of garment the is focused on fit and modelling the human body with an appreciation of beauty at the same time, correcting problematical areas. That is why we decided to separate the back patterns from step 4 into two parts (**Figure 4.d**):

- separate the right back from the waist, move the darts in the middle back on the top pattern (**Figure 8.a**),
- separate the left back from the waist, move the darts on the side and the middle back on the top pattern (**Figure 8.b**).

After an adjustment of the back, the front was improved by integrating other darts for moulding the body, giving the final result of the pattern alteration process

for a given virtual fabric (Denim Cotton, density 342 g/m²) as a garment simulation made by using Lectra's Modaris software (**Figure 9**).

This result shows that the garment is very close to the body, with the ease allowance values close to a 0 value.

3D pattern-making method directly on the morphology

The second method presented was based on the approach presented in [8, 9], which can be described as 3D direct tailoring. We start our procedure by the locating of anthropometric landmarks on the virtual body. Using DC3D software, different XY planes were defined with respect to the requirements of the garment creation method and the morphology of the body. Our next step was to find of the position

of the morphological curves (waist, hip, chest...) following the 3D deformation of the spine. Consequently each XY plane created has to be oriented differently in the 3D space (**Figure 10.a**). In the following step, we use these planes to cut the body and create the morphological curves (**Figure 10.b**). The software tool allows to adjust the right position visually by the inclination of the XY planes. Next different points are defined on these curves, enabling to control the ease allowance of the garment (**Figure 10.c**).

The ease allowance represents the distance between the body and the garment [10 - 18], which can be managed by different lines attached to these points, whose directions are adjusted in 3D (**Figure 11.a**). The length of these lines depends on the value of ease allowance given at this place. Afterwards it is possi-

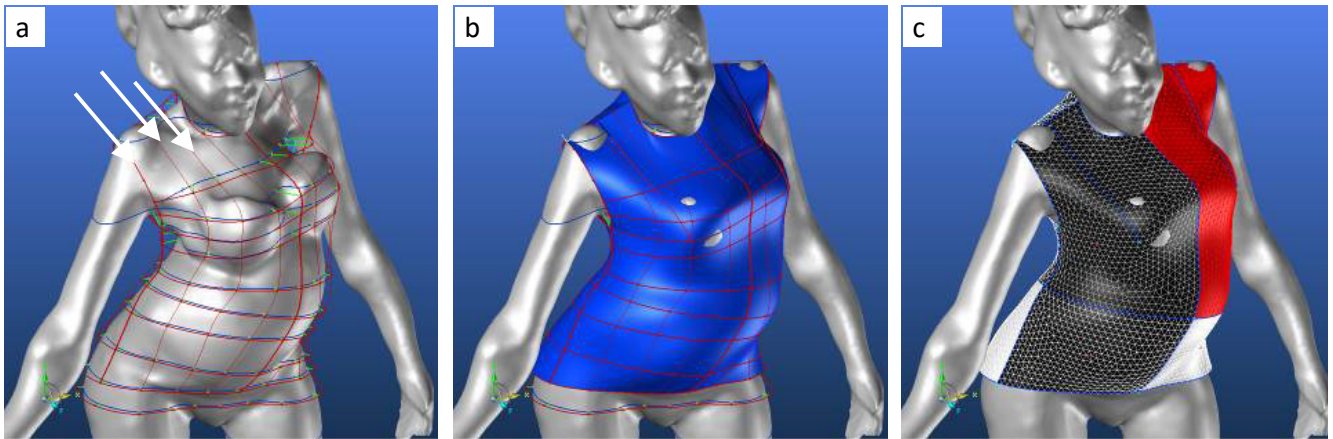


Figure 12. 3D direct tailoring procedure: curves of garment patterns in vertical direction (a), surfaces of garment (b), meshed surfaces of garment (c).

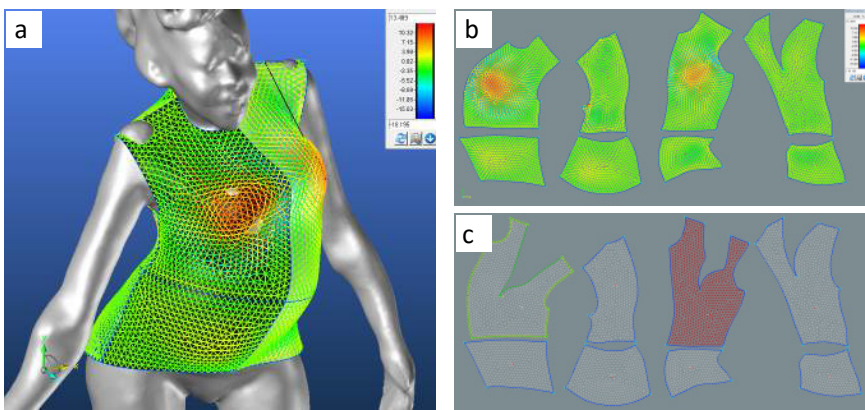


Figure 13. Deformation analysis of meshed surfaces during flattening process (a, b) and optimisation of the darts position (c).

ble to define the neck and armhole curves based on anthropometrics points, such as the 7th cervical, the clavicle/sternum and the acromia (**Figure 11.b**). The extremities of the ease allowance lines (**Figure 11.c**) are used to create the main curves defining the shapes of the 3D garment patterns.

We repeated the same operation in the vertical direction in order to create a network of curves balanced in both directions of the fabric surface (in red **Figure 12.a**). From this curve network, we finally created the surfaces of the front and back patterns (**Figure 12.b**) and the meshes of these surfaces were divid-

ed into four parts: right front, left front, right back and left back (**Figure 12.c**).

The deformation analysis of the meshed garment surfaces during the flattening process shows big constraints on the chest and back area (**Figures 13.a, 13.b**), which can be solved by introducing different darts in these places [19, 20]. The goal of this step is to improve it by drawing the dart lines directly on the 3D surface. Even if these lines are drawn as straight ones in the pattern flattening process they followed the morphology of the given body, leading to the curved darts (**Figure 13.c**).

The virtual try-on shows the quality of the garment fit on this atypical morphology (**Figure 14**); the values of ease allowance are chosen correctly for a given virtual worsted fabric (density 288 g/m²).

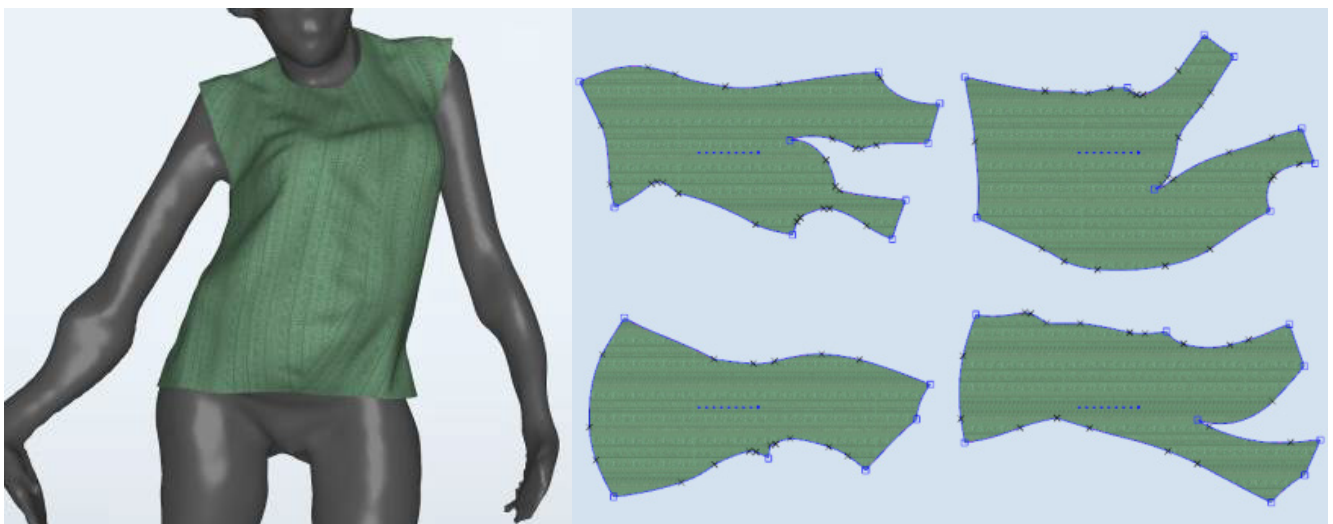


Figure 14. Virtual try-on of the garment using Lectra's Modaris software

■ Discussions

The first method presented leads to patterns with two additional darts to follow the morphology of the body perfectly. This method is based on a traditional tailoring idea, supported by CAD solutions as a module of virtual try-on. The success of this method is an issue of many aspects, with the morphology of the scanned body among them. In spite of 3D support, in a given case, this method still requires a lot of pattern-maker experience and can be very ambiguous (trial-and-error method) or imprecise. Moreover it leads to enhancing the defects of the body (garment takes into account all disproportions of the body in following beauty attributes for perfect body molding, consequently causing an excess of unnecessary darts). On the other hand, this result could be interesting in the case of a garment able to stretch (elastic) because it is very difficult to manage and know the value of ease allowance.

However, the second method has the advantage of fully managing the ease allowance of the garment as well as the well-fitting and user comfort. Additionally it is not an empirical method and can be applied to any morphology, typical or atypical.

■ Conclusions

In conclusion, we noticed that study presented showed that a 3D garment can fit the body in a 3D space during virtual try-on by uniquely modifying the 2D patterns of the garment. This work can lead to the garment customisation using data of the ready-to-wear industry. The first method presented is very empirical with atypical morphology, but it can be better managed with the morphology with small or no defect.

In answer to this problem, a new approach to create a 3D garment has been proposed. This technique allows to adjust a garment perfectly. We used the morphological contours of the virtual body to manage the position of the garment by means of ease points and lines. However, this method requires much finesse and experience in the placement of XY reference planes. According to the aim of the study, we have an opportunity to choose one of these two alternatives.

Future works will be focused on the creation of a parametric mannequin managed

by the spine in order to take into account an atypical silhouette. [21 - 23].



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■ Received 07.09.2015 Reviewed 14.01.2016