

3D Grading and Pattern Unwrapping Technique for Loose-fitting Shirt Part 2: Functionality

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ABSTRACT

The functionality of a resizable template developed for the creation of virtual loose-fitting shirts, along with its support of automatic 3D grading and pattern flattening is described in this paper. The capacity of the system for performing as a 3D drawing platform and for supporting pattern flattening and 3D grading is tested and evaluated. Aspects of the design work are limited because the sleeves have been created separately from the body; this constraint may be addressed by building the template as a single shape. In other respects the template was found to be fully functional and ready for use by fashion designers and pattern technicians, allowing them to combine fashion illustration and pattern creation into a single step.

Keywords: Virtual shirt, pattern flattening, 3D grading

Introduction

Part 1 of this paper described the application of reverse engineering (RE) and geometric modelling techniques in the development of a resizable shirt template from a set of construction curves extracted from body scan data, and the scaling process to impart resizability to the template as well as the ability to generate various different silhouettes from the resizable template. This part describes the operation of the template.

As a part of the functionality testing, its performance as a 3D drawing board to produce virtual clothing on it and to support the creation of a wide range of adjustable silhouettes and fashion illustrations was judged. Flat pattern pieces were extracted and physical prototypes were created in order that the quality of the flattened pattern pieces might be evaluated. The template was converted into different sizes with the help of variable size databases so that the facility

for performing automatic 3D grading of virtual garments could be assessed.

Functionality Tests

Drawing Platform and Virtual Clothing

In order to check the functionality of the shirt template as a 3D drawing and design platform, a diverse assortment of free-hand curves and outlines of different shirt designs were drawn on the shirt template. Figure 1 shows the drawn outline of a long-sleeved shirt. As the template is a model of the upper body surface to which operational levels of

ease have been appended, drawing on the template effectively defines the 3D outlines of an appropriately-sized garment. Once a drawing has been completed, an area of triangulated mesh is created on the template using the mesh generation tool available within the 3D CAD software used in this research. Figure 2 shows the triangulated form generated from the drawn out-lines. This triangulated shape thus forms the virtual clothing. Similarly, designs of short sleeve shirts and other upper body men's outerwear were developed on the 3D shirt template to check its functionality.

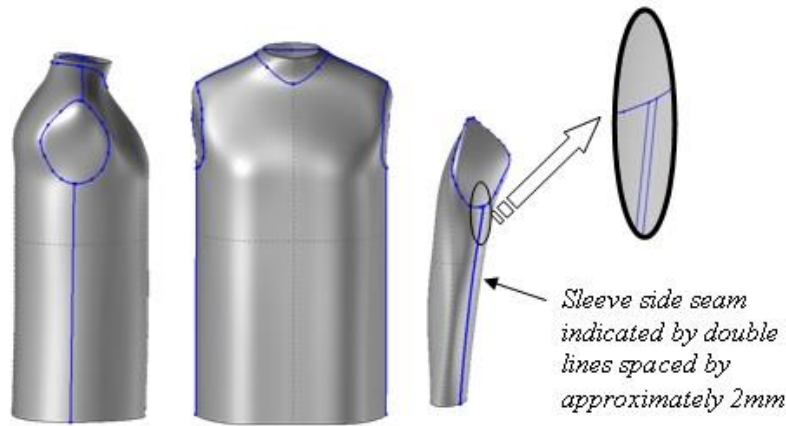


Figure 1. Shirt Outline drawn on the Shirt Template

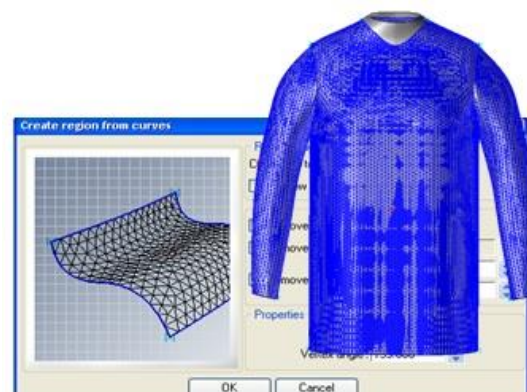


Figure 2. A Triangulated 3D Mesh Structure created from the Drawn Outline

Resizability and Grading in 3D

The resizability of the shirt template was checked by individually varying the values of different size parameters, the changes in the size and position of the scaled curves and the resulting shapes of the body and sleeves were analyzed. To check the resizability of all of the scaled curves together as a group and to assess the capacity for the grading of virtual clothing in space, the pre-developed size databases were linked with the 3D shirt template using the “Excel link” facility available within the 3D software suite. The changes in size and shape of the shirt template, as well as the virtual shirt drawn on it, were all assessed.

Pattern Flattening

A physically-based surface flattening engine was used to unwrap the virtual clothing designed on the shirt template, part by part, echoing the clothing manufacturing process. Figure 3 illustrates the flattening process of the front part of the 3D tee-shirt design developed using the shirt template. In order to maintain the dimensional integrity of the flat pattern pieces with the 3D design, relevant flattening options as described in Sayem, Kennon and Clarke (2012) was utilized. Similarly the back part and the sleeves were also flattened into 2D pattern pieces.

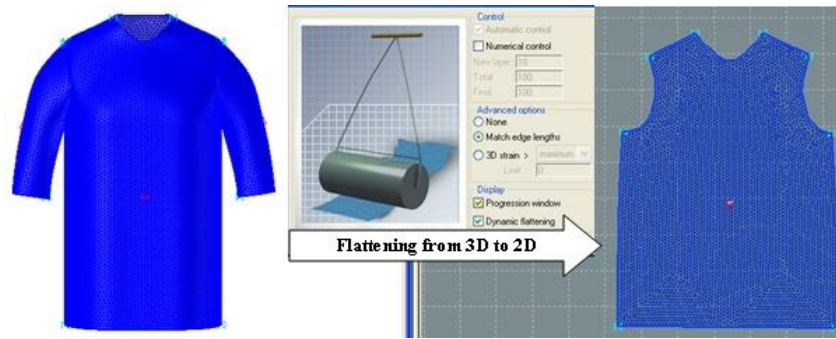


Figure 3. Flattening of 3D Component into a 2D Pattern

The virtual shirt designs were graded into different sizes and flat pattern pieces were derived from them. Measurements of the lengths of all the edges of the flattened pattern pieces were compared with those of the original 3D design.

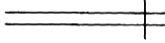
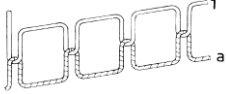


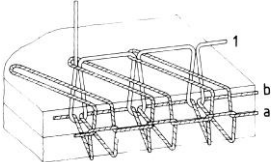
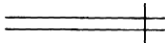
Physical Prototyping

Two physical prototypes of men’s short-sleeved tee-shirts, one in size 38 and another in size 40, were made of 100% cotton single

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jersey knitted fabric of 180 g/m² based on the printed pattern pieces derived through the flattening process described in the previous section. The manufacturing specifications of the tee-shirt prototypes are presented in Table 1. The seam classes, stitch classes and their illustrations are presented in the tables according to the British standards BS 3870-1 (1991) and BS 3870-2 (1991) which are equivalent to ISO 4915 (1991) and ISO 4916 (1991).

Table 1. Specifications of the T-shirts made in sizes 38 and 40

	Seam/Joining Area	Seam Class	Seam Illustration	Stitch Type and Class	Stitch Illustration	
1	Sleeve and Body joints at the Armholes	1.01.01		Lock Stitch (301)	 <p>1= Needle thread, a= Bobbin thread</p>	
2	Side seams					
3	Neck	6.02.03		Lock Stitch (301)		
4	Bottom opening					
5	Sleeve opening	6.01.01		Overedge Chain Stitch (504)		 <p>1=Needle thread, a & b = Looper threads</p>
6	Shoulder Seams	1.01.01				

Trials of the physical prototypes were arranged with live models to check the general fit quality and to assess the success with which the flattened pattern pieces had been derived from the 3D shirt template.

Fashion Illustration in 3D

Virtual shirts developed on the design platform were rendered with a number of different graphical surfaces, using the existing design capability of the software to gauge the practicality of executing fashion illustration using a 3D format.

Results & Discussion

Drawing Interface and Virtual Clothing

The shirt template developed within the framework of this research has been found to be fully functional as an appropriately-

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sized 3D drawing board which allows sketching and development of virtual clothing on its surface (see Figures 1 & 4). Using 3D drawing tools, it was found possible to draw any open or closed curve on it. With the help of mesh generation tools, a layer of triangulated mesh network could be successfully created from the curves drawn as design outlines on the templates, as illustrated in Figures 3 & 5. Such a mesh network automatically adopts the surface geometry of the template on which it is based. This appearance may be subsequently modified through the adoption of a rigid exterior surface which transforms the visualization and provides the opportunity for creating and exhibiting a wide range of 3D clothing designs with their shape defined by the original template.

Outlines of different components of shirts and similar products were successfully

drawn on the shirt template as can be seen in Figures 1, 4, 5 and 7. It has been found that a collection of men's shirts that have sleeves joined using a traditional seam around the

armhole can easily be designed on the 3D shirt template. Even the design of a suit jacket, as shown in Figure 4, can also be developed on it.

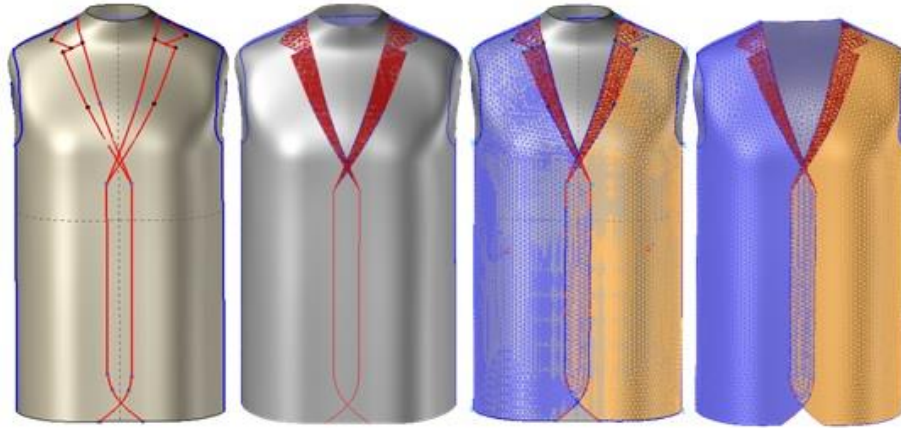


Figure 4. Virtual Suit Jacket designed on the Shirt Template

However, as the sleeve templates were created separately from the torso and subsequently joined to form the finished 3D shirt template, an associated design limitation has been discovered. Whilst it is straightforward to design and visualize a raglan sleeve on the shirt template, as in Figure 5 for example, the raglan sleeve design cannot be flattened as a single pattern piece because the underlying template dissociates the sleeve at the line where the sleeve template was originally joined to the

torso as may also be seen in Figure 5. A modified shirt template with the sleeves fully merged with the body parts may need to be developed, as it would address this problem. If the sleeves could be seamlessly compounded with the body of the shirt template, there would no longer be any restrictions on the design work that could be performed, hence raglan sleeves (or any other profile) could be developed and subsequently flattened into 2D patterns.

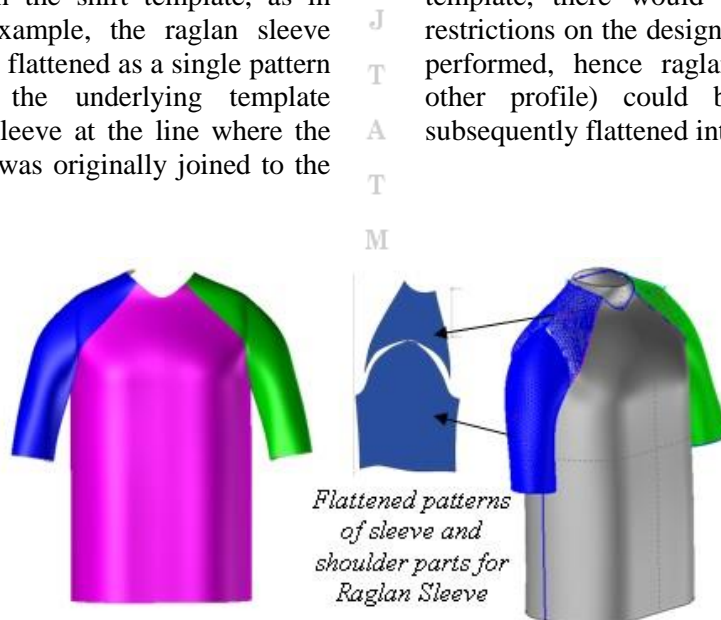


Figure 5. Visualization of Raglan Sleeves and Flattened Patterns

It was also found that there were restrictions on the types of collar that could be developed on the shirt template. A standard straight collar (Figure 6A) and two-piece collars such as the standard straight collar with stand (Figure 6C) and the alternative shirt collar with stand as depicted in Figure 6D can be developed on the shirt template without difficulty. Figure 8 illustrates a two-piece shirt collar with stand that has been designed on the shirt template. However, it

is not possible to develop a one-piece shirt collar, such as that shown in Figure 6B, because the software tools used for flattening cannot unwrap an overlapping surface into a single 2D component. In the case of the two-piece shirt collar shown in Figure 7, in which the collar and stand designs overlap each other on the shirt template, they can be flattened separately into two 2D components, but they cannot be flattened into a single pattern piece.

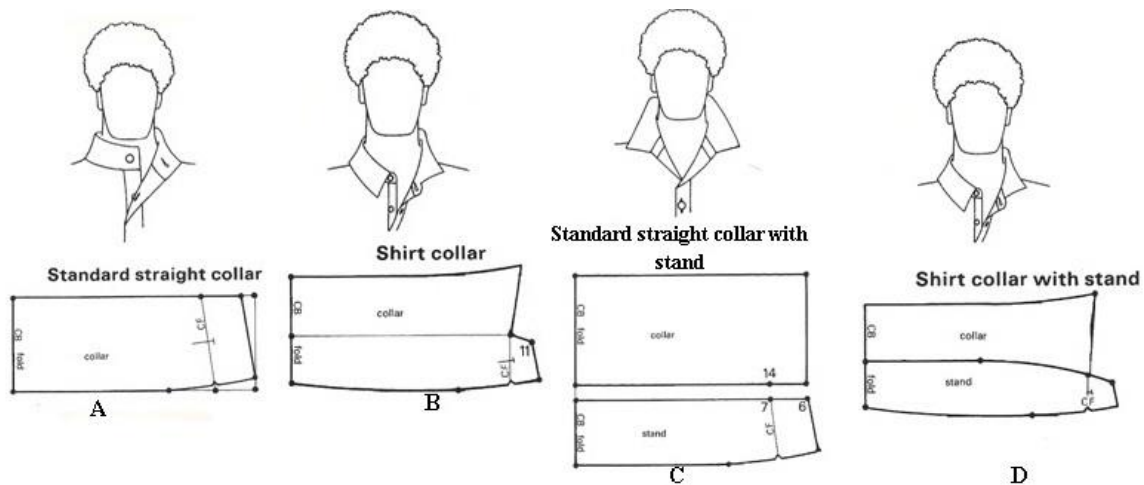


Figure 6. Different Types of Shirt Collar (Aldrich, 1990)

Considering the limitation in collar design, one solution may be to include a library of different 3D collars within the 3D CAD system. Then the designer could select the required shape and change the size to match

the neck size of the shirt. Alternatively, a facility might be included to merge the two pattern pieces which result from the flattening of an overlapping design and recombine them into a single pattern piece.

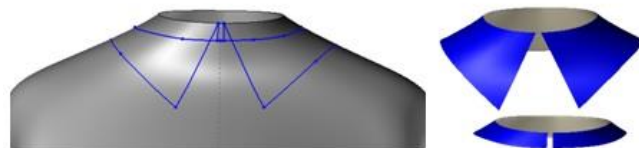


Figure 7. Development of a Two-Piece Collar using the Shirt Template

Resizability and Variable Silhouette

Virtual clothing developed on one of the 3D design templates is maintained in a location linked to the directory in which the top layer

of the surface of the 3D templates is stored on the computer. The geometry of the virtual clothing generated on the 3D template is dependent on the geometry of the template itself. As a result, any change in the size and

shape of the 3D template is automatically reproduced in the virtual clothing developed on it. The shirt template is resizable using 12 parameters and these parameters can be changed individually or in a group.

It was found that a variable silhouette could easily be produced by changing the values of

relevant parameters. For example, when the waist girth measurement of the shirt template was reduced from 11.6 cm to 10.6 cm, while keeping all other size parameters unchanged, the silhouette of a tailored shirt could be produced as can be seen in Figure 8.

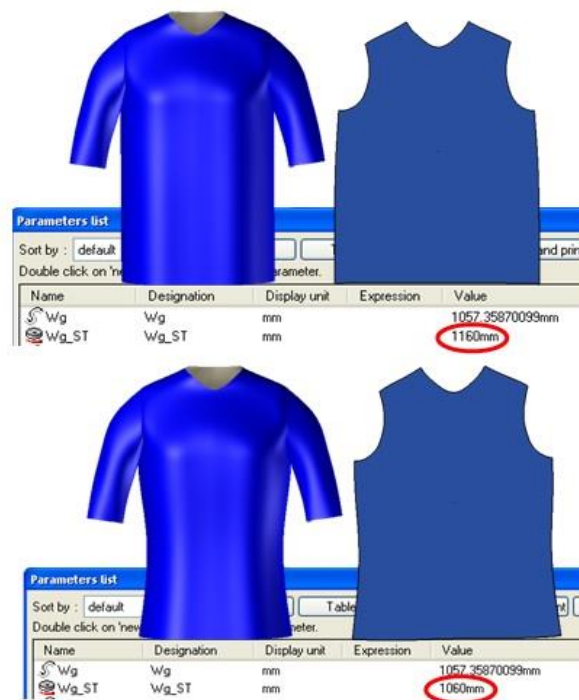


Figure 8. Varied Shirt Silhouettes

Automatic Grading in 3D

The virtual garments created using this technology have been made resizable by incorporating values from appropriate size databases developed previously and described in part 1. Hence, this facility provides an opportunity for successfully

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executing 3D grading. After drawing the virtual shirt, the garment may have its size varied by changing the size of the design platform. Figure 9 depicts the virtual long sleeved and short sleeved shirts graded into different sizes which were produced by incorporating the size databases for sizes 37, 39, 41, 43 and 45, as elaborated in Part 1.

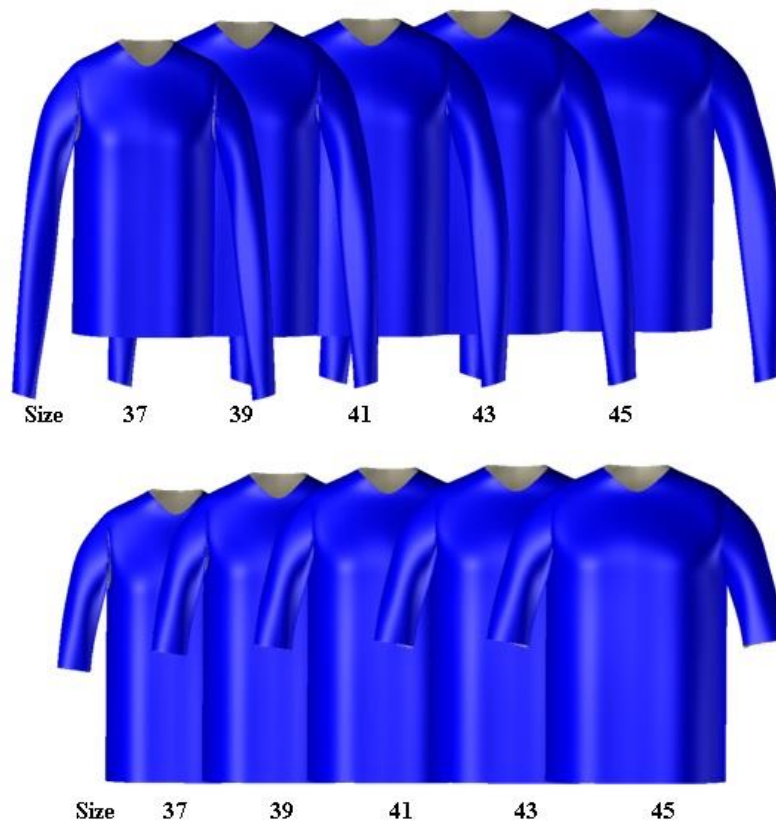


Figure 9. Examples of 3D Grading using the Shirt Template

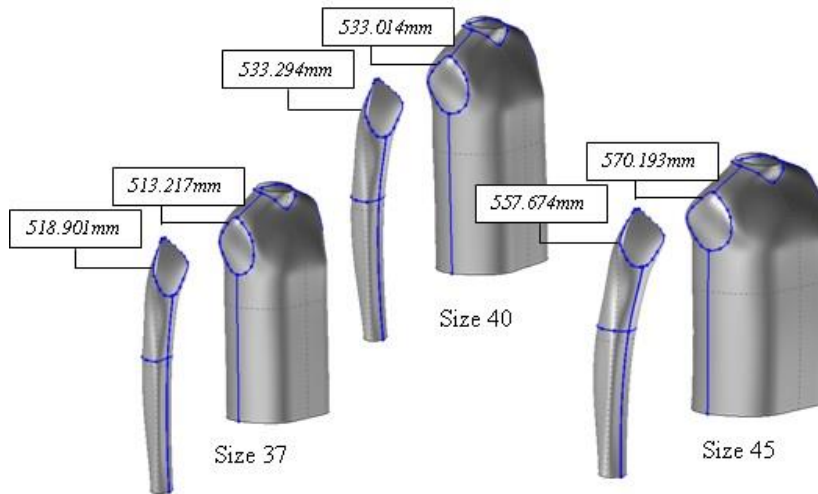


Figure 10. Armhole Measurements in the Body and Sleeve Parts of a Shirt Template in Different Sizes

It was, however, found that the armhole of the shirt design did not change equally in both the sleeve part and in the body part of the shirt template, as can be seen in Figure 10, and manual correction was required. Size 40 was selected as the base size to draw outlines of a virtual shirt on the shirt template. Armholes were drawn on both the body and the sleeve parts, using almost identical measurements. When 3D grading was applied using the size databases described in Part1, the size of the armhole curves on the torso part of the template changed appreciably more than the armhole curves on the sleeve parts of the shirt template and the discrepancies were found to be bigger in the larger sizes of shirt. When graded to size 45, the armhole curves on the torso were found to be about 1.3 cm bigger than the armhole curves on the sleeve parts. Whereas, grading down to size 37 generated armhole curves on the torso which became about 5 mm smaller than the graded armhole curves on the sleeves.

This problem has arisen because the armhole was not considered to be a scaling parameter and was not incorporated within the scaling procedure for the construction curves of the shirt template. To address this problem, an attempt should be taken in future to merge the sleeve parts with the body part of the shirt template so that both sleeve and body have a common armhole curve and also the length of the armhole should be designated as a parameter in the scaling procedure.

Flattened Patterns

The surface of the virtual clothing generated using the 3D templates may be completely converted into 2D by the execution of the flattening engine. Moreover, the flattened pieces maintain the exact dimensional

properties of the virtual shirts as a consequence of the efficiency of the flattening engine available within the 3D CAD software suite in use. It has been found that the edge lengths of any 3D design were almost unchanged after flattening into 2D, as can be seen in Figure 11.

The lengths of seven out of the eight edges of the shirt front panel designed on the shirt template, remained unchanged in the flattened pattern piece, as shown in Figure 11. Only the length of one edge (numbered 7 in the figure) was by the flattening process, and the alteration was less than half a millimetre, which is negligible in context of clothing manufacture. So the flattened pattern pieces from this technology can be used directly as production patterns after the addition of suitable stitch and seam allowances.

Physical Prototypes

When trialled by live models the prototypes of tee-shirts, made based on the flattened pattern pieces, of both sizes 38 and 40 resulted in manufactured garments with an acceptable overall fit which passed visual inspection. The fit of the chest, shoulder and armhole areas were found to be particularly good, as can be seen in the photographs in Figure 12. This indicated the functionality of the designated technique. Although visual assessment did identify some wrinkling and waviness in different areas both at the front and back parts of the prototypes during wearer trials, it did not provide consequential information about the fit of the items of clothing or the quality of pattern pieces used to create it. Such waviness in clothing is acceptable and cannot be avoided, as it is due to the general properties of textile fabrics.

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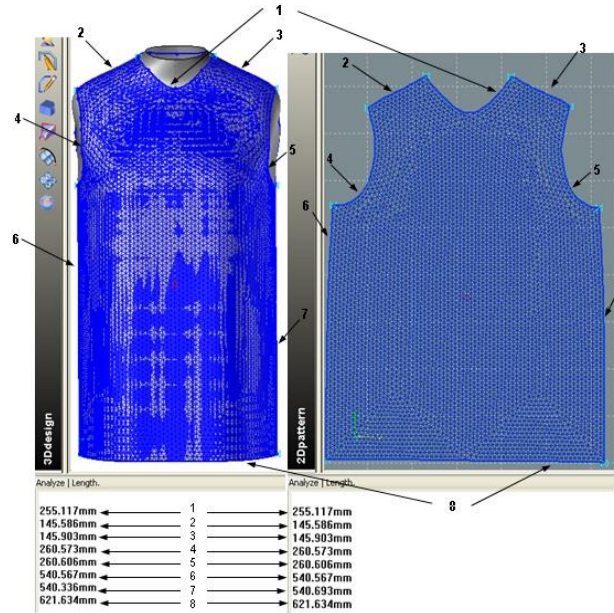


Figure 11. Length Analysis of a Flattened Shirt Pattern of



Figure 12. Trials of Shirt Prototype in Size 40

Combining Fashion Illustration and Pattern Creation

It has been found that the virtual clothing created as a triangulated mesh surface on both the shirt and trouser templates can be satisfactorily visualised in an alternative, solid form, which allows the figure to be viewed with a coloured surface or permits it to be adorned with diverse graphical features; examples are presented in Figures

5 & 13. This facilitates fashion illustration in a 3D format and such 3D illustrations may be used for preparing a range of visual boards at different stages of the design process. Mood Boards, which are extensively used as communication and marketing tools in the fashion industry (Cassidy, 2008), may thus include more realistic 3D illustrations of clothing in respect of its actual shape and silhouette. As the virtual clothing created using this

technique can also be flattened into accurately-measured flat pattern pieces automatically, designers will be able to have pattern pieces already created during the design stage. No additional effort will be needed for pattern creation. This has significant implications for the clothing industry in terms of time, manpower and

cost, as both creative design and technical design aspects of clothing development may be combined into one. It has, however, been found that multi-layer fabrics could not be visualised properly using the existing capability of the CAD system used in this work. This requires an improvement in the rendering strength of the CAD system.



Figure 13. Examples of Different Print Effects on a Virtual Shirt

Conclusions

Although there are technical and financial advantages in being able to flatten virtual clothing into 2D pattern pieces, this is not being practised in the clothing industry due to the lack of availability of appropriate CAD systems that include a sufficiently functional 3D platform (Sayem, Kennon & Clarke, 2010). This research has demonstrated the development and application of a resizable shirt template which supports the creation of virtual outerwear, pattern unwrapping into 2D and as well as performing automatic 3D grading. Except for a few limitations with this initial development model, the template has been found to be fully functional. However, further research is recommended so that the sleeves and the body may be incorporated into a single seamless template and for the further improvement of the flattening engine so that designs featuring overlapping panels may be satisfactorily converted into individual 2D pattern pieces.

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