Development and Usage of 3D-Modeled Body Shapes for 3D-Pattern Making

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Abstract

Today's pattern making methods for industrial purposes are including construction principles, which are based on mathematical formula and sizing charts. As a result, there are two-dimensional flats, which can be converted into a three-dimensional garment. Because of their high linearity, those patterns are incapable of recreating the complexity of the human body, which results in insufficient fit. Subsequent changes of the pattern require a high degree of experience and lead to an inefficient product development process. It is known that draping allows the development of more complex and demanding patterns, which corresponds more to the actual body shape. Therefore, this method is used in custom tailoring and haute couture to achieve perfect garment fit but is also associated with time.

So, there is the act of defiance to improve the fit of garments, to speed up production but maintain a good value for money. Reutlingen University is therefore working on the development of 3D-modelled body shapes for 3D draping, considering different layers of clothing, such as jackets or coats. For this purpose, 3D modelling is used to develop 3D-bodies that correspond to the finished dimensions of the garment. By flattening of the modelled body, it is then possible to obtain an optimal 2D Pattern of the body. The comparison of the conventional method and the developed method is done by 3D simulation.

Finally, the optical fit test is demonstrated by the simulated basic cuts, that a significantly better body wrapping through the newly developed methodology could be achieved. Unlike in the basic cuts, which were achieved by classical design principles have been created, only a few adjustments are necessary to obtain an optimized basic cut. Also, when considering the body distance, it is shown that the newly developed basic patterns provide a more even enclosure of the body.

Keywords: patternmaking, 3D-flattening, clothing, modelling, garment fit

1. Introduction

The production of clothing is based on the pattern of the garment. There are three known methods that lead to the development of the pattern: system pattern making, draping and flattening. Especially in industrial production, this has so far been created through system pattern making by using measurement tables, mathematical formulae and construction principles to create a two-dimensional image of the desired garment. Due to the high degree of linearity resulting from the pattern construction, the complexity of the human body and the wrapping thereof by clothing, cannot be retraced It is well-known that an improved fit can be achieved by draping. Therefore, the design is modelled directly onto a tailor's bust that has been made to measure, and the individual sections are detached along the shape of the body in order to obtain an impression of the body that is as accurate as possible. Due to the extensive time and manual effort involved, this procedure is only used in tailoring and haute couture, but it demonstrates the practicality of creating a pattern that takes the body surface into account. Due to currently existing technical possibilities in terms of CAD systems, the pattern design could be made more efficient, but the classical construction of garment patterns does not represent a long-term solution for the fast-changing fashion market. The importance of using flattening methods, the main point of the paper, is increasing. The clothing industry is therefore under increased pressure to make new products available in the shortest possible time, while at the same time constantly improving quality and price-performance levels are required. This can only be accomplished through innovative processes and rational use of currently available digital means, considering conventional product development methods.

Studies already exist today that deal with an alternative pattern development method that enables the transformation of the three-dimensional surface of a scan file into a two-dimensional pattern through flattening [1,2,3,4]. The expediency of using flattening methods to create garment patterns is thus shown to be expedient. However, almost all studies show that the flattening process is an attempt to get as close as possible to conventional pattern shapes as known from construction. Furthermore, there is insufficient information available regarding reproducibility and thus a practically based solution.

Therefore, this paper is concerned with the development of standardised 3D modelled bodies for an unstructured and reproducible pattern design considering different clothing layers, as well as the validation of a methodology for the application in technical and creative product development.

The aim is the development of a practice-relevant product development process, which provides the possibility to combine all development steps from design to pattern sewing with the help of currently available 3D technologies and thus to design more efficiently. This allows work steps up to prototyping to be significantly shortened. The central focus of the project is the creation of a standardised method for achieving new pattern shapes without construction.

2. Methodology

The development is focused on a complete and practice-oriented Product Development Process, which combines all steps from design to pattern sewing and consequently makes them more efficient.

For this purpose, first prototypes for 3D-optimal bodies will be developed and on the based on these, a procedure for sectional sampling of the pattern, will be tested. Therefore, CLO3D [5] and Optitex was [6] used, since they provide 3D-Flattening which is turned directly to the garment. During the processing period, the aim is to create 3D optimised bodies for different clothing classes, such as swimwear, blouses, jackets and coats. The resulting basic patterns are then compared with those resulting from the classic drafting process. The results are expected to show first directions of practicability and provide the basis for an innovative and efficient design of the production step of pattern design.

Subsequently, all cuts are digitally sewn using 3D simulation software, such as Assyst Vidya [7] and CLO3D, and checked for their fit. For this purpose, all parameters such as stretch or stiffness of the material are adapted to the respective garment in the simulation.

Finally, the optimally designed bodies are examined for their suitability as a design tool. By incorporating design elements such as seam placement and the use of simple section modification, the extent to which the 3D bodies can be used in terms of design is verified.

2.1. Prototyping 3D-optimal bodies

The development of three-dimensional models, which enable the optimised and reproducible basic pattern design by flattening the surface, considering different layers of clothing, is the main focus of this work. The application focuses on ready-made garments. Possible adaptations for made-to-measure production or mass customisation are not excluded, though.

The development priorities for the first prototypes are listed below:

- ➔ Definition of construction and finished dimensions, i.e. the nominal dimension
- ➔ Generating basic body shapes based on the defined dimensions as a Modelling basis
- ➔ 3D modelling and inspection of critical body parts
- ➔ Definition of landmarks to ensure reproducible results
- ➔ Completion and drawing of the pattern lines for flattening

Before starting the modelling process the required construction dimensions and body dimensions of the basic body must be defined. They are based on the women's wear size 38 and are adjusted to the individual layers of clothing according to the recommendation of Fernando Burgo [8] for ease allowance. As this is initially a prototype production and feasibility study, the average values of the recommended ease allowances were used. Thus, body measurements such as bust width, hip width, waist width, shoulder width and neck width were adapted to the ready-made size 38 for the different clothing degrees.

By using the defined bodies or construction dimensions, digital human models were created, which correspond in their dimensions to the pre-defined values. Table 1 shows the dimensions used for the basic body as well as the finished dimensions, which the individual 3D-modelled bodies should correspond to.

Table 1 defined dimensions for different clothing degrees according to [8]

Measurement [cm]	Body dimensions Size 38	1st degree	2nd degree	3rd degree
Body height	168,00	168,00	168,00	168,00
Chest width	88,00	92,00	97,00	102,00
Waist width	72,00	76,00	81,00	86,00
Hip width	97,00	101,00	106,00	111,00
Shoulder width	12,70	12,70	14,20	14,70

The created avatars are brought into a shape that allows an optimal flattening of the surface for the basic pattern of the garment. The aim is to model the inner shape of the garment in a way comparable to a negative print.

For this purpose, the shapes of the bodies must be modified so that they correspond to the shape of the desired garment. In this way, for example, different clothing silhouettes can be created (Fig.1). In this work, the focus was on a silhouette, that reflects the original shape of the human body.

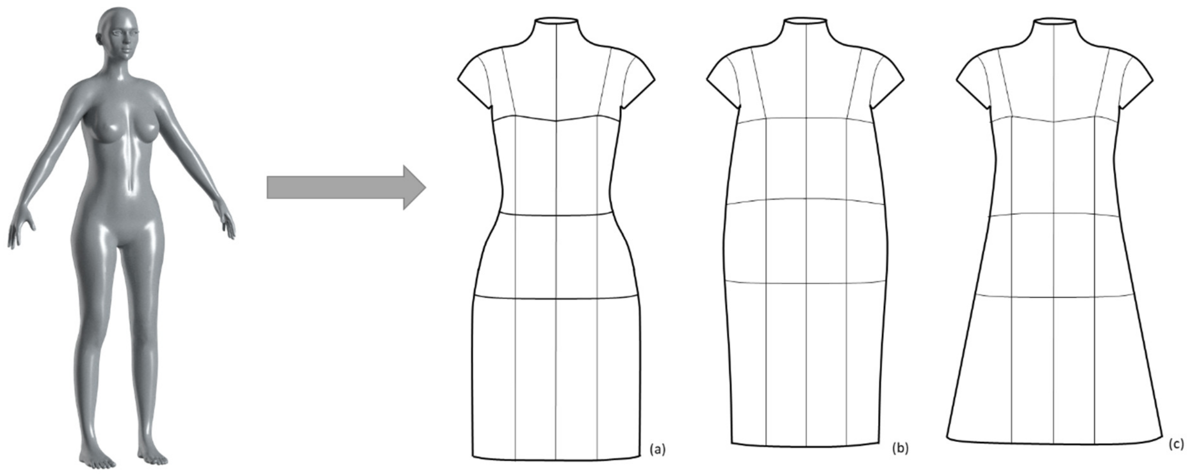

Figure 1 Sketching of examples of different 3d modelled silhouettes from human body shape (a) X-Silhouette (b) O-Silhouette (c) A-Silhouette

At the same time, the modelling will be used to design the 3D bodies to be developed along the lines of tailor's busts. Since this work will initially concentrate only on the development of tops, the body region below the hips must be adapted in such a way that it does not cause any deformation, e.g. by legs, in the top basic pattern.

2.2. 3D-Flattening and definition of landmarks

After the prototype development of the 3D bodies was completed, the validation of the methodology for pattern drafting without construction took place. Here, the finished bodies are flattened into two-dimensional surfaces on the modelled body according to their clothing degree. For this purpose, it had to be examined to what extent the body has to be divided by lines in order to get an accurate 2D image of the 3D model.

Another important aspect to be considered in the development of 3D modelled bodies is the creation of a possibility for reproducible pattern design. For this purpose, measuring points must be defined and integrated within the 3D model. These should be kept as low as possible to retain sufficient freedom in the pattern design but should be sufficiently available to ensure a high degree of reproducibility. It must also be estimated whether and to what extent the planned markings can be applied to the 3D body so that an error-free import into all types of clothing software is possible.

The aim here was not to bring the flattened shape as close as possible to the shape of the conventional pattern construction, but rather to create a new type of pattern, through which the curves of the desired garment shape can be optimally reproduced on the 2D surface.

2.3. Comparison – 3D-Flattening vs. Pattern drafting

The validation includes the additional basic pattern by means of classical construction. Only in this way the patterns created from the flattening can be compared in the later simulation. In contrast to the usual clothing technology, individual basic patterns are made for all layers of clothing. The construction dimensions correspond to the nominal values of the body dimensions of the 3D model. This ensures the comparability of the results from both methods for the basic cut.

It is therefore not examined to what extent the new shape of the garment pattern approximates the original constructed pattern, but rather to what extent it is closer to the actual human shape.

2.5. Simulation and Comparison of Garment fit

The simulations carried out are then checked for their fit in an optical comparison. Based on wrinkling or compression, it can be determined in which areas there is a lack of fit. In addition, the results from the classic design are compared with the method developed from the new process and the difference to the desired target value is calculated.

2.6. Usage of 3D-modeled body shapes

Even though the 3D-Models were initially conceived as a tool for the more efficient creation of basic patterns, a great potential for creative use was identified during the work. Therefore, in a final step, examples will be worked out to show to what extent the developed cutting envelopes can be used as a design tool.

In this work step, a complete product development process, though in a highly simplified form, is simulated to prove the feasibility and efficiency of the methodology developed in this work.

3. Results and Discussion

At the beginning of the prototyping and first preliminary tests, it was found that a proportional adjustment of the body dimensions resulted in an incorrect pattern. It is admitted that circumference measurements must be adapted to the finished measurements of the garment. Length and distance measurements, such as the front length, must be kept constant. Even if the 3D body is slightly adjusted with simultaneous changes in length measurements, there will be severe fit deficits in the fit check, especially when positioning bust darts or shaping the waist.

In initial preliminary tests it was finally noticed that the actual body shape is not suitable as a form of clothing. For example, the middle of the chest was not filled up. This results in an undesirable clothing shape along the front centre at breast level (Fig.2). Therefore, the next step was to adjust the chest area of the avatar so that it more closely matches the desired clothing shape. In direct comparison, it becomes clear that the adaptation of the model shape results in a much better fit, as the centre front does not extend to the ribcage.

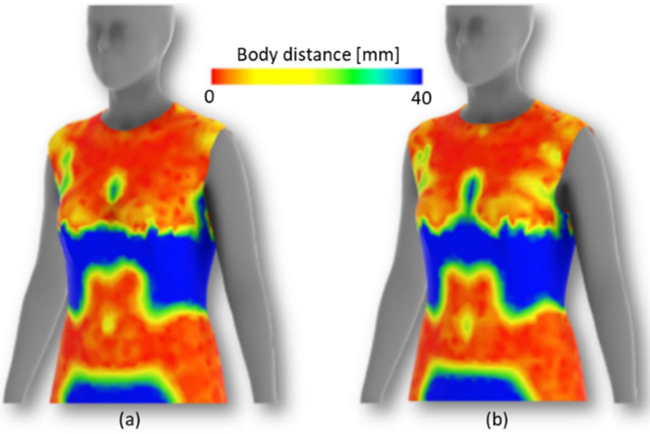

Figure 2 Comparison of the fit by (a) flattening of the avatar and (b) flattening after modelling of the breast region

To ensure the reproducibility of the basic cuts resulting from the 3D bodies, fixed points had to be defined which allow the exact drawing of the cut lines.

For this purpose, it had to be determined first which section lines, comparable to construction lines in classic pattern drafting, had to be applied to the 3D body. For the feasibility studies, the landmarks were based on the studies of Choi et al. [4] and Zhang [9] and are suitable for making base and very simple patterns. For more complex structures and shapes, it is considered to position the landmarks variably.

The landmarks are an important part of the modelled bodies to achieve reproducible results. Since the positioning of lines for flattening has a high degree of subjectivity, depending on where the user defines body points, a possibility was required to obtain the same results by flattening at any time. The landmarks are defining intersection points between each line of the basic pattern. By connecting the marker points, the basic pattern can be developed (Fig.3).

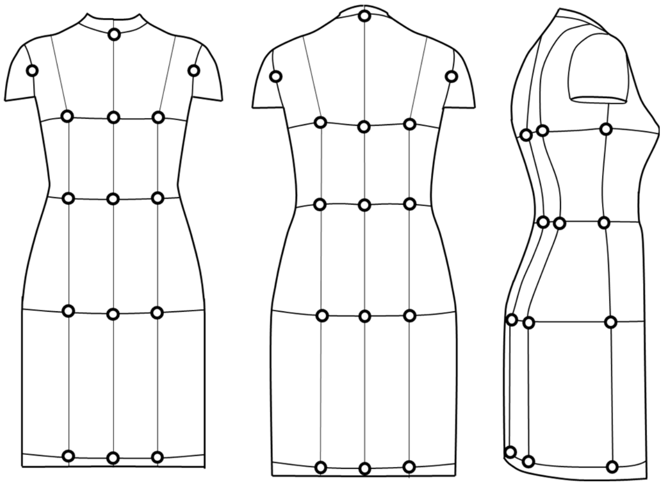

Figure 3 Positioning of Landmarks on 3D modeled body

For this purpose, markers were placed at the intersections of the base lines. These are made by the geometrical shape of the torus. This makes it possible to directly selection of the surface of the 3D model through the recess of the torus. Since the geometries of the tori and the modelled 3D body are not connected, there is no falsification of the unrolled 2D surface since the lines run below the markers (Fig.4). It is also possible to apply markers or lines through the texture of the 3D object. Due to some import problems and a presumably lower accuracy when drawing the 3D lines, this method is only useful for special applications.

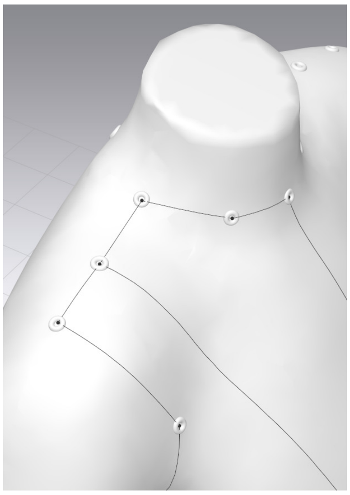

Figure 4 Example of Flattening lines on 3D modeled body

After the development of the 3d bodies, the basic pattern was created. This takes place on the one hand through the surface unrolling of the developed 3D models and on the other hand by the classic pattern drafting (Fig.5).

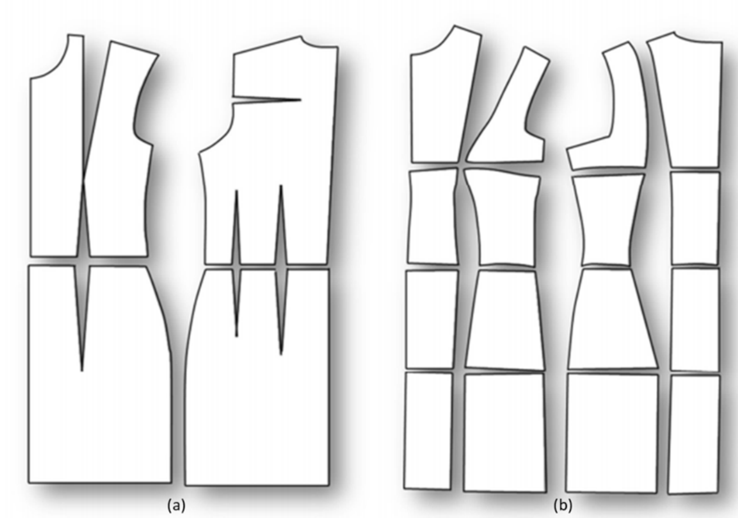

Figure 5 Basic patterns from different drafting methods (a) from classic pattern drafting (b) from flattening of 3d modeled body shapes

A visual comparison already shows the first differences in the shape of the cut pieces. While the basic pattern from the construction shows a clear linearity, the pattern, which is created by the flattening, consists mainly of curves and a complex geometry. From this one can already suspect, that the garment pattern, which is created by the flattening, will lead to an improved fit in the garment. The new shape of the cut pieces also opens up new possibilities for designing clothing, as the scope for design is no longer limited by conventional shapes. It also increases the scalability of cutting patterns. Due to the limitation of construction cuts in their dimensions, not all body sizes can always be considered. This is made possible by 3d bodies and the flattening of these.

Since the shape of the pattern alone cannot provide reliable information about the actual fit, the finished dimensions from both pattern making processes were also compared with the defined target value (Fig.6).

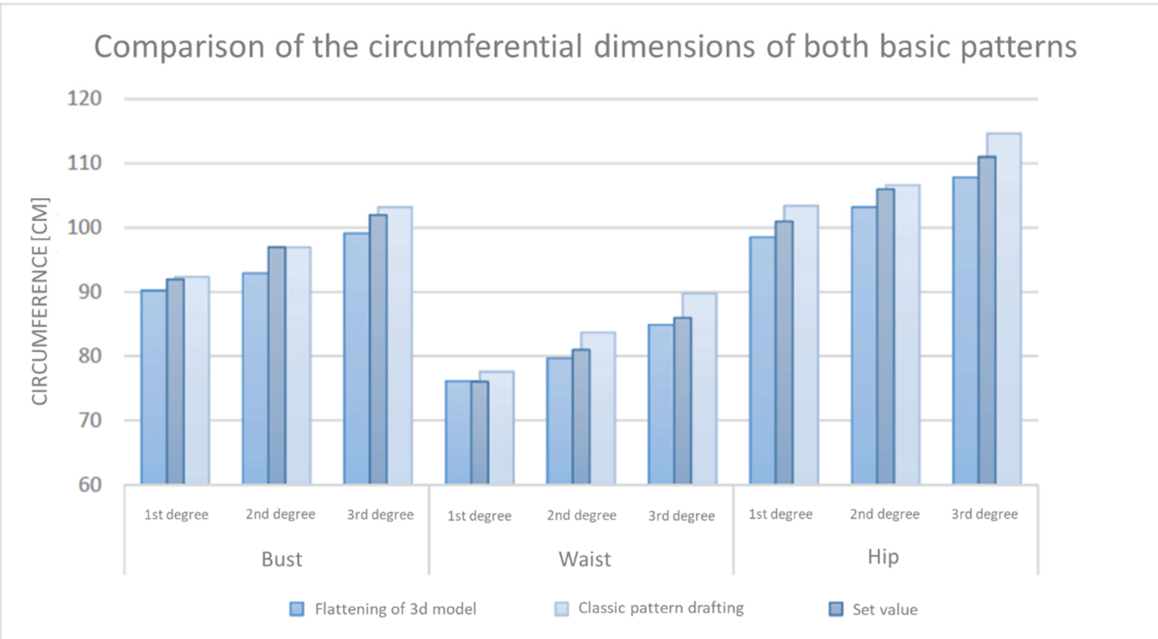

Figure 6 Comparison of the circumferential dimensions of both basic patterns

With both methods, the target value cannot be reached exactly. All in all, the circumferential dimensions are smaller due to the flattening method, whereas the dimensions of the classic construction lead to larger circumferential dimensions than desired. However, it can be seen that a largely constant difference could be achieved for those sections which were created by the 3D models. For further development, it should therefore be noted that the 3d models should possibly be larger in their circumference than the actual target value. For this purpose, further attempts should be made to obtain statistically relevant evaluations.

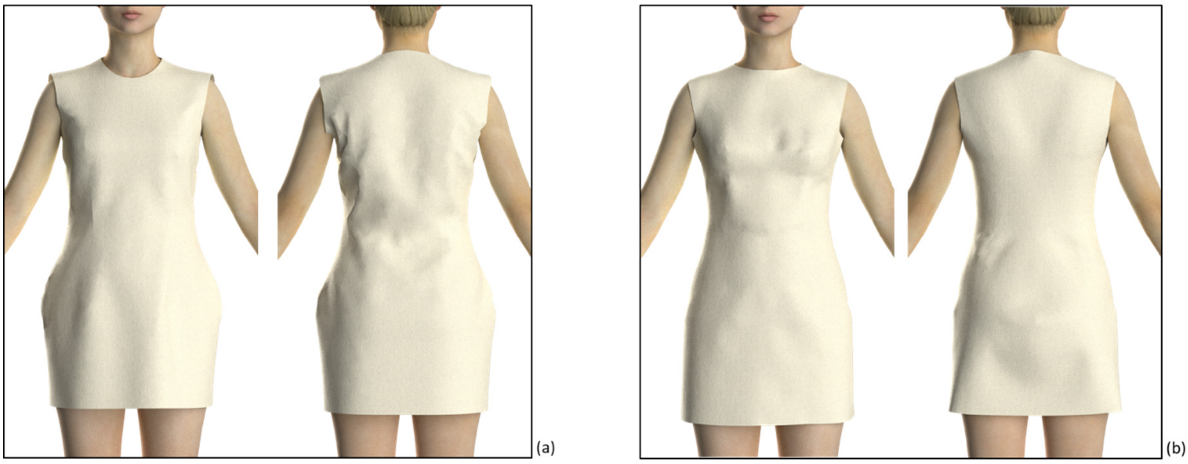

Figure 7 Comparison of the fit (a) classic pattern drafting (b) flattening of 3D modeled body shape

A direct comparison shows that the pattern through flattening provides a much more precise image of the actual body shape that can be achieved (Fig.7). Particularly in the hip area there is no optimal pattern, that could be achieved without any additional adjustments. Further show in the back part, there are strong deficits in the fit. This leads to an increased formation of wrinkles in the area of the lower back, which indicates unwanted extra width. In addition, there is a suboptimal shaping of the armhole on the back.

Another aspect that was used to check the fit, was to examine the balance of the garments in the simulation. For this purpose, the simulated clothing was strengthened so that it would produce the stiffest possible image and the maximum possible distance from the body. Particularly in the third degree there are clear differences between the constructed pattern (Fig. 8a) and the pattern from the flattening (Fig. 8b). It can be seen that the garment created by the 3D model has a much better balance and gives the garment a better shape to the body.

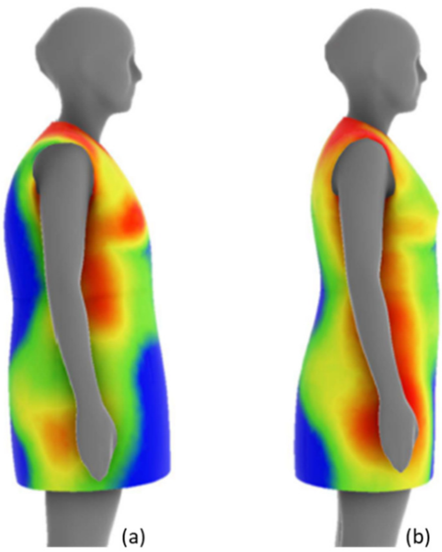

Figure 8 Comparison of the balanced fit (a) classic pattern drafting (b) flattening of 3D modeled body shape

3.1. Usage as Design Tool

The origin of the study was to develop a reproducible process for basic pattern development. During the work on this topic, however, it could be recognized that the developed bodies are also suitable for the creation of model pattern design. A special focus was put on larger cut pieces and pattern lines which do not run along the intended lines for the basic pattern. The aim is to investigate to what extent the large number of cut lines resulting from the basic pattern can be reduced for design purposes.

For this purpose, a design was first created which corresponds to the silhouette of the 3d bodies, but differs from the original cut lines. A princess seam was planned for the front part and the shoulder area was cut out with curved lines (Fig. 9a). According to the design, the planned lines were then applied directly to the 3D body. The landmarks attached were used for orientation (Fig.9b). The designer is free to set further landmarks to realize his design or to make it more complex. While lines like the front center could be drawn through the landmarks with only a few pins, several pins were necessary for particularly strongly curved lines. However, this does not result in a deficit in the methodology itself. The model pattern resulting from flattening is very different from known patterns. Especially in the front and back center the usual straight lines are missing. In addition, the straps in the shoulder and neck area, unlike in the classic pattern construction, do not run in a straight line, but are adapted to the actual rounding and shaping of the shoulder (Fig.9c). The subsequent simulation shows that the drawn lines in the finished garment correspond to the planned positions. Only a few or even no compressions or wrinkles can be seen. The fit of the garment can therefore be rated as a satisfactory one (Fig.9d).

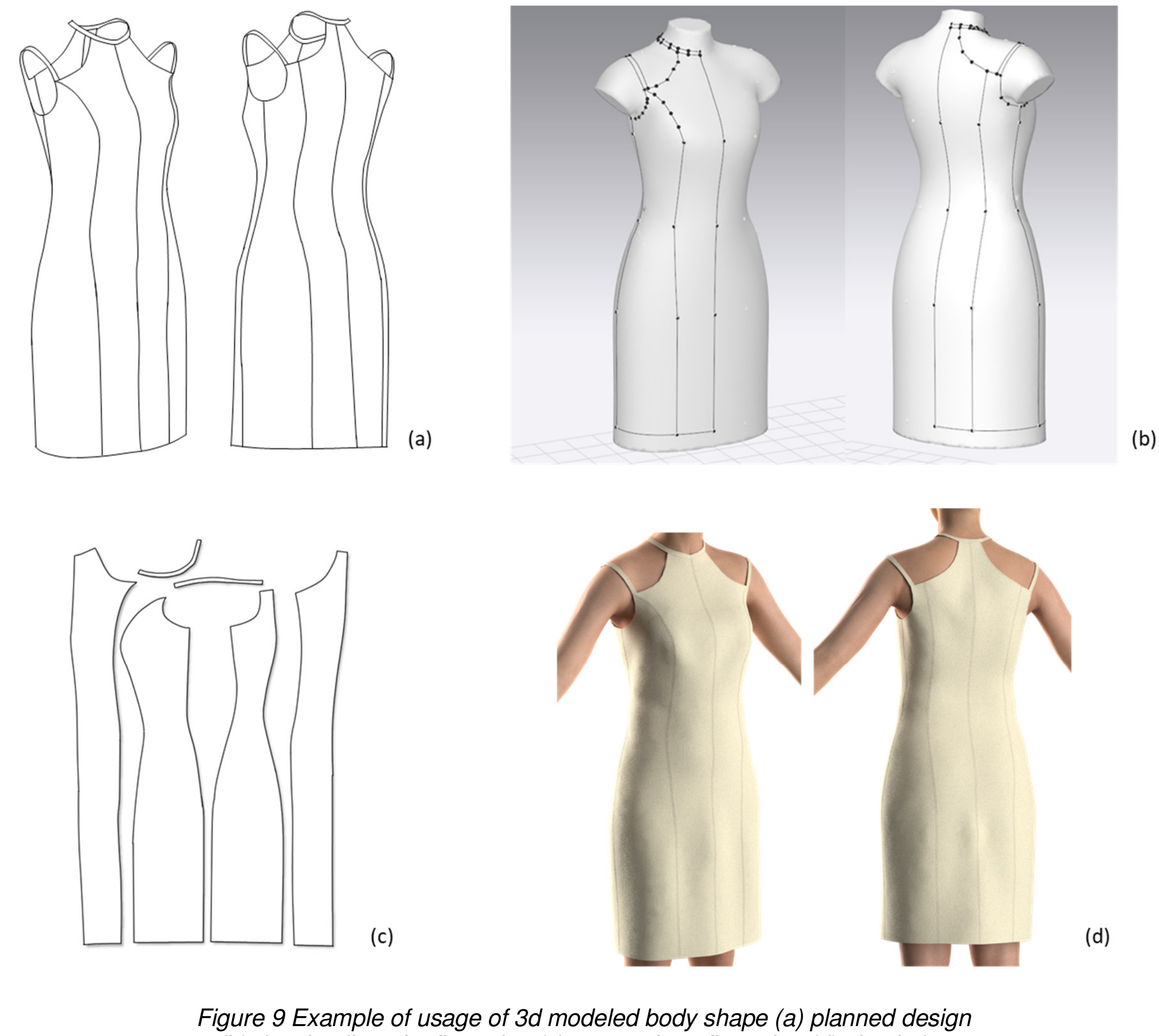

Figure 9 Example of usage of 3d modeled body shape (a) planned design (b) drawing lines for flattening (c) pattern from flattening (d) simulation

4. Conclusion

The project aimed at developing a practice-oriented methodology for reproducible basic pattern development for different clothing degrees, which uses commercial software for clothing simulation. By directly comparing construction patterns and the new pattern shape, it could be determined that flattening results in a significantly better fit of the garments. Due to the high degree of subjectivity that is expected from drawing the 3D lines, a solution was sought that would deliver reproducible results easily and universally, i.e from as many programs as possible. For this purpose, additional geometries were applied to the modelled 3D body, which allow a targeted placement of the 3D lines and also do not distort the surface that is being flattened.

It was also examined to what extent the 3D modelled bodies are suitable for generating model patterns. It could be observed that the extraction of model-based patterns through flattening has little to no fit deficits. The positioned seams, which are applied to the body by 3D lines, are exactly reproduced in the simulation on the real body.

Nevertheless, these are initially feasibility studies, which must be investigated in more detail in further research work. In addition, procedures are to be developed which enable a mathematically based creation of the 3D bodies. Moreover, it is necessary to verify the method sufficiently by means of further experiments, as previous applications have been tested in a few cases only.

Overall, the project results in a practically applicable tool for the efficient creation of optimised and novel patterns with a significantly improved fit.

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