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Key steps in the development of production guidelines for 3D garment simulations

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ABSTRACT

Over the last years, 3D garment simulations have improved the workflow of garment production in the clothing industry. While some brands have established themselves as pioneers in this area, planning collections only digitally, other brands are still considering how to start with 3D. 3D clothing simulations enable a clear reduction in product development times from the design idea to the point of sale. To be able to reduce the number of prototypes, it is crucial to create virtual prototypes that are as close as possible to the final product. To reduce the differences between the physical and virtual garment, production guidelines are needed to establish rules regarding the workmanship of virtual prototypes. A step-by-step description of the processing of virtual garments was made using the simulation system CLO3D. Different variations of virtual workmanships were shown, with their advantages, disadvantages, optical differences, and applicability. The production guidelines were created for basic garments and then for more challenging products such as winter jackets and bras. It is time consuming to create production guidelines, but the effort is worth it. It enables users and companies to achieve reliable and consistent simulation results.

Keywords
virtual processing,
virtual workmanship,
3D garment simulation,
clothing simulation,
virtual prototyping,
virtual prototype,
virtual clothing,
simulation result,
production guideline

1 Introduction

Over the last years, 3D garment simulations have improved the workflow of garment production in the clothing industry. They are many different definitions to virtual clothing. In some areas, virtual clothing is even created without ever being produced physically (digital-only fashion). Digital-only fashion refers to clothing that exists solely in the digital realm. Virtual clothing, on the other hand, refers to garments that are designed to be worn exclusively in the digital space, enhancing one's online presence and self-expression [1]. Some brands have established themselves as pioneers in this area, planning collections only digitally until they are produced at the end. Meanwhile, other brands are still considering how to start with 3D.

Technologies such as 3D clothing simulation enable a clear reduction in product development times from the design idea to the point of sale [2-6]. This reduction of production time is mostly achieved by an improvement of communication between all involved partners and an improvement of the production workflows using 3D simulations. It’s no longer needed to wait for physical samples from all over the world because some prototypes can be replaced by a virtual prototype.

To be able to reduce the number of prototypes with the implementation of 3D technologies efficiently, it is crucial to create reliable virtual prototypes, that are as close as possible to the final product. The 3D simulations systems offer a huge variety of tools to achieve true to reality results. Unfortunately, those tools can also allow the users to embellish, falsify or manipulate the results of the simulation, purposely or not. In fact, the influence of the user was shown in a study where three 3D users were given a technical sketch as a basis to create a 3D garment [7]. The results showed many differences, depending on the skill level of the users. Some used tools to create volume and stiffness in certain areas of the garment, others used transparency to hide pattern pieces while keeping the hold of those pattern pieces.

In the traditional fashion industry, it is common to create technical specifications of garments to accompany their industrial production (Fig. 1). Those specifications are listed in Tech Packs that contain not only information about the fabrics and finished dimensions, but also information regarding the workmanship. A Tech Pack minimizes risks for both the manufacturer and the designer, by clearly setting out what the desired specifications are for the future product [8]. For example, stitch type and form are classified by international standards. Only in this way, it is possible to achieve conformity and uniformity along the production.

This process must be done simultaneously in the 3D process. Therefore, it is essential to reduce the eventual influence of the 3D users, by creating boundaries regarding the workmanship of virtual garments. This can only be done with production guidelines for 3D garment simulations. Otherwise, the results of the simulations can vary significantly, from one user to the other, although they use the same basics: same avatar, pattern, and fabric.

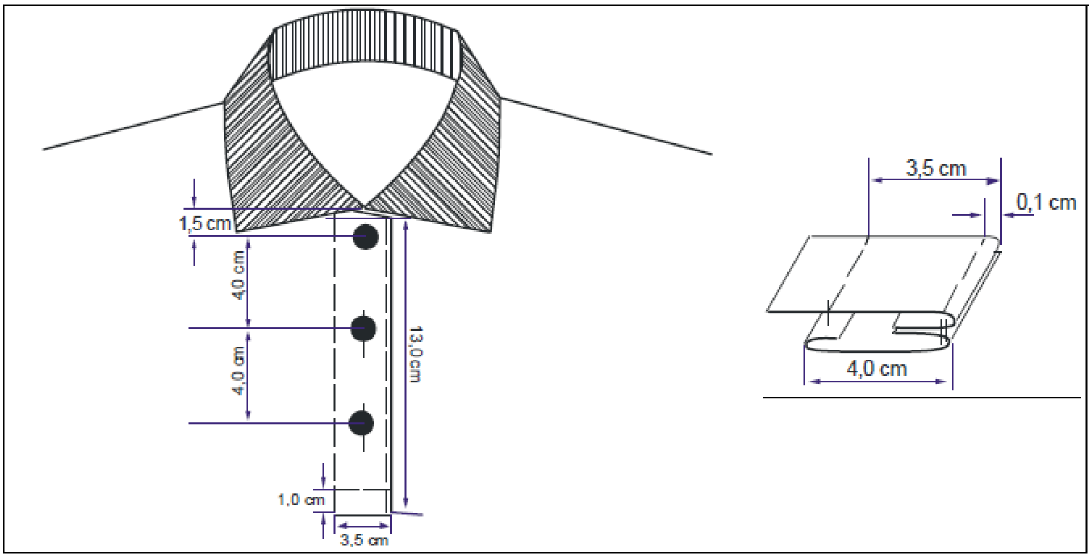

Fig. 1 Extract of Hohenstein technical specification: processing example, closure of a polo shirt.

2 Method

2.1 Method

The state-of-the-art garment simulation makes it possible to fasten the production in the fashion industry. To achieve this goal, it is essential to create virtual garments that reflect the reality. Therefore, the virtual workmanship should be as close as possible to reality [9].

Production guidelines for 3D garment simulations are needed. The aim of the guideline is to provide a practical tool that enables 3D users to achieve reliable and constant simulation's results. Because every 3D system works differently, and to achieve this practicability, such a guideline cannot be a general concept that can be used for all the 3D systems on the market. Therefore, it was necessary to focus on one 3D System. CLO3D was randomly chosen for this work. The guideline will be a step-by-step description of the processing of virtual garments, from the import of the required components to the final garment. This contains the processing order of the different parts of a virtual clothing, including the different variations possible. The aim of the description was to enable any 3D user, no matter the skill level (beginner, advanced or expert), to achieve the save simulation's results using the guideline.

The skill levels were categorized as follow:

- Beginner – user that has completed the basic training provided by the software supplier.
- Advanced – intermediate user between beginner and expert, with experienced handling of the software
- Expert – user that have a deep knowledge of the software and can achieve very accurate and detailed simulations in an optimal time.

For an easy understanding and clarity, pattern and avatar were used in standard German size 38 (bust girth 88.0 cm) for women and German size 50 (chest girth 100.0 cm) for men. The simulation's results were categorized based on the level of precision and the simulation's time that was needed (Table 1). Recommendations on the purpose of the simulation were then made based on the appearance of the result (level of precision).

The level of precision for the simulation was defined independently of the user. It explains how detailed the simulation should be. The very low level of precision describes a simulation, where the pattern pieces are only sewn together. The low level is defined by shortcuts in the workflows, that brings satisfying results or results that are close to reality. The high level describes a virtual workmanship that is as close as possible to reality. The aim of this highest level of precision is to obtain a digital twin of the garment. A digital twin that mimics physical processes, enabling real-time analysis of various factors such as production line layout, equipment, raw materials, and finished goods [10].

Table 1. Simulation's categories and purpose based on level of precision and time.

	Level of precision	Simulation time	Description of workflow	Recommended purpose
1	**Very low, unrealistic result**	very fast	Beginner, basic	First check of design, proportions, basic block, prototype 1
2	**Low, satisfying result**	fast and efficient	Advanced, useful	Communication, Techpaks, virtual fit, from prototype 2
3	**High, realistic result**	time consuming	Expert, complex, accurate, detailed	Showrooms, webshop, virtual fit, final prototype

Along the process it was important to find the most optimal workflow for the different steps. The aim was to achieve the best result in the shortest time. Many trials were made here and the workflows with the shortest realization's time were maintained.

The concept of the guideline is to create a practical tool that can guide users through their work with 3D simulation systems. It can help companies to create standardized workflows to process their virtual prototypes and train new employees. To keep the practical character and for an easy understanding, the guidelines have more pictures and less text.

2.2 Tests

A test phase of the guidelines was necessary at the end. Three different users of the simulation software CLO3D, with the skill levels beginner, advanced and expert were asked to follow the instructions and create the described virtual garment. The results were compared regarding deviations. In a second step the guidelines were optimized to avoid those deviations.

It is also important to note that CLO3D updates the software almost weekly. Those updates sometimes bring major changes in the functionality and tools. This was also taken into consideration.

3 Results

As a result, a step-by-step description of the workmanship of each garment was created as the user guideline. The file included overviews of the different steps as well as the tools that were used. The starting points in the content of the production guidelines were:

- import of avatar and pattern,
- pattern preparation: insert of symmetry, assigning of fabric,
    - here the default fabric was used in different colors for a better distinction between the fabrics (e.g., lining, and main fabric). The final fabric was added at the end
- arrangement of pattern pieces around the avatar (Fig. 2),
- first sewing operations.

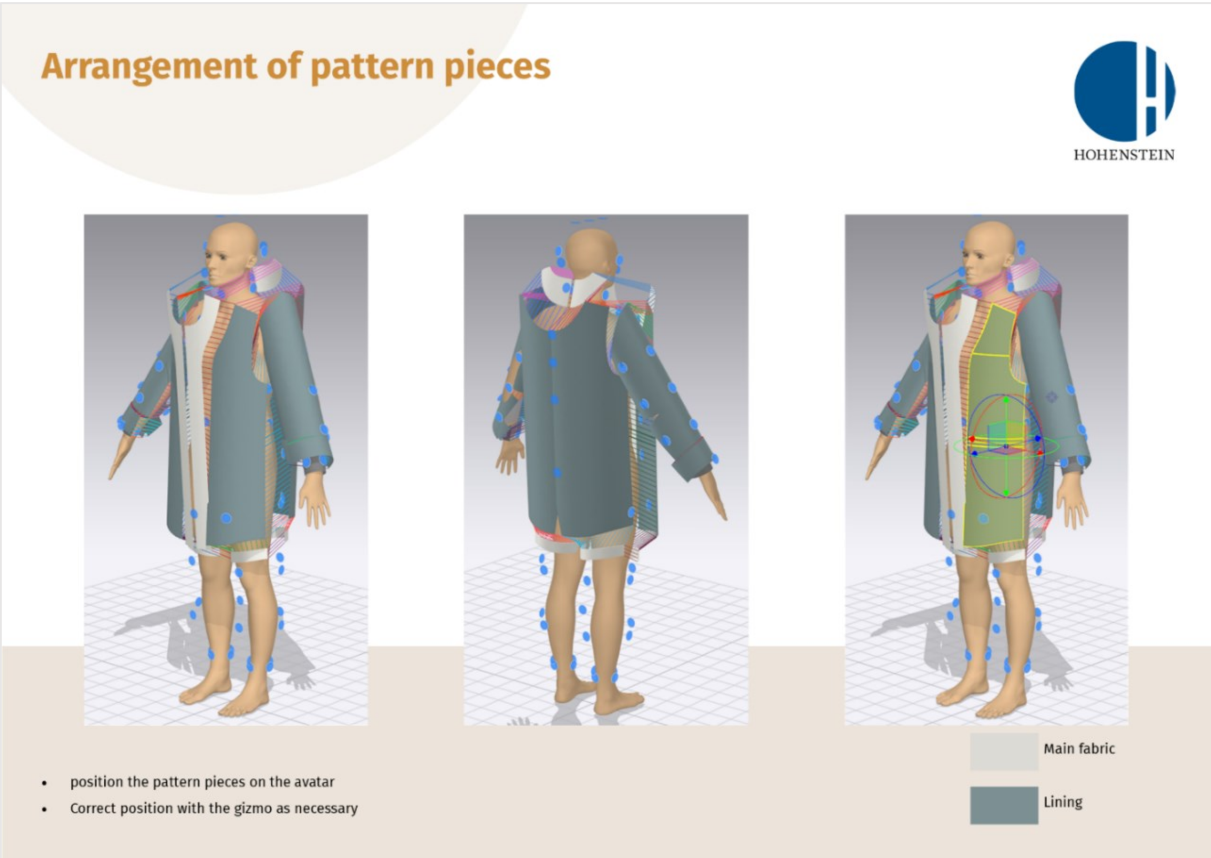

Fig. 2 First steps of the guideline, arrangement of pattern pieces around the avatar.

Through the process not only tips and tricks to speed up the workflow were given, but also settings that accompany the different working steps. Many options of operating methods were pointed out to guide the users in their choices and show the results if they decide to use one or the other method.

For specific areas of the garment, different variations of those possible virtual workmanships were shown, as well as their advantages, disadvantages, optical differences, and their applicability (Fig. 3).

Fig. 3 Extract from the production guideline of a sleeve hem cuff, complex garment winter jacket, CLO3D

Final settings were shown at the end to optimize the look of the simulation. The more details a simulation has, the slower the simulation gets. Therefore, it is necessary to apply certain settings only at the end otherwise it will slow down the whole process.

The extract of the production guideline in Fig. 4 shows an example of final settings for a winter jacket. The first two pictures are an overview of the pattern pieces (main fabric and lining). Then the final settings of the particle distance (size of the mesh) are shown underneath. The smaller the pattern, the smaller the particle distance can be. And finally, the simulation mode “Fitting (Accurate Fabric)” should be chosen for the last simulation. In this mode, the system calculates the material parameter accurately.

Fig. 4 Extract of the production guideline winter jacket, final settings, CLO3D.

The settings that can slow down the simulation and are better to be added at the end are for example:

- Reduction of the particle distance (size of the mesh)
- Adding complex hardware, trims, and accessories
- Using complex simulation's tools such as shirring, brush …
- Using the simulation mode "Fitting (Accurate Fabric)"

Nevertheless, some settings can be added before the end to refine the optic depending on the purpose (for example when partial sections of the simulation are needed for communication (see Fig. 5 & Fig. 6).

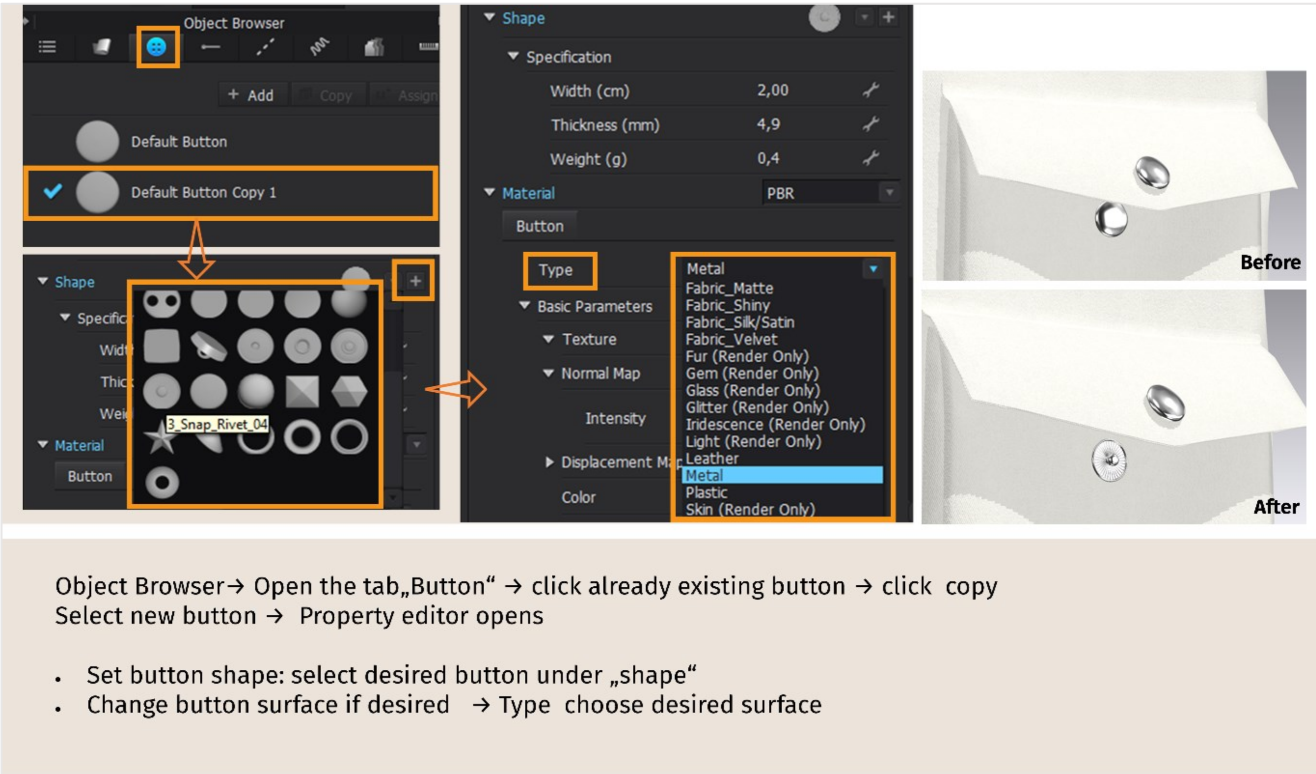

Fig. 5 Extract of the production guideline, winter jacket, buttons setting, CLO3D.

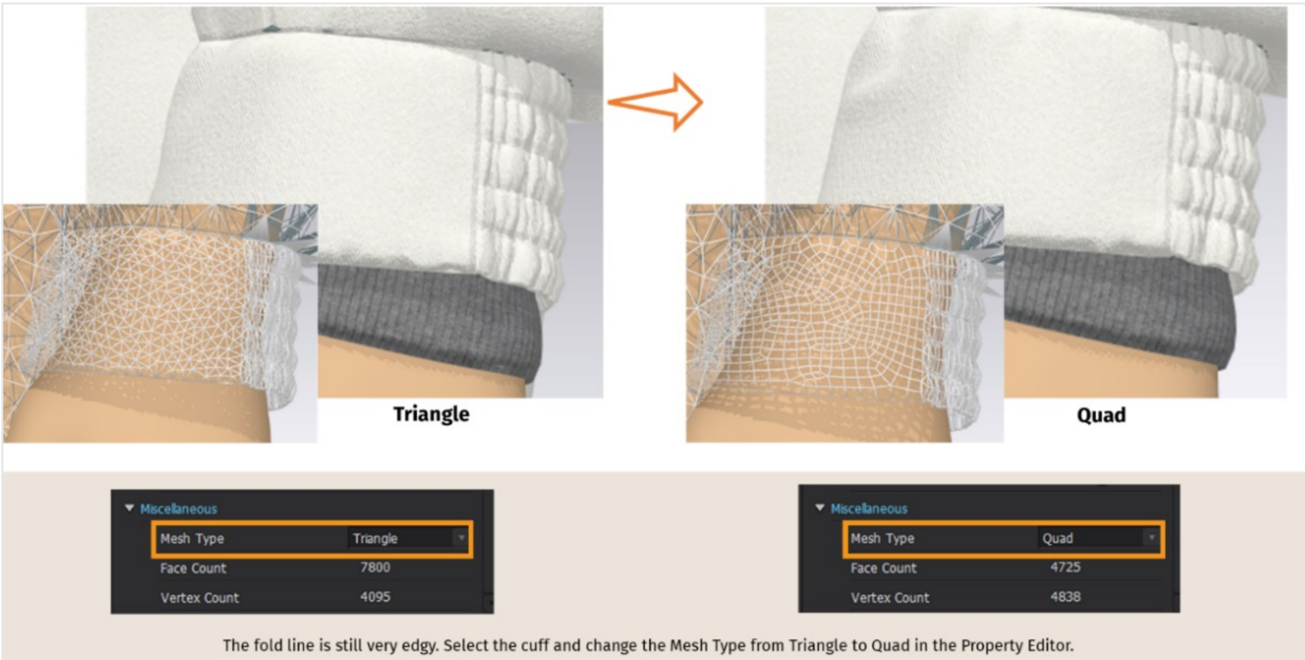

Fig. 6 Extract of the production guideline, winter jacket, cuff processing, mesh setting, CLO3D.

The production guidelines were created in the first run for basic and intermediate garments such as T-shirts, polo shirts, sweaters, hoodies, shirts, leggings, pencil skirts, dresses, and trousers. Basic garments are relatively simple and suitable for beginners. The guidelines then went on with more challenging and complex products such as winter jackets (Fig. 7) and bras.

Fig. 7 Extract of the production guideline, final result, complex garment winter jacket, CLO3D.

At the end it was possible to classify the garments in levels of complexity (Fig. 8). The more expertise the users get, the further they can go in the level of difficulty. The guidelines finally had from 35 pages for simple garments to over 200 pages for complex garments.

Fig. 8 Classification of simulations' level of difficulty in relation to the expertise of users.

4 Conclusions

It is time-consuming to create production guidelines. Yet, it enables users and companies to achieve reliable and consistent simulation's results. User guidelines lead to standardized processes.

The classification of the different variations of workflows in the guidelines can be used to set rules about the level of detail in relation to the purpose of the simulation. However, the guidelines need to be constantly updated because the 3D simulation systems improve with every update, often bringing out new functions that simplify workflows. Especially CLO3D have updates of the software almost weekly. Those updates sometimes bring enormous changes in the functionality and tools. It is advisable to take this into consideration and always write down the version in which the file was created.

A validation was not performed yet because of the intensity of the execution:

- size of the guidelines (up to 200 pages)
- finding enough users with the different skill levels
- constant software updates

Therefore, the test phase was accepted as a first step to a validation of the guideline. In the future a validation by more users is planned.

Author Contributions

Flora Zangue: conceptualization, formal analysis, investigation, data curation, writing, project administration; Anke Klepser: methodology, review and editing, supervision; Simone Morlock: resources, supervision, review; Ailing Chen: validation, draft preparation. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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