Image-based 3D Avatar for Virtual Try-on Applications

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ABSTRACT

This paper presents a fast and complete pipeline for a Virtual Try-On application. It includes a full body 3D scanning system that allows to scan a user easily with only a few manual tweaks. The proposed system also includes cloth fitting and simulation.
In the last decades, research on Virtual Try-On application has been conducted. However, the generation of the 3D avatar has proven to be a significant challenge and has limit commercial usage due to the high costs associated. Nowadays, improvements in image-based 3D reconstruction and camera hardware allow us to reduce the cost of 3D scanners drastically. In a mass customer scenario, this approach advances the vision of a complete Virtual Try-On system accessible to the general public.

1. INTRODUCTION

Nowadays, various fields such as medical and entertainment industries, education or cultural preservation are using virtual humans. Much work has been done in the computer graphics domain to push the limits of realism of virtual humans further and also to automatize the pipeline for the avatar creation. Human body modeling is a difficult task that requires manual work of designers and animators to create a 3D geometry that represent a person. In this paper, we propose a fast pipeline for human body modeling that uses recent image-based 3D reconstruction approaches.
In the last decade, the online fashion market has been growing fast. In France, for example, garments are the most traded goods in web retail. In 2012, more than 27% of online sales were clothes whereas they were less than 15% in 2007 (Gombault, 2012). A major challenge is the high return rate for this sector compared to other markets. Recently, a German study showed that four out of ten online customers expect to return a product during the checkout process. Moreover, the study also discusses the reasons for product returns (Pur et al. 2013). 38% are due to the fact that consumers ordered several variations of a garment such as colour or size to make a selection at home. 52% are related to a bad fitting of the product. Finally, in 59% of the cases, the customer returns the product because they do not like it.

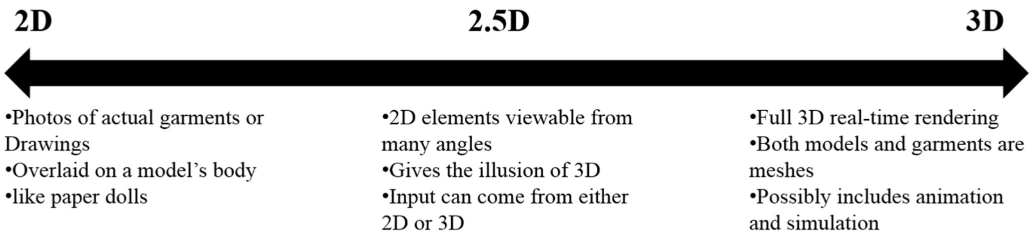


Figure 1.1: A spectrum of VTO approaches.

Virtual Try-On is one of the solutions proposed to reduce the return rate. A Virtual Try-On (VTO) is a 3D application that allows users to try on garments on a virtual representation of their own bodies (Figure 1.1). Simple approaches use two-dimensional applications that overlay 2D graphics to achieve the effect of a dressed avatar (e.g. My Virtual Model, Mimic me). More sophisticated three-dimensional applications use 3D avatars to show garments from every point of view (e.g. Modaris 3D Fit, 3D Runway). They might even include real-time physically based simulation of the garments involved to allow for the evaluation of style and fitting.

Virtual Try-On technologies are composed of many different complex tasks. They include user representation, cloth positioning, garment fitting and cloth simulation. Additionally, a digital garment prototype has to be created (Magnenat-Thalmann, 2010). Most of the existing Virtual Try-On implementation use a deformable template avatar based on user measurements. These avatars are not looking very natural, especially regarding their texture and body shape. Moreover, most of the proposed systems are deforming the cloth instead of trying to fit an existing garment to the user avatar. We propose a complete pipeline from avatar creation to garment simulation, including garment prototyping and fitting. An overview is shown in Figure 1.2, we discuss the presented details in the following sections.

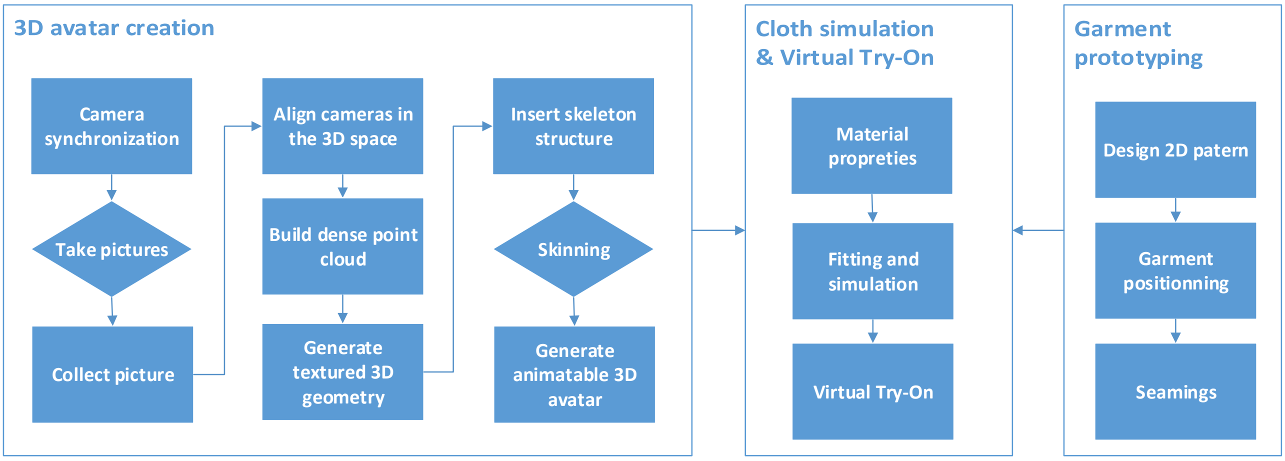


Figure 1.2: Overview of the pipeline.

First we will describe the developed 3D avatar creation. 3D garment prototyping is then detailed. Finally, we describe the cloth simulation process and its applications.

2. 3D AVATAR CREATION

The time-consuming manual process of avatar creation has been replaced over time by several techniques. Different methodologies have been proposed and can be classified into three mains categories: creative (Ratner, 2012), reconstructive (Allen et al., 2003) and interpolated methods (Bastioni et al., 2008). We propose a reconstruction based technique that uses an image-based 3D scanner to capture the user in a fast and accurate manner. The setup is movable and can be installed easily in different places. The position of the cameras can also be adjusted to change the acquisition volume. Finally, the post-processing time and the cost of the installation have been significantly decreased.
The new system is based on photogrammetry technologies. It is composed of a large number of compact cameras that are synchronized and controlled by a computer (Figure 2.1). Within less than a second, pictures of the subject are taken by the camera cluster from different angles. This very short delay during the capture minimizes user movements, which drastically reduces the noise in the generated model. The images can then be used for 3D reconstruction. Finally, a virtual skeleton is inserted into the model to be able to animate it.

2.1. Scanner construction and camera setup

Our proposed system is composed of a cluster of 80 compact cameras. They have been placed onto a hexagonal support structure. Our acquisition volume covers an adult human, and the number of cameras and their positions have been chosen accordingly. A made-to-measure green fabric has been placed over the support structure to control the light conditions and to facilitate the post-processing of the acquired data. To get diffuse light inside the scanner, flexible led ribbons have been attached to the support structure.

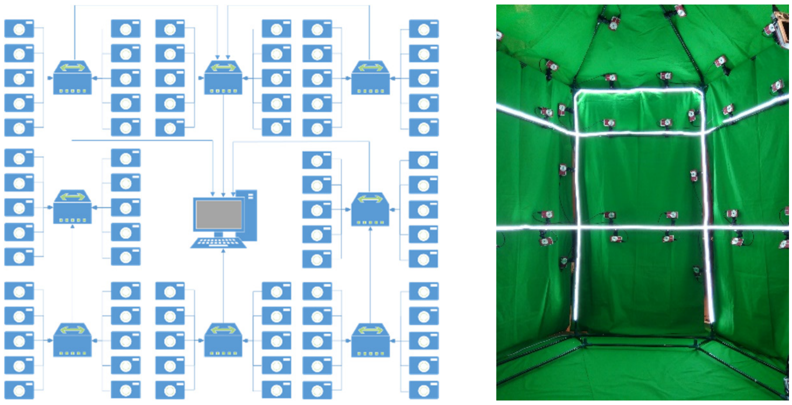


Figure 2.1: Overview of the image-based 3D scanner.

All cameras are connected to a single computer. A dedicated library has been used to control, to synchronize and to take pictures with the camera remotely (CHDK). Custom scripts have been written to remotely control and synchronize the individual cameras, to adjust the zoom, to take shots and to copy back recorded pictures to the controller computer. After a short synchronization step, we can remotely take a synchronized shots. All 80 pictures are taken nearly simultaneously within less than 200 milliseconds.
The user simply has to stand inside the structure and to hold the position for a second. Once the pictures are taken, they are automatically copied to the hard drive of the controller computer for reconstruction.

2.2. Image Processing

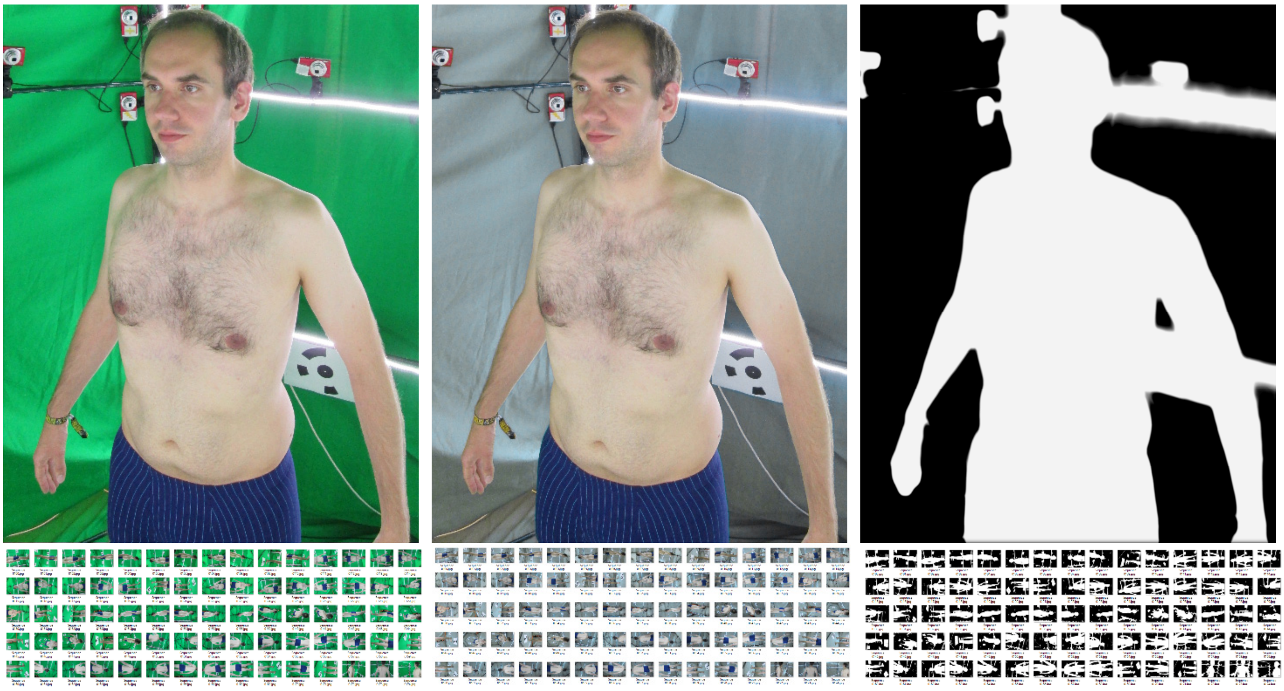
In order to facilitate the 3D reconstruction of the avatar and to reduce computational cost, we have defined an automatic pipeline to pre-process the taken images. Removing the background increases the quality of the reconstructed model as well as the quality of the texture. Furthermore, using a picture mask reduces the computation time as the quantity of data to be processed on each picture are lower. An automation of this task is crucial for high user number since a manual creation takes a long time per user and image and does not scale.

Figure 2.2: Example of mask automatically generated.

The background detection can be used to generate masks that facilitate the 3D reconstruction. As a result we obtain a black and white picture, on which the black area represent the area that can be ignored during the reconstruction whereas the white part represent important areas for the reconstruction. The mask includes the user, the cameras, and the LED ribbons.

Figure 2.3: Example of colour correction automatically generated, highlights some areas where the green reflection can be seen on the user skin.

The green fabric can be used to detect and mask the background in the acquired images. Our algorithm uses Chroma key detection to replace the green by a neutral colour. Due to the construction of the support structure, small reflections of the green fabric are visible on the user skin. We apply our colour correction technique to reduce his artefact.



Original pictures Colour corrected pictures Mask pictures

Figure 2.4: Automatic image processing.

2.3. 3D reconstruction

We are able to generate the 3D avatar mesh by using an image based 3D reconstruction software (Agisoft PhotoScan). As input, it requires a set of images. An optional mask can be used for accelerated 3D reconstruction. The process can be divided into four steps: camera alignment, point cloud creation, mesh reconstruction and texturing (see Figure 2.5).

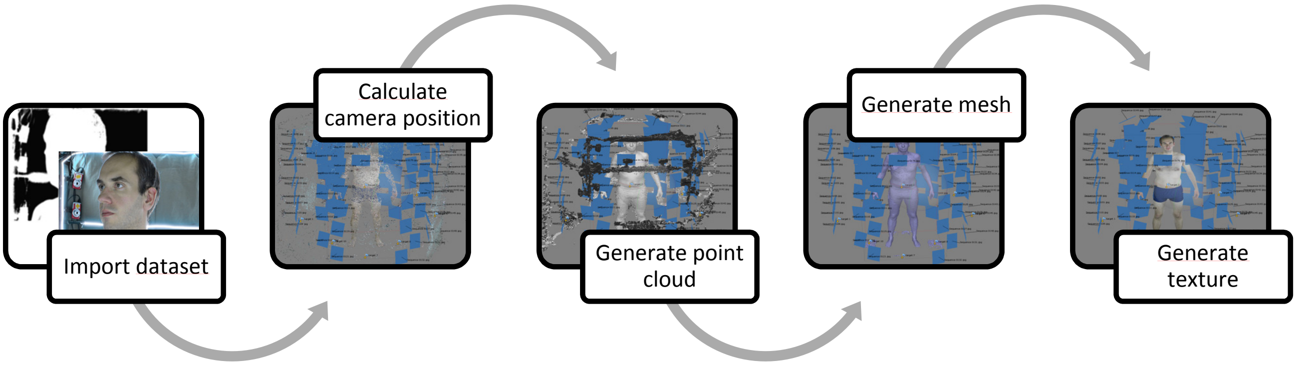
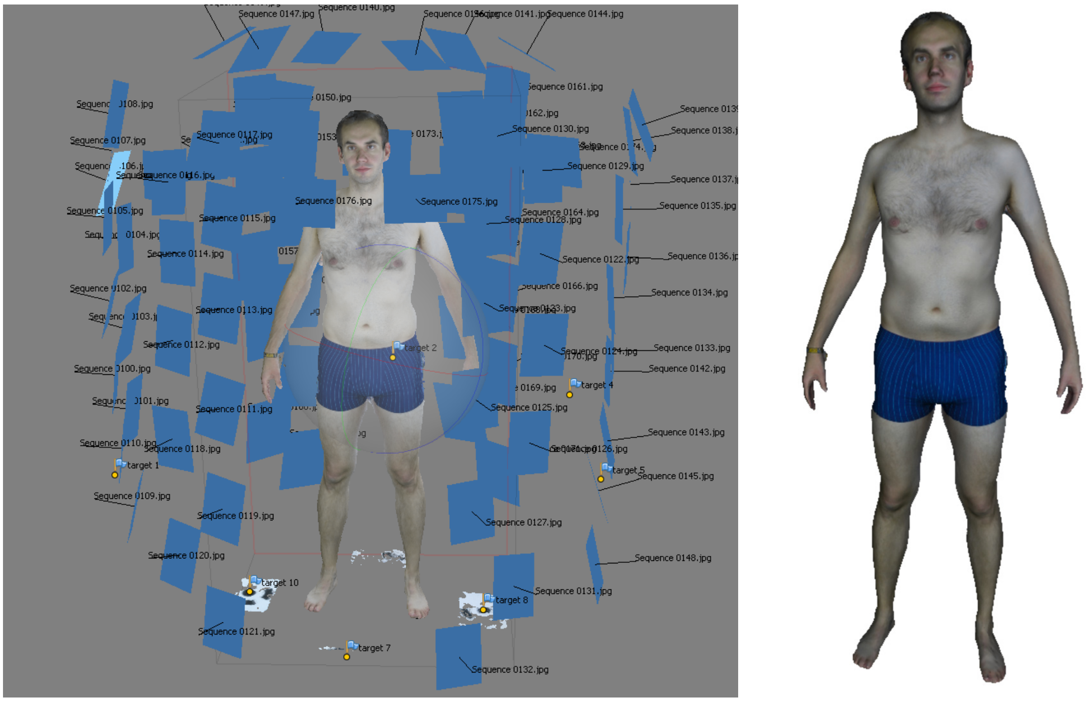


Figure 2.5: 3D reconstruction pipeline using image-based method.

The camera alignment consists of two steps. First, features are detected in all images. In a second step, the software tries to match the features pair-wise in the set of images. Therefore, a sufficient overlap of the images is needed. This can be achieved by carefully controlling position and zoom level of the cameras. Several tests have been conducted to develop our current setup.



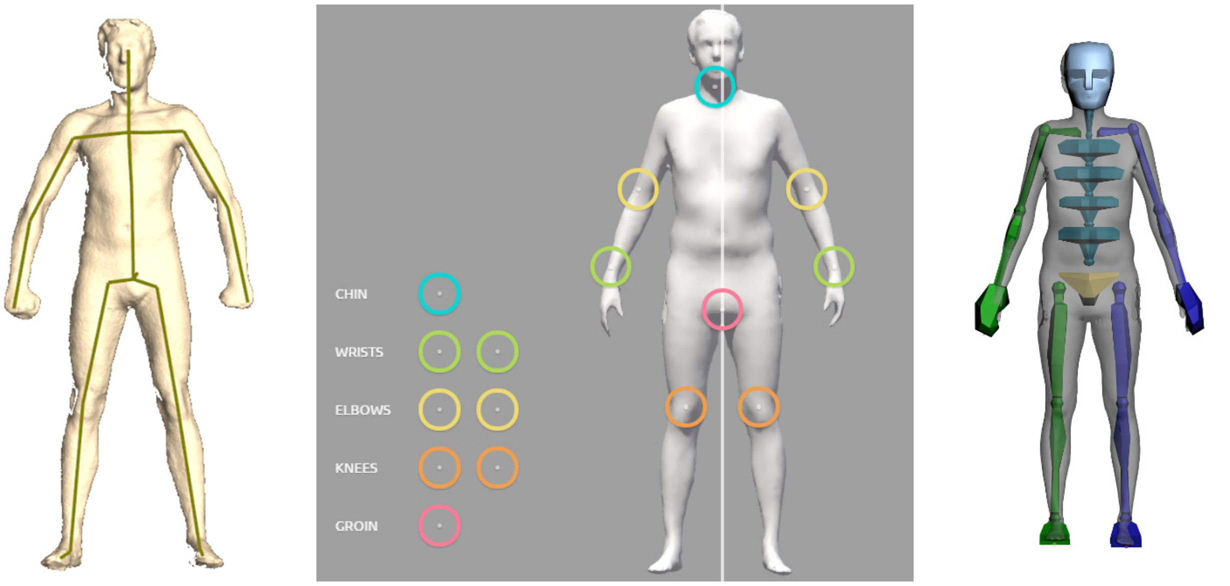
Textured model Cleaned model

Figure 2.6: Example of 3D reconstructed avatar.

We obtain a fully reconstructed and textured 3D mesh (Figure 2.6). However, small corrections are needed to remove mesh artefacts in the obtained 3D model. First, we apply Laplacian smoothing to reduce the noise and to smooth the mesh. Then, to reduce the number of polygons and to get a regular grid on the 3D mesh, we apply a Quadric Edge Collapse Decimation algorithm.

2.4. Avatar rigging

An animation structure has to be included in the created static 3D model. Several methods can be applied to get an animatable model. They include automatic rigging by using a medial axis based algorithm (Baran and Popovic 2007), a semi-automatic rigging technique (Mixamo) or by manually adding a bipedal animation structure to the obtained 3D model (3ds Max).



a. Medial axis-based b. Assisted rigging c. Manual rigging

Figure 2.7: Rigging methods.

Each technique can be used for the rigging, but the quality is higher when using manual rigging that allows to avoid well-known artefacts for complex joints such as shoulders. In scenarios with many users, an automatic or assisted rigging is needed. These approaches provide good results without needing any animation or modelling knowledge. While automated approaches are required for a large number of users, complex movements benefit from manual rigging. Therefore, the number of users is an important criterion for the selection of a technique.

3. GARMENT PROTOTYPING

Several 3D CAD programs dedicated to 3D garment modelling have been released in the last decade (eg Lectra, Gerber and Assyst). Some are animation oriented whereas other are dedicated to the fashion industry. For our VTO application, virtual garments are designed in our in-house garment CAD software Fashionizer (Volino, Magnenat-Thalmann, 2005). It can be used for fashion purposes as well as for animation. It supports the import of 2D pattern from external sources such as Lectra devices or Illustrator. It is also possible to create 2D patterns directly in the software. Then seamings between patterns are defined, and fabrics information is added. Fabric information includes fabric tensile, fabric texture as well as material properties to be used during the simulation process.

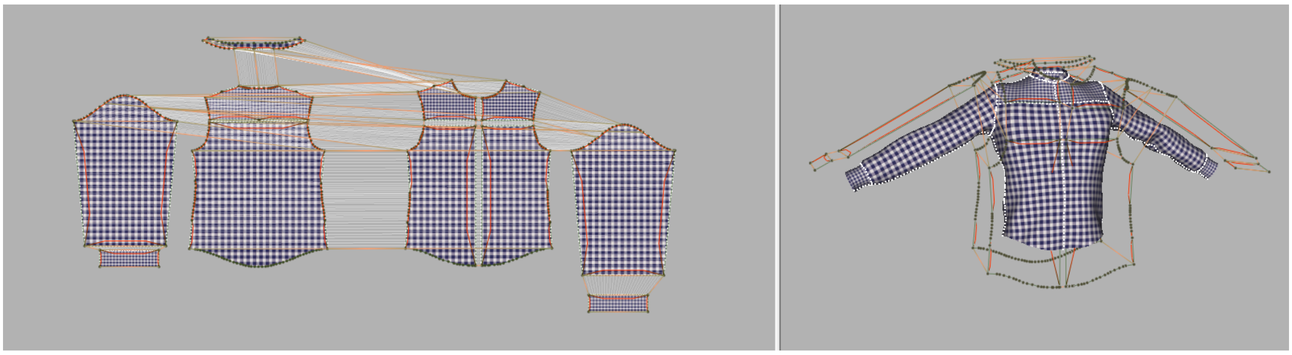
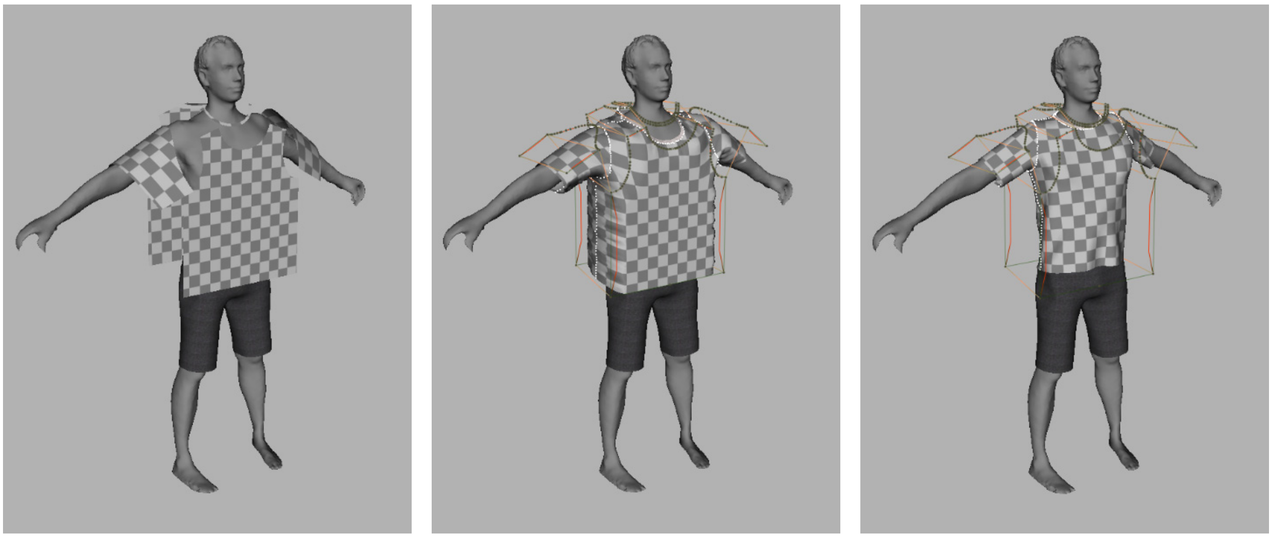


Figure 3.1: Garment prototyping from 2D patterns.

All kinds of garments can be designed using Fashionizer, complex garments may be composed of multiple layers. Moreover, small details such as pockets or a collar can be modelled.



a. 2D pattern alignment b. Virtual seamings c. Tightening

Figure 3.2: Garment alignment with the 3D avatar.

After creating a virtual garment, it has to be aligned with the 3D avatar. This process can be divided into three steps. First, the designer lays the 2D patterns over the 3D avatar. Then, based on the seaming information contained in the garment, the different parts of the cloth are attached to each other. Finally, the seamings are tightened until the correction position of the garment is found.

4. GARMENT FITTING AND SIMULATION

The cloth simulation is a complex task, it requires the calculation of the deformation of the fabric based on the material properties as well as the detection and handling of collisions between the skin, the garment and its different layers. Nowadays, the garment simulation process can be divided into two main branches: physically based deformation and geometry based deformation.
Physically based simulation requires complex and heavy computation, and can offer very precise and accurate results. Geometry based simulation is mainly used in real-time applications to animate dressed 3D avatars with only simple deformations.

We are using a physically based simulation that uses the Finite-Elements method (Volino et al., 2009). It requires carries high computational costs for estimating the position of each mesh element and for collision detection.
A multi-layer system has been proposed in order to reduce the computation costs of the simulation process. The idea is to calculate the deformation on a simplified version of the cloth to have a first estimation. Then, the results obtained on the low-resolution garment are propagated and used to complete the simulation of the high-resolution garment.

The simulation process uses physical properties of the garment to calculate the cloth deformation. The physical properties of fabric have been defined by experimental procedures, based on tensile and bending tests (Magnenat-Thalmann, 2007). We can calculate and render strain and stress state of the cloth. It gives a good estimation of the fitting of a garment. Fashionizer includes a dual view of the garment, featuring both the 2D view of the patterns and a synchronized the 3D view of the garment worn by a 3D avatar (Figure 4.1).

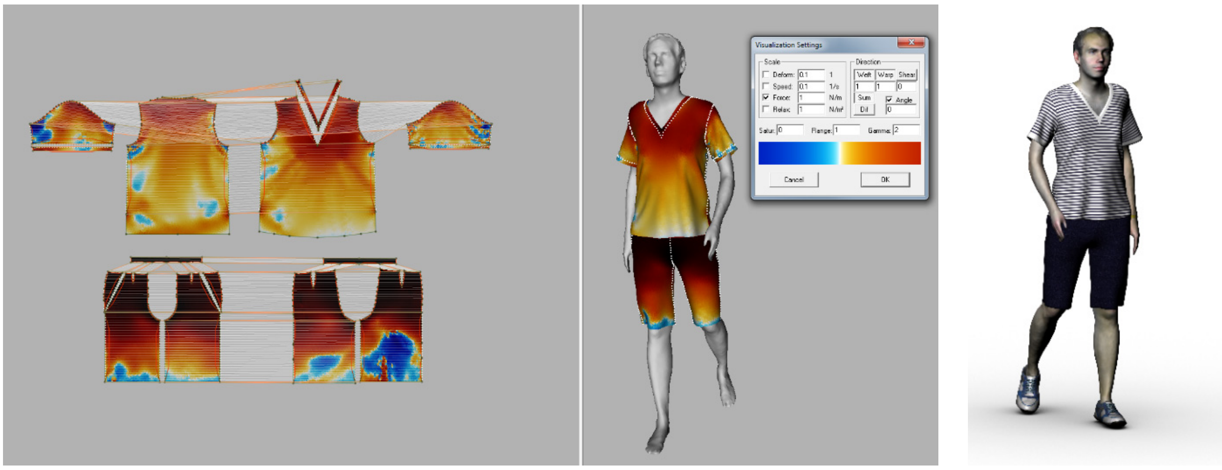


Figure 4.1: Visualization of the fitting and example of rendered simulation.

Finally, the simulation algorithm can be applied to an animated 3D avatar. Two different complexities of the simulation process can be used, one real-time and one for non-real-time rendering. The real-time version is an approximation of the physically based simulation and gives immediate results. The high-quality simulation can be calculated and rendered in Fashionizer. It is also possible to export and to render it in modelling software such as 3Ds Max.

5. VIRTUAL TRY-ON

MIRALab has developed a Virtual Try-On system over the past years. It is a real-time 3D VTO that allows the user to select and try virtual garments. In environments without a scanner available, the user can be represented by a template model deformed based on morphological parameters (Kasap, 2011). Otherwise, they can import their scan into the application.

The VTO contains a customizable garment collection. The user can navigate in the proposed dataset, select a garment and directly see it on its avatar. Additional customizations can be done, e.g. the colour of the fabric can be changed. It is also possible to dynamically change the shape of the garment. For example, the user can increase the length of the sleeves or adjust the shape of the collar. Finally, pre-recorded animations can be played on the 3D avatar. The user can see the garment fit while the avatar is moving.

Figure 5.1: Virtual Try-On desktop client with a scanned 3D avatar.

Our system supports multiple platforms, e.g. desktop machines, a tablets or phones. As the cloth simulation is an expensive process in term of computation, a distributed rendering service has been developed and was integrated into our VTO (Nijdam, 2013).
This adaptive remote rendering system allows to use the VTO in a collaborative environment. Multiple users can be connected simultaneously to the same application and interact with it by using their own Graphical User Interface. The interface and the interaction design are dynamically generated based on hardware specifications (e.g. screen resolution, input and output of the device).
Finally, a Virtual Mirror version has been implemented. The user is tracked with a Kinect sensor and can control the application by using simple gestures. They can select and customize virtual garments with their hands. The user movements are replicated on the 3D avatar, so they can move and see how the garment fit just like in a retail store.

6. CONCLUSIONS

In this paper, we have proposed a fast method to generate a virtual clone of a person for our Virtual Try-On application. Our work describes a full VTO pipeline including fast 3D avatar creation, garment prototyping, garment fitting and simulation, and our VTO application. We contribute a solution to improve 3D reconstruction by applying colour correction techniques and the automatic creation of masks.
Using an accurate representation of the user's morphology, the fitting and the simulation results are increased in comparison to template based avatars. Although template based avatars can be generated by using multiple morphological parameters (up to 26 in our case), they are not sufficient to cover all variations of the human body. Furthermore, the posture of the user is not taken into account while using a template based avatar. Having an accurate representation is an important input that is neglected in current Virtual Try-On systems.

For future work, we look into automatic positioning the virtual garment on the 3D reconstructed avatar. Currently, this task still required some manual assistance and is the missing last step to having an automatic pipeline from 3D scan to Virtual Try-On.
Our proposed pipeline can lead to commercial benefits from fewer returns. Currently, many products ordered online are returned due to bad fitting. Using our Virtual Try-On application with a 3D scan of the consumer, stores can reduce the high percentage of returns. The current limitation is access to 3D scanners for potential customers. By using our setup, costs and manual processing are drastically reduced so it can facilitate the access to such device for the public. Moreover, as the system can moved easily and set up in different places, fewer system allow to scan a large population. Finally, the avatar creation does not need design or modeling skills so that a non-expert could operate it.

7. ACKNOWLEDGEMENTS

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