

ICT Technology for Innovating the Garment Design Process in Fashion Industry

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Abstract The Italian fashion industry is nowadays subject to radical transformation; therefore, it needs to remain competitive and, at the same time, innovate itself, in order to strengthen its position in the global market. An important opportunity of innovation can be the introduction of ICT technologies in the garment design process, which today is based on traditional methods and tools. Moreover, this innovation could be particularly important for online sales, in order to reduce the customers' doubts during purchasing. The research presented in this paper describes a framework for designing clothes as realistic 3D digital models and for allowing customers to evaluate the designed clothes by using realistic virtual mannequins of their bodies instead of the standard ones. A case study will be presented in the paper. The obtained results show that the framework can innovate the traditional garment design process and it could have a huge impact on fashion industry and customers behaviours.

Keywords Virtual prototype · Design process · Cloth simulation · Body scanning · Motion capture

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1 Introduction

Fashion is one of the most important industrial sectors in Italy, and it is based on long tradition, knowledge and expertise. Nowadays, similarly to other sectors, it is subject to radical transformation, due to the rapid evolution of the fashion global market. Therefore, it needs to remain competitive and, at the same time, innovate itself, in order to strengthen its position on the global market.

In this scenario, an important opportunity of innovation can be the introduction of ICT technologies in the garment design process. Indeed, up to now, the Italian fashion industry refers to a traditional design process, based on artisans' knowledge and skills, and ICT technologies are only integrated in few phases (as for instance, the development of cutting layouts) of the development process. On the other hand, the extensive usage of ICT technologies can represent a competitive advantage, as demonstrated in other design sectors (furniture, lighting, automotive, etc.).

Moreover, this approach could be particularly important for online sales. In fact, this strategic area is not really exploited because of customers' doubts during the purchasing. While for other goods (e.g. computer, household appliances, and furniture) customers can evaluate their characteristics by checking their technical and functional features and by considering their aesthetics, for clothes they can only make hypotheses about the wearability on their body, and the fabric behaviours according to a declared "standard size".

The research presented in this paper describes a framework for designing clothes as realistic 3D digital models. The novelty of this approach concerns the combination of a set of existent IT applications (e.g., Microsoft Kinect, Blender and Clo3D), which have been integrated in order to create a unique workflow for garment design. The framework allows customers to evaluate the results through realistic virtual mannequins. Specifically, virtual models of clothes can be designed and interactively modified in a 3D environment starting from 2D sewing patterns, which are today the most used tools in the fashion industry. Furthermore, different fabrics, prints and finishing effects with realistic behaviours (facings, hems, etc.) can be applied to the virtual clothes.

Then, customers can evaluate the designed clothes by using realistic virtual mannequins instead of the standard ones. These mannequins are accurate reproductions of the body and movements of customers, since the framework integrates systems for the acquisition of body shape and movements. In an envisaged scenario, both the shape and movement acquisitions can be performed in few minutes in specifically equipped shops.

A case study developed by using the framework will be presented in the paper.

2 Related Works

2.1 *Garment Design Process in the Fashion Industry*

The design process in the fashion industry can vary depending on the category of products to develop (haute couture or ready-to-wear). However, in general, the process begins with the collection of information and inspirations and, then, the conceptual phase, which consists in the definition of the type of products, and the generation of the first ideas of products. Therefore, designers create some first sketches, in which information about materials, finishing etc. are also integrated.

In the following phase patterns are developed from scratch or, more typically, by modifying existing ones. A pattern is the graphic representation of the structure of a cloth, and it is at the base for the next phases of the design and manufacturing process. Through these first patterns it is possible to create the physical prototype of the cloth and, in an iterative process, modify the prototype and the patterns up to the definition of the collection.

Then, some phases are required before the manufacturing process. Specifically, in the grading phase the patterns of the cloth in all sizes are developed, while in the placement all the developed patterns are placed on the fabric in order to reduce the scrap during the cutting. Finally, we have the production phases constituted by tissue preparation, cutting planning and execution, sewing and finishing, which includes operations, such as adding details, and ironing.

The phases of patterns creation (or modification), grading, placement and cutting planning and execution have been converted from “on paper” to digital, and are now widely supported by 2D CAD/CAM systems (e.g., Lectra Modaris—www.lectra.com). However, no changes or optimization strategies concerning times and costs have been introduced in the traditional design process.

2.2 *Methods and Tools for 3D Shape Acquisition and Body Motion Tracking*

A full virtual clothing design environment requires the acquisition of customer’s body. Three steps are required: 3D body scanning, motion capture and 3D rigging to link the skeleton of animation to the 3D body model. Regarding 3D customer acquisition, many commercial solutions are available with different costs depending on their precision, accuracy and operating principle [1]. In this research work, we mainly focused the attention on low-cost devices. Consequently, a marker-less motion capture system based on four Microsoft Kinect v2 devices has been exploited as tool for acquiring the customer’s body together with Skanect (<http://skanect.occipital.com/>, Skanect), which exports the 3D model in an OBJ file.

Another technology concerns motion capture to acquire customers’ movements. Two different solutions have been considered. The first relies on the use of two

Microsoft Kinect v2 sensors together with iPiSoft (<http://ipisoft.com/>) to track and elaborate data and come up with usable results. It permits to export a BVH file, which contains all information and data relative to both the skeleton and associated animation. The second solution implies using the optical motion capture system Optitrack (<https://www.optitrack.com/>). This system allows capturing the human movements by means of specific cameras that are able to follow the position of spherical infrared-reflecting markers located onto the customer's body.

For the last issue, Blender (<https://www.blender.org/>), an open source 3D modelling and animation application, has been used to manage body animations and automatic association of an animation to the 3D human avatar [2]. Blender is also used to export/import 3D models in several animation format, such as BVH, C3D and DAE. These formats are the most common to manage motion capture in several commercial Mocap systems, such as iPiSoft and Optitrack.

2.3 *Virtual Prototyping of Clothes*

Virtual Prototyping (VP) is widely used in the design process and in other application fields, from engineering to medicine, and has already proven its effectiveness for the evaluation of the design solutions of new products [3, 4].

In recent years, in the fashion industry, the impact of VP is growing and more and more companies are using software for the development of virtual prototypes of clothes. Systems for creating virtual prototypes represent a significant change in the design process by reducing the number of 2D drawings, the cycles of the design process and allowing the definition of patterns directly from the 3D cloth. By using these tools, indeed, it is possible to create in a very easy and fast way the 3D model of clothes starting from 2D patterns, and then modify it, apply textures and finishing effects and so on. These 3D models are realistic representations of clothes, because they simulate the real behaviours of pieces of fabrics affected by different kind of cuts, seams, finishing effects in order to verify the real behaviours of clothes, the wearability and, also, the aesthetic appearance. Usually these possibilities are obtained through the numerical simulation of fabrics. The main advantages are the reduction of costs and times of the design process and of the number of physical prototypes necessary for the collection. These systems have initially developed and validated in the academic world [5–7].

Today, on the market there are several tools for the 3D modelling of clothes. The most important ones, according to their characteristics and distribution, we have Optitex (<http://optitex.com/solutions/odev/>), Brow |z| wear (<http://www.browzwear.com/>), Lectra (<http://www.lectra.com/en/fashion-and-apparel>), and CLO3D (<https://clo3d.com/>).

3 Research Hypotheses and Experimental Framework

The research presented in this paper describes a framework for designing clothes as realistic 3D digital models. The framework allows customers to evaluate the results through realistic virtual mannequins.

The authors focused on the definition and development of an “automatic process”. In this process, virtual prototypes of clothes, in different sizes, are developed by designers while, on the other hand, it is possible to easily and quickly acquire the body and movements of customers. Then, these elements are integrated into a unique virtual environment.

As a result, the phases of the process can be divided into two main areas: *acquisition of body and movements of customers and file processing* and *development of virtual prototypes of garments and integration of customers’ virtual mannequin*.

These phases are graphically summarized in Fig. 1 and are detailed in the following paragraph, in which one of the practical examples developed by using the framework will be presented.

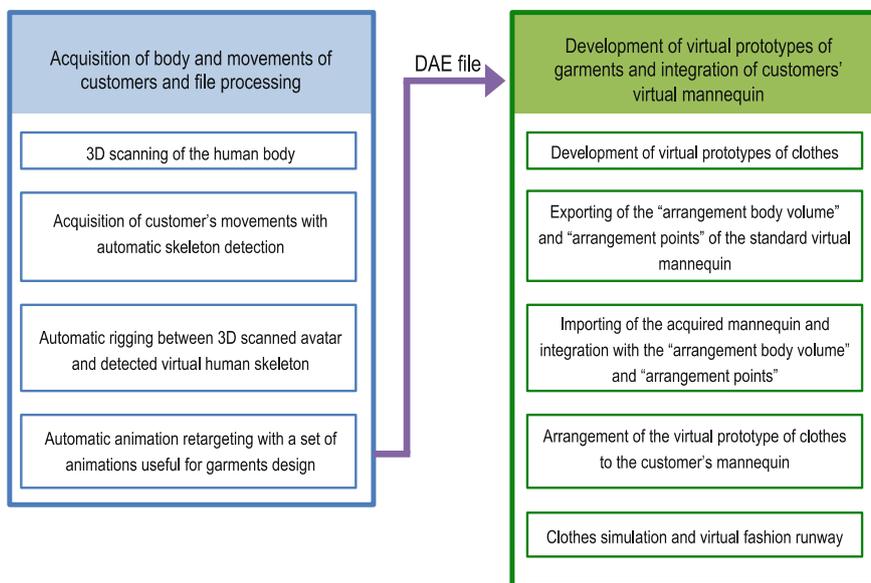


Fig. 1 Structure of the experimental framework

4 Case Study

The above-described framework has been defined via several experiments in which each part has been developed separately. Then, the authors decided to perform an experimental case study in which all the phases have been carried out sequentially to simulate the complete process. Specifically, the body and the movements of a customer (a man) have been acquired, the virtual prototype of a shirt has been developed on a standard mannequin and, finally, it has been put on the acquired mannequin.

4.1 Acquisition of Customer's Body and Movements

Firstly, customer has to maintain the T-pose for 2–3 min, in order to acquire his/her body shape, and then to walk for a while in a room to allow the system to acquire his movements. In both cases, the acquisitions were performed using the Microsoft Kinect v2 sensors together with iPiSoft solution already presented in Sect. 2.2. Then, we executed the “3D rigging” between the customer's avatar and the detected virtual human skeleton and the “animation retargeting” with a set of animations useful for garments design, such as position of arms and shoulder.

Automatic rigging and automatic animation retargeting are crucial issues and ad hoc software modules that permit to automatically executed these operations. They have been implemented by using the open source software Blender.

The 3D rigging prepares the mesh for animation by organizing the mesh points in vertex groups. Animation retargeting allows translating an animation from a skeleton to another one, which can have either the same or different set of bones. This is necessary when the skeleton of the acquired human avatar is different from the skeleton used for animation and occurs when the animation is acquired with marker-based motion capture system, such as Optitrack.

Figure 2 shows the procedure based on Blender that permits the automatic association of an animation to the 3D model of the human body. First, the acquired skeleton is linked to the 3D human avatar in the correct position. Then, the vertex groups are generated and populated according to the position of each vertex to the nearest bone of the skeleton. When the automatic 3D rigging is completed, the skeleton can be moved and the 3D human avatar is animated accordingly (Fig. 2a).

The procedure generates a DAE file containing both animation and 3D mesh (Fig. 2b). The generated DAE file is the input for 3D environment for clothing design (Fig. 2c).

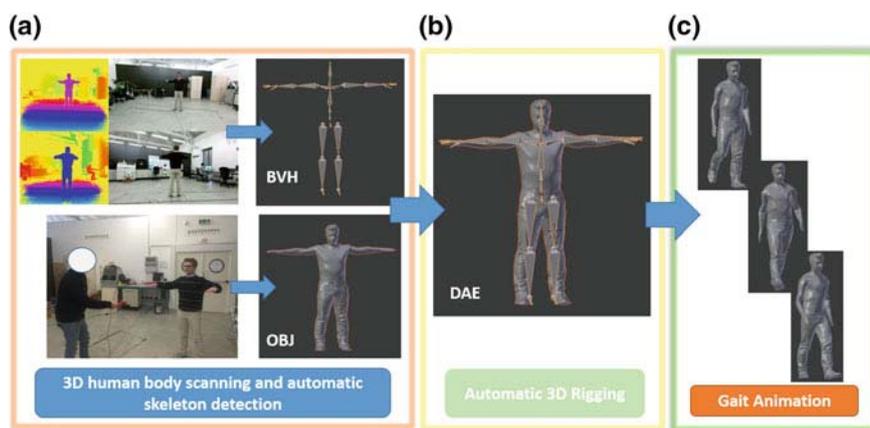


Fig. 2 Main steps of the first phase of the experimental framework

4.2 Development of Virtual Prototypes

The operative workflow of the second part of this process consists in the following main steps:

- Development of virtual prototypes of clothes (in different sizes);
- Exporting of the “arrangement body volume” and “arrangement points” of the standard virtual mannequin;
- Importing of the acquired mannequin and integration with the “arrangement body volume” and “arrangement points”;
- Arrangement of the virtual prototype of clothes to the customer’s mannequin.
- Clothes simulation and virtual fashion runway.

Concerning the virtual simulation of clothes, among the commercial software for cloth simulation, the authors selected CLO3D as the most appropriate one for the purpose of this research work. One of the most important characteristics of this software is the real-time simulation of the cloth behaviour (not only aesthetically, but according to the characteristics of the fabric and cuts). CLO3D allows the creation, importing and modification of patterns; then, it is possible to put the cloth on a virtual mannequin and start the simulation. Each pattern can be modified in 2D, and it is possible to define some different characteristics of the cloth, such as the kind of fabric, of sewing, of texture, the hems, the presence of buttons, of different layers of fabrics and so on. Finally, it is also possible to create a virtual runway show. Thanks to this tool it is possible to save time, mainly for what concerns the first part of the process, in which many modifications of the patterns can be necessary before reaching the desired result.

Then, in the first step of this second phase, the authors developed the virtual prototype of a shirt on a standard mannequin of CLO3D. Specifically, the virtual

mannequin (a woman) has been modified in a man, and its height and other body sizes have been changed in order to be similar to those of the acquired customer.

Specifically, the patterns of the shirt, in a .dxf file, have been imported in CLO3D. Then, the patterns, displayed in the 2D part of the CLO3D interface, have been sewn (in 2D) and then put on the virtual mannequin by using the “arrangement points”, which are specific features of the standard virtual mannequin in CLO3D. By using these points, the software is able to recognize the front and the back of the garment and the torso and the back of the avatar.

Therefore, the authors started the simulation, in which the various patterns are sewn together and adapted to the mannequin, also according to the characteristics of the selected fabric (in this case cotton). The described procedure is the same normally used in CLO3D and the results, with two different colours, are shown in Fig. 3.

The following step concerned the exporting of the “arrangement body volume” and “arrangement points” of the standard virtual mannequin, in order to use them for the acquired mannequin. It has been verified, in fact, that the imported mannequins from the DAE file do not automatically incorporate these features, which have to be specifically created. The “arrangement body volumes” are graphically represented as green cylinders, while the “arrangement points” are blue points (arrangement points are shown in Fig. 4b). CLO3D needs the setting of these features in order to easily fit the developed cloth on the human body. CLO3D allows increasing or decreasing their number, but we have exploited the standard ones during this case study in order to demonstrate the ease of use of the proposed method.

Subsequently, the DAE file generated in the first phase of the process was imported as avatar to replace the standard one. In the following, the authors

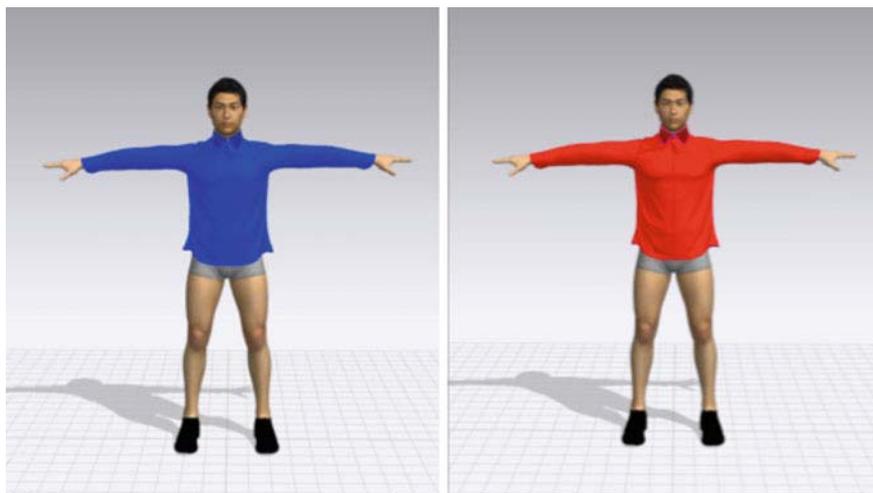


Fig. 3 The shirt on the standard mannequin

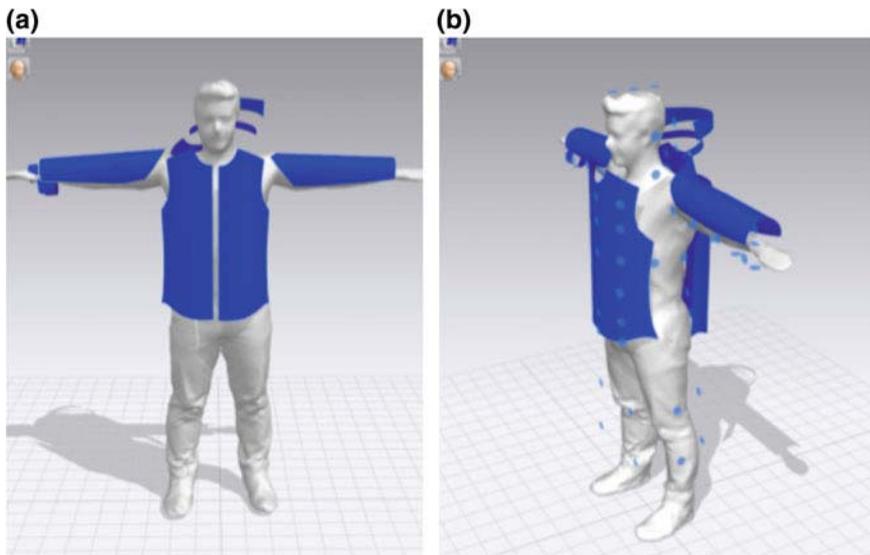


Fig. 4 The shirt patterns attached to the attachment points of the acquired customer

re-imported and associated to the mannequin the “arrangement body volume” and “arrangement points” previously exported. Then, the previously simulated shirt, which had lost the reference points, has been put onto the virtual mannequin of the customer (each pattern of the shirts has been attached to a specific imported attachment point, see Fig. 4a, b). As a result, the simulation of the garment on the

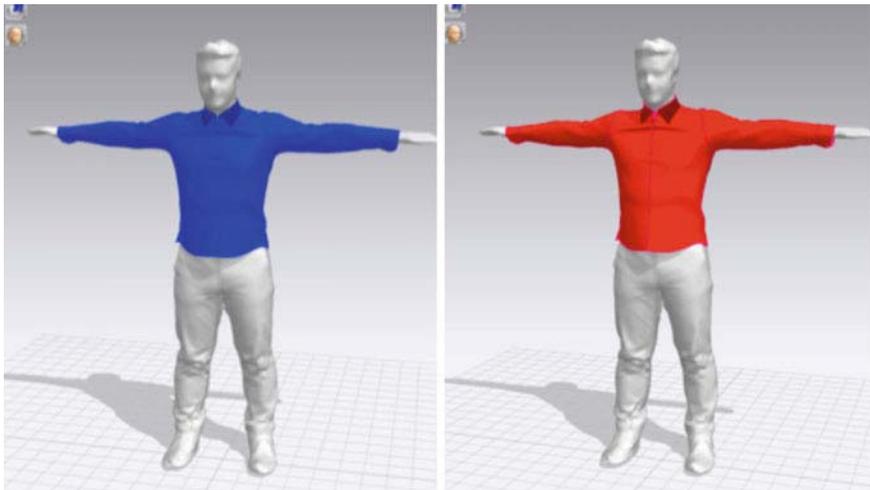


Fig. 5 The shirt on the acquired customer

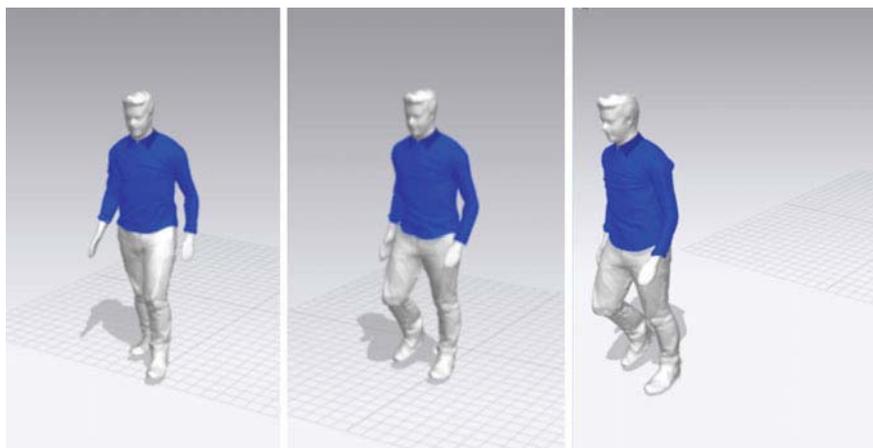


Fig. 6 The final virtual fashion runway

imported mannequin was started and the virtual prototype of the shirt on the virtual mannequin of the customer has been automatically generated (Fig. 5).

Finally, since the DAE file also contains the movements of the customer, the authors started the virtual fashion runway, in which the virtual mannequin performs exactly the captured movements and wears the shirt (Fig. 6).

5 Conclusion

Fashion is one of the most important industrial sectors in Italy, but it is subject to a significant transformation caused by the evolution of the fashion global market. Even if it is still based on traditional processes and on tailors' knowledge, it needs to innovate to remain competitive in the global market. This is also related to the new possibilities given by the online sales, by using which, it is possible to reach customers everywhere and at any time. However, many customers are not comfortable in buying clothes online, due to the fact that it is difficult to evaluate their quality and also their wearability on their body.

The research presented in this paper focuses on the introduction of Virtual Prototyping methods in the garment design process both for innovating and optimizing it and for allowing customers to evaluate clothes through realistic virtual mannequins of their bodies.

Specifically, the paper presents a framework for acquiring customer' body and movements, for creating virtual prototypes of clothes and for integrating these two elements in a virtual environment through a case study.

The results obtained are both methodological and practical. The framework will innovate the traditional garment design process used in the fashion industry and it could have a huge impact on fashion industry and customers behaviours.

Indeed, by using this framework, fashion companies will be able to create their own collections faster, also reducing design process timing, costs, and the number of prototypes to be made. In addition, customers will easily obtain their realistic virtual mannequins, with realistic movements, for performing online purchases in a more reliable way.

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