Title:
A Virtual Environment to Emulate Tailor's Work

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Introduction:
Virtual clothing environments have been made available on the market through the enhancements of 3D technology. In particular, 3D body scanners and applications for virtual clothing modeling and simulation have been developed and introduced into the fashion industry. Both 2D and 3D CAD/CAM systems are used to design virtual clothing and textiles [4][10]. 2D CAD systems permit to design the 2D patterns of the final garment; then, by using 3D CAD system they can be assembled to generate and emulate the behavior of the virtual garment on a 3D human avatar. Furthermore, many companies are using IT solutions (e.g., PLM suites) systems to improve product development process and reduce costs. However, some of these solutions, especially 3D CAD systems for garment design are still far from be extensively used in the clothing industry, due also to the skilled-labor dependent nature of apparel design.

In this paper we focus the attention on the first step of the garment design process during which the tailor takes customer's measurements by using a tape measure. This task heavily relies on tailor's experience and permits to realize highly customized garments that will fit the customer's body. There are some solutions that derive such measures automatically from body-scanner acquisitions; however, problems still remain.

Research aim:
Our aim is to develop a virtual environment, named Taylor LABoratory-TLAB, based on mixed reality technology to emulate the work made by tailors during the traditional garment design.

Several IT devices for mixed reality applications have been developed, such as head mounted displays and hand tracking devices. Head mounted displays allow the visualization of 3D environments by emulating the depth sense through the use of stereo cameras. Hand-tracking devices permit the detection of hands and parts of hands into 3D space with high precision. Among several available devices, we considered low cost solutions, and precisely: Microsoft Kinect v2 [7] as body scanner (Fig. 1.a.), Leap Motion device [6] as hand-tracking device (Fig. 1.b.) and Oculus Rift [9] as head mounted display (Fig. 1.c.).

In our solution, the Microsoft Kinect v2 is used to acquire the customer's body shape. During the acquisition, Microsoft Kinect v2 detects the different parts of the human body creating the virtual skeleton, which will be used to animate the model and define body postures according to the tailor's needs. The Leap Motion permits to interact with the acquired body model by hands or thin objects held in hand to get the customer's measurements. Finally, Oculus Rift is used to visualize the 3D virtual mannequin/human-body shape and the whole 3D environment for garment design. All this should permit to emulate the tailor's task during which s/he uses hands to get the measures on the customer's body also in specific postures in order to design a customized garment.

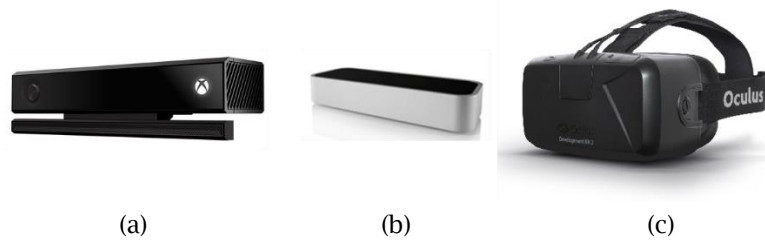(a)   (b)   (c)

Fig. 1: Adopted Low cost devices.

Software development of TLAB:

TLAB includes a set of automatic or semi-automatic operations the tailor can apply to get measures on the customer's avatar acquired with the body scanner. To this end, various animations are available to emulate traditional body posture according to the different types of garments (e.g., shirt, pant and jacket) and they are applied automatically to avatar's mesh in the virtual environment. A virtual tape measure had been developed and an ad-hoc Natural User Interface has been designed and implemented in order to simply interact with virtual objects (
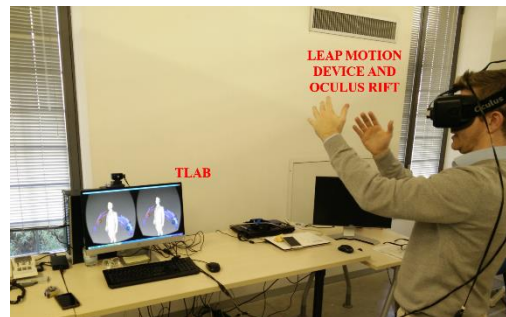Fig. *2*.).

Fig. 2: Interaction with VLAB using hands.

TLAB has been implemented using low-cost and free IT solutions for both hardware and software and developing ad hoc modules also based on software solutions realized in previous research works [2][3]. The software architecture (
Fig. 4.) has been entirely implemented using C++ language. The development has been done starting from a set of software development kits. TLAB comprises:

- **3D acquisition** of human avatar and skeleton recognition by Microsoft Kinect Fusion. It makes available 3D object scanning and model creation using the Microsoft Kinect v2. The user can get a scene with the Kinect camera and simultaneously see, and interact with, a detailed 3D model of the scene.
- **Hand-tracking** using Leap Motion SDK. It makes available a set of modules to easily detect a broad type of gestures. In order to make the interaction simple and comfortable, a research study has been made to design the best Natural User Interface (NUI) for application based on interaction by hands. The developed NUI is based on the SDK of Leap Motion as well as an ad-hoc developed module that extends the C++ class of VTK to interact with the virtual environment of TLAB.
- **Immersive vision inside a 3D virtual world** using Oculus Rift SDK 2.0. The TLAB environment is automatically visualized in the user's field of view of the Oculus Rift when 3D body shape is detected and thus, the tailor can start to take measurements using hands/fingers detected by the Leap Motion device.
- **Visualization Tool Kit (VTK).** TLAB is composed by a set of widgets, such as sliders, buttons and the virtual tape. The virtual tape measure is a virtual widget based on the use of a 3D line.

The user takes the measure by pinching the initial point and moving the line representing tha tape along the human avatar until he reaches the ending point. Once the virtual tape measure has been properly placed, the associated measurement is calculated and visualized visualized in the field of view of TLAB environment.

- **Blender**, an open source 3D modeling and animation application. In our application, it is used to manage body animations and automatic association of an animation to the 3D human avatar [1] in order to define different body postures. First, the acquired skeleton (Fig. 3(a).) is linked to the 3D human avatar (Fig. 3(b).) in the correct position (Fig. 3(c).). Then, the vertex groups are generated and populated according to the position of each vertex to the nearest bone of the skeleton (Fig. 3(d-e)). When the automatic 3D association is completed, the skeleton can be moved and the 3D human avatar is animated accordingly.
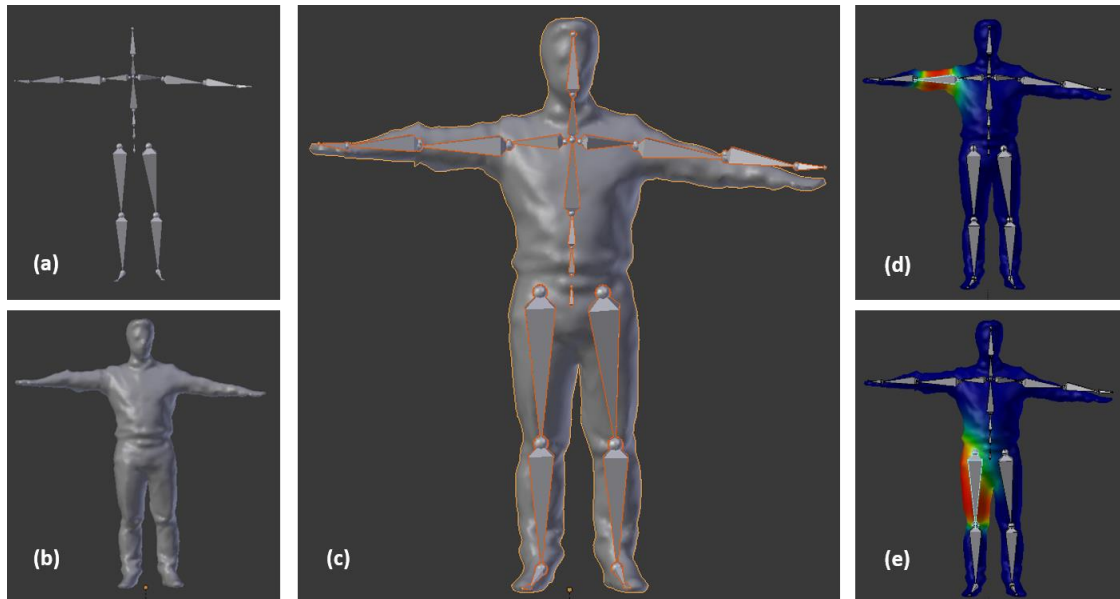

Fig. 3: 3D automatic association.

Furthermore, Blender is 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 [5] and VICON [8]. The 3D Blender engine permits the tailor to position the selected part of human avatar (e.g., upper arm, shoulders and legs) according to the required measure and type of garment interacting through the Leap Motion Device.

- **3D Animations Library**, a set of body animations (composed by BVH files) to define different avatar postures. For example, the postures shown in Fig. 5 have been obtained through two different animations that are part of 3D animations library. Once defined the correct posture, the tailor can take the measurements necessary to design, in this case, a shirt (Fig. 5.). The library is composed by several subsets of animations according to the type of garments.

- **3D Standard mannequins**. TLAB can be used starting from either a 3D human body acquired with Microsoft Kinect v2 or standard 3D mannequins; therefore is makes available a set of standard mannequins for industrial clothing design whose sizes respect the Europeans standards for both males and females.
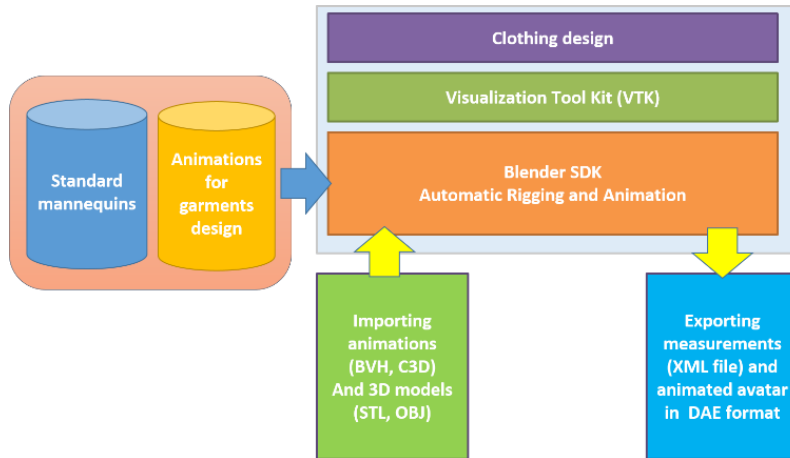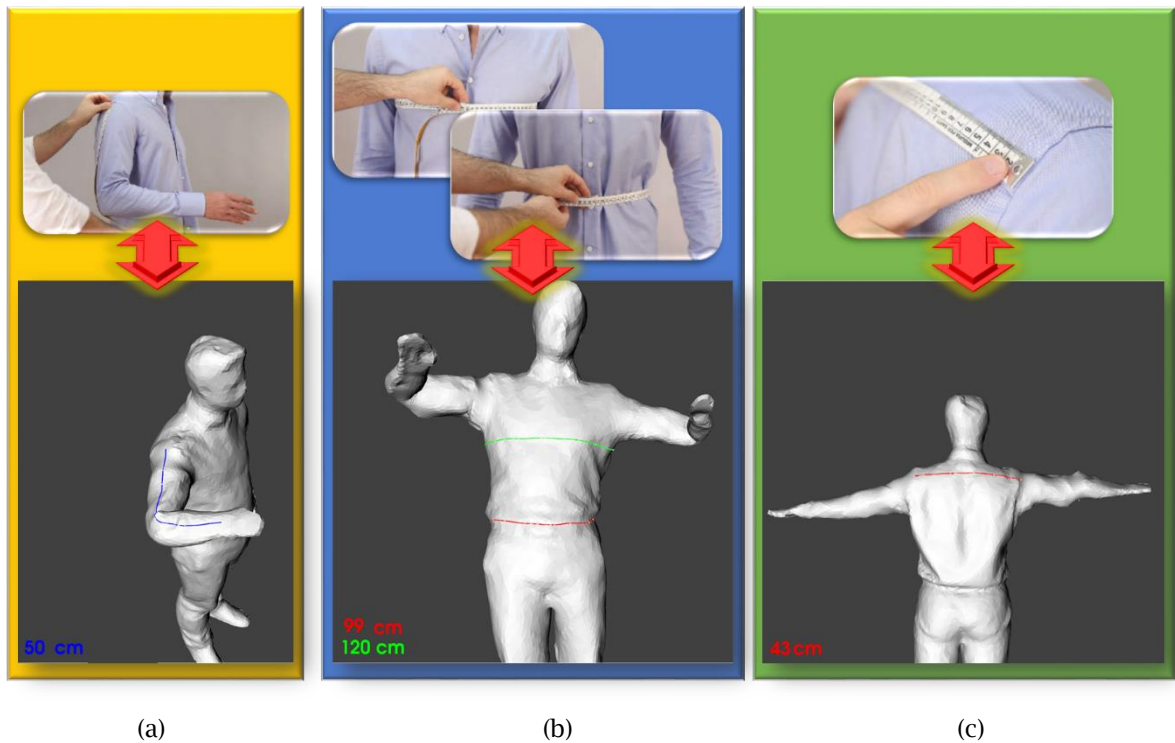
Fig. 4: TLAB software architecture.

(a)   (b)   (c)

Fig. 5: Basic measurements to design shirt using virtual tape measure inside TLAB: (a) mesaure of the arm; (b) measure of the chest (green line) and waist (red line); (c) measure of shoulders.

Finally, TLAB permits to manage the data of several measurements through a database, which can be connected with other type of applications, such as 2D/3D CAD for garments design as well as mobile applications.

Conclusion:

Preliminary tests have been made with engineering students in order to verify the potentiality of the mixed-reality solution and the new interface to interact with TLAB using the Leap Motion device. In

particular, the testers had to take two different sets of measurements in order to design a shirt starting from an acquired 3D human body model. The testers were able to learn how to interact in few minutes and the use of virtual measure tape was easy. Even if the automatic animations allowed taking measurements in a very simple way, there have been several problems about the deformation of mesh, in particular for the upper arm. In addition, difficulties have been highlighted to get measures necessary to design pants.

Future developments have been planned to add a first automatic reconstruction of a garment starting from taken measurements. Furthermore, a software module is under development to emulate the physical characteristic of the garments directly into TLAB by exploiting parallel computing. A final test has been planned with tailor of garment firm in order to validate the system.

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