Moving Statistical Body Shape Models Using Blender

Scataglini, Sofia; Danckaers, Femke ; Haelterman, Robby; Huysmans, Toon; Sijbers, Jan

DOI
10.1007/978-3-319-96077-7_4

Publication date
2019

Document Version
Final published version

Published in
Proceedings of the 20th Congress of the International Ergonomics Association (IEA 2018)

Moving Statistical Body Shape Models Using Blender

Sofia Scataglini[1,2](✉), Femke Danckaers[3], Robby Haelterman[1], Toon Huysmans[3,4], and Jan Sijbers[3]

[1] Department of Mathematics (MWMW), Royal Military Academy, Renaissancelaan 30, 1000 Brussels, Belgium
sofia.scataglini@rma.ac.be
[2] Military Hospital Queen Astrid, Bruynstraat 1, 1120 Brussels, Belgium
[3] imec – Vision Lab, Department of Physics, University of Antwerp, Universiteitsplein 1, 2610 Antwerp, Belgium
[4] Applied Ergonomics and Design, Department of Industrial Design, TU Delft, Landbergstraat 15, 2628 CE Delft, Netherlands

Abstract. In this paper, we present a new framework to integrate movement acquired by a motion capture system to a statistical body shape model using Blender. This provides a visualization of a digital human model based upon anthropometry and biomechanics of the subject. A moving statistical body shape model helps to visualize physical tasks with inter-individual variability in body shapes as well as anthropometric dimensions. This parametric modeling approach is useful for reliable prediction and simulation of the body shape movement of a specific population with a few given predictors such as stature, body mass index and age.

Keywords: Statistical body shape modeling · Digital human modeling Blender · Motion capture

1 Introduction

Statistical body shape modeling (SBSM) is an intuitive approach to map out body shapes variability of a 3D body anthropometric database. The shape variance is described by shape parameters, which can be adapted to form a new realistic shape. Furthermore, body shapes belonging to a specific percentile of a target group, can be visualized.

Body shape modeling can be classified as static or dynamic. Static represents the human body at one particular pose like standing or sitting. Dynamic shape modeling deals with shape variations due to pose changes or a subject moving during scanning. Body shape variation can be decomposed into rigid (associated with the orientations and positions of the segments) and non-rigid deformation (e.g. changes in shape because of soft tissues associated with the segment in motion) [1].

Nowadays, an inertial motion capture system (mocap) can capture the movement of a subject during a physical task [2]. This information can be translated as a skeletal animation as a Biovision Hierarchy (BVH) character animation file [3]. Commercial

S. Bagnara et al. (Eds.): IEA 2018, AISC 822, pp. 28–38, 2019.
https://doi.org/10.1007/978-3-319-96077-7_4

modeling tools (e.g. Autodesk Maya, Autodesk 3dsMax) and Open-Source software (Blender) can be used to integrate the body shape with the motion [4–6].

The 3D modeling software includes programs and tools for animation, simulation, rendering, video editing, motion tracking and game creation. Human activities can then be replicated based on body shape and a motion data collected on a subject. This provides a visualization of a digital human model based upon anthropometry and biomechanics of the subject [7].

In this paper, we propose a new framework to integrate the movement acquired by the inertial motion capture system with a statistical body shape model (SBSM) using Blender version 2.78 [4]. This allows product designers, ergonomists, and engineers to simulate realistic human behavior [8]. The data-driven human activities can be included into scenarios in a virtual environment to visualize whether particular tasks are supported or hindered by the design.

2 Methods

In this section, a framework to create moving statistical body shape models using Blender is described (Fig. 1). First, an SBSM is built from 3D human body scans. Next, the body mesh is rigged with a BVH file. As a result, motion is added to the SBSM.

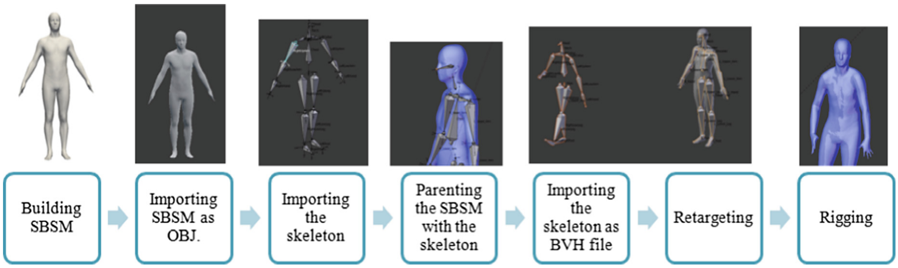

Fig. 1. A framework for moving SBSM using Blender.

2.1 Building a Statistical Body Shape Model

First, a reference surface is registered in a marker-less way to N target surfaces to obtain a homologous point-to-point correspondence [9]. Then, a statistical shape model, or principal component (PC) model, is built from the corresponded shapes [9, 10], as shown in Fig. 2. A specific feature of a person's shape, such as height, can be adapted by adding a linear combination of principal components to the person's shape vector. Furthermore, a body shape with specific features can be generated by multiplying a feature vector to the mapping matrix of the shape model [11, 12].

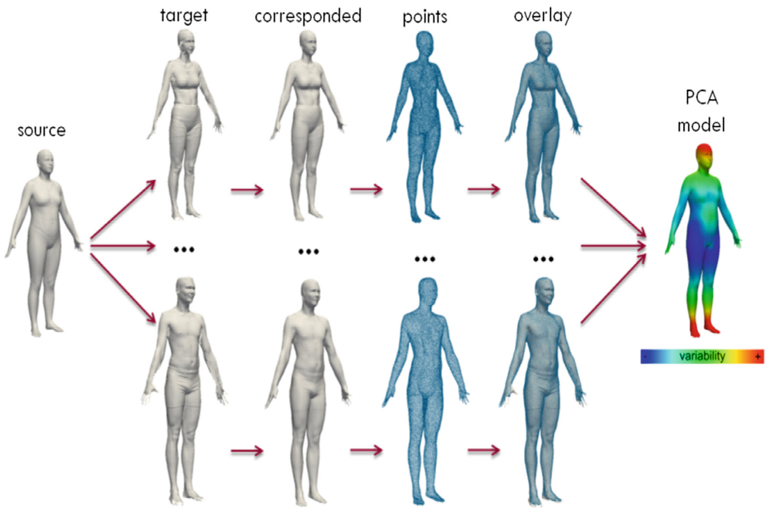

Fig. 2. Schematic overview of the building of an SBSM [9]. First, a source surface is registered to every target surface to obtain a point-to-point correspondence. From the corresponding surface, a statistical shape model is built.

2.2 Acquisition of the Subject During a Physical Task (Walking)

A mocap system can be used to acquire the subject's movement. For this experiment we asked the subject to wear a motion tracking system (17 x Yost Labs 3- Space™ Sensor Wireless Device). This system is supported by Yost Labs 3-Space Mocap Studio software in Fig. 3 [13].

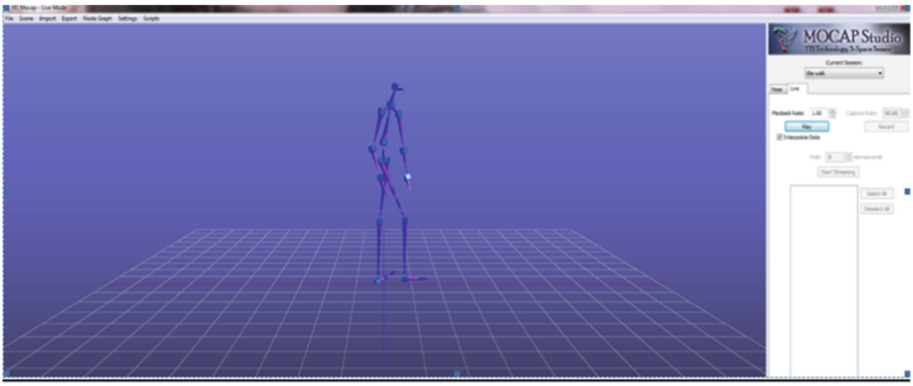

Fig. 3. YEI Mocap studio software data representation.

After an initial calibration on the T-pose, we asked the subject to walk. Motion data was recorded (number of frames: 285, frame time: 0.016 s) and exported as BVH file.

2.3 Blender Workflow

The Blender user interface is divided into three frames (Fig. 4): the toolbar, the 3D view and the tools region. The toolbar contains the following menus: File, Render, Window, and Help, the spin boxes and a short description of the Blender scene.

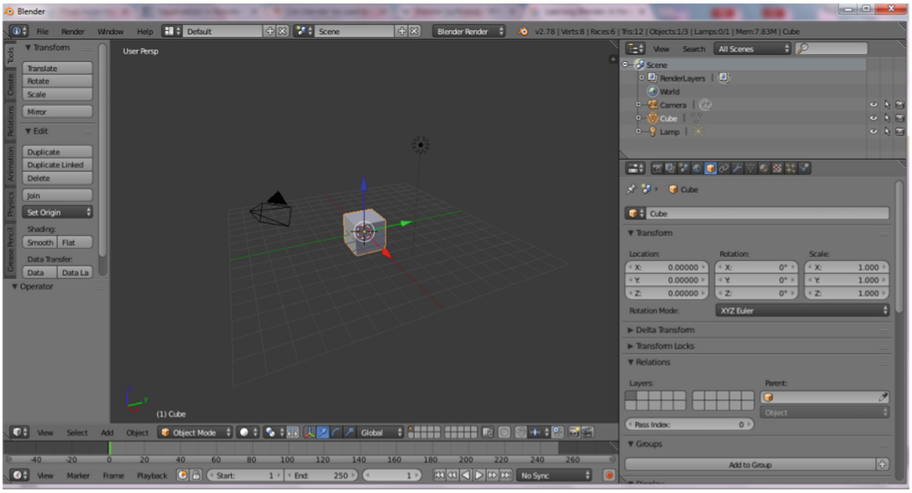

Fig. 4. Blender user interface.

The 3D view is the place where the DHM it is created. Finally, there is a tool region on the left of the panel that consists of tabs related to relations, animation, tool, physics, and grace pencil [14].

In this specific case, we defined a workflow that describes all the steps necessary to moving statistical body shape using Blender (Fig. 5):

(1) Importing the SBSM.

In this step the SBSM previously created is imported in Blender as an OBJ file from the Menu: Info Editor ‣ File ‣ Import/Export.

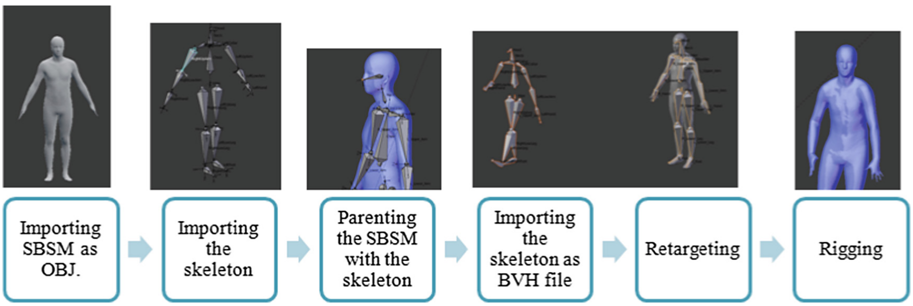

Fig. 5. Blender workflow.

(2) Importing the skeleton from the mocap system into Blender.

The skeleton from YEI Mocap is imported in Blender as an OBJ file from the Menu: Info Editor ‣ File ‣ Import/Export.

(3) Parenting the SBSM with the skeleton.

The humanoid mesh is aligned with the skeleton. In order to have the humanoid mesh assigned to the different bones that compose the skeleton we need to setup a Vertex Group. To do this, first we need to select the humanoid mesh, and shift select the armature (skeleton) and open the parent menu (Ctrl + P) to and select "with the automatic weights". This calculates the influence of a bone on vertices based on the distance from those vertices to a bone, the so-called bone heat algorithm [15].

(4) Re-importing the skeleton.

The skeleton from YEI Mocap is imported in Blender as a BVH file from the Menu: Info Editor ‣ File ‣ Import/Export.

(5) Retargeting

Using the retargeting tool, that is part of the Motion Capture Blender add on, we transfer the animation from the imported mocap skeleton (armature) to the SBSM. This is because we have two armatures: the SBSM parenting with one armature and the skeleton (armature) from the mocap system. At that phase you can use the "auto guess" feature or manual mapping.

(6) Final rigging

The armature from the motion tracking system is parented with the humanoid mesh.

3 Experiment and Results

In this section, the results of building an SBSM and adding motion to them is described (Fig. 6).

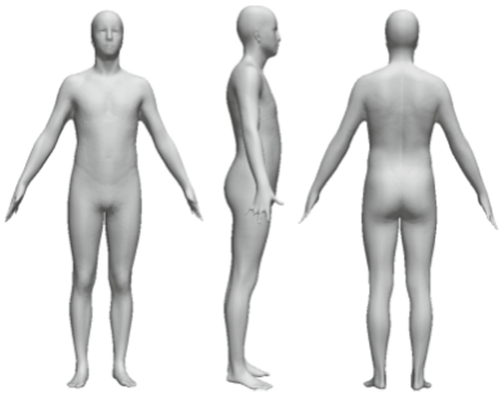

Fig. 6. Average soldier (male, height: 1840 mm, age: 27.9 years, BMI: 22.4).

3.1 Building a Statistical Shape Model

A statistical shape model was built from the CAESAR™ database [16]. We selected 57 soldier body shapes (male, height 1520 mm–2100 mm, age 18y–35y, BMI 18–25) to build our model (Fig. 6 and Table 1).

Table 1. Anthropometric measurements (mean values in mm).

Waist circumference	846
Chest circumference	951
Hip circumference	990
Arm length	654
Crotch height	873
knee height	570
Shoulder breath	466
Sitting height	953
Thigh circumference	568

From these meshes, we removed posture variances and finally built a statistical shape model (Fig. 7). Using this statistical shape model, a new body shape was calculated.

3.2 Importing the SBSM into Blender

The previously created SBSM (Fig. 7) was introduced in Blender as an object file (OBJ), (Fig. 8).

Next, the armature from the mocap system was imported into Blender and it was aligned with the humanoid mesh (Fig. 9).

The following step was the automatic weights parenting: calculating the influence of a bone on vertices based on the distance from those vertices to a bone, the so-called bone heat algorithm [15]. This influence was assigned as weights in the vertex groups. Weight painting mode was used to tweak which part of the mesh was affected by each group [17, 18], (Fig. 10).

Once it was verified that the armature was parented with the mesh, we imported the BVH file (number of frames: 285, frame time: 0.016 s) representing the walking of the subject into Blender (Fig. 11).

At that phase we linked each bone of the armature previously parented with the new one. This phase is called retargeting (Fig. 12). Using the retargeting tool, that is part of the Motion Capture Blender add on, we transferred the animation from the imported mocap skeleton (armature) to the SBSM. In this phase we changed the names of one armature and we manually linked each bone with the other.

The armature from the motion tracking system was parented with the humanoid mesh. When the rigging was completed, the armature (skeleton) could move and the DHM was animated accordingly (Fig. 13).

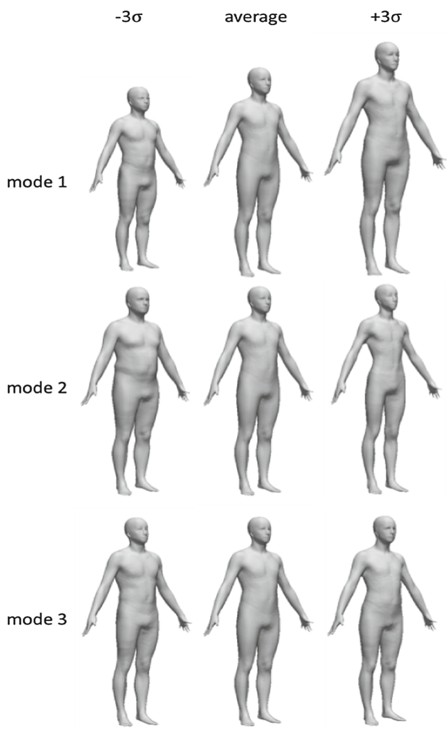

Fig. 7. The first three eigenmodes of the soldier SBSM plus (right) and minus (left) three standard deviations (σ) and the average body shape (center).

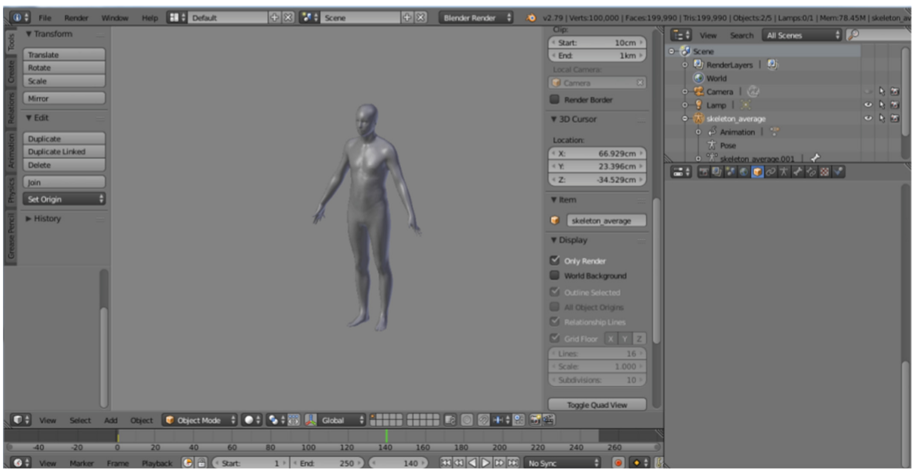

Fig. 8. The SBSM imported into Blender as OBJ file.

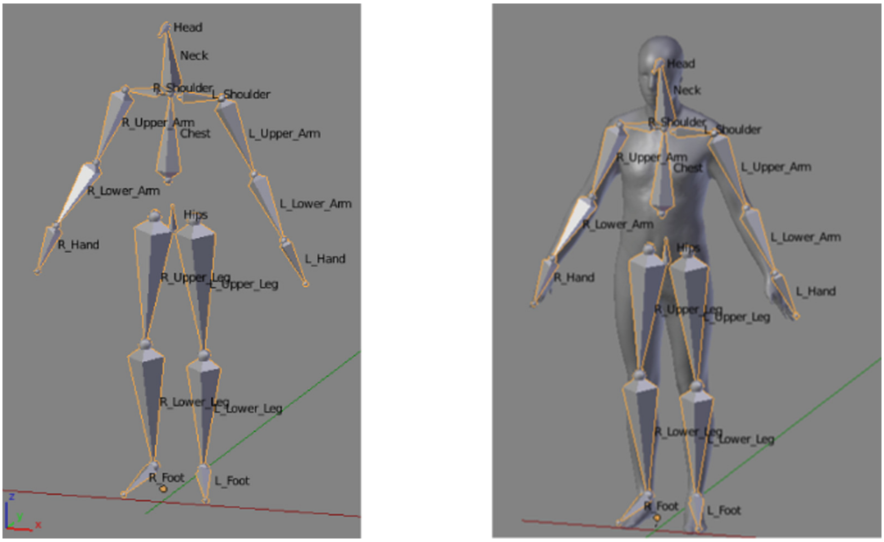

Fig. 9. Armature from the motion tracking system (left) and the humanoid mesh aligned with the armature (right).

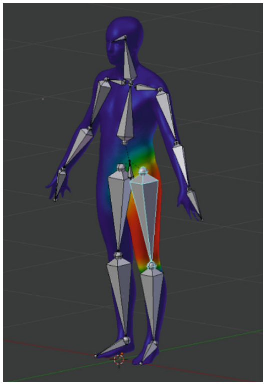

Fig. 10. Weight painting (RED = 100% weighted, BLUE = 0% weighted). (Color figure online)

4 Conclusion

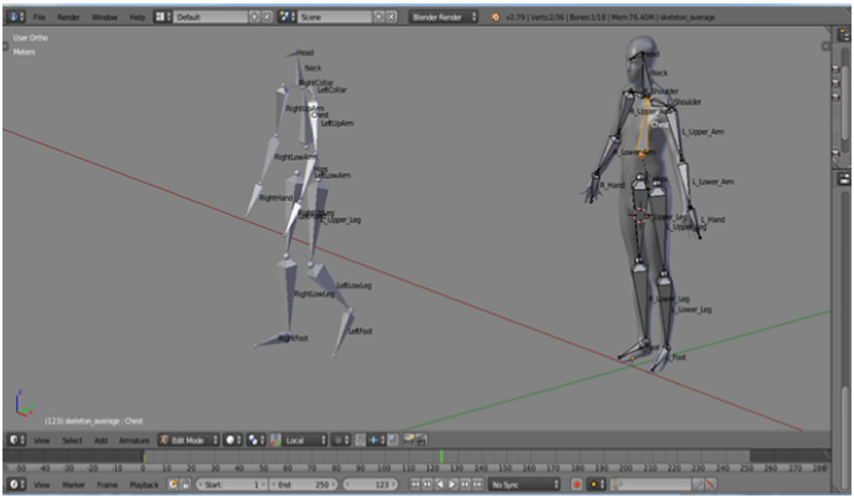

Fig. 11. Armature from the motion tracking system (left) and the humanoid mesh (right).

Fig. 12. Retargeting.

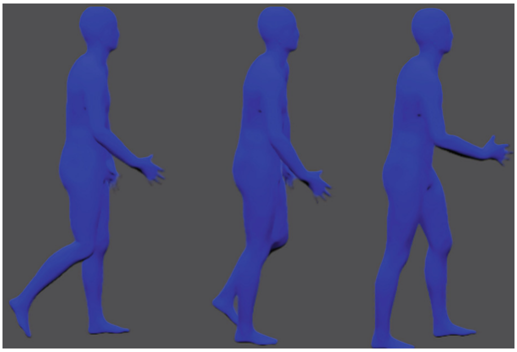

Fig. 13. Walking SBSM.

We proposed a framework to rig a statistical shape model in open source software. Results show that our framework leads to detailed, realistic body shapes, moving in a natural way. By using an SBSM, the same motion can be applied to a wide range of body shapes. Our proposed methodology allows users, designers, and ergonomists, to simulate realistic human movement.

Acknowledgement. This work was supported by the Agency for Innovation by Science and Technology in Flanders (IWT-SB 141520). We acknowledge Alain Vanhove of the Royal Military Academy for his contribution in the 3D modeling. We would also like to thank all the participants in this study.

References

1. Cherng Z, Mosher S, Camp J, Lochtefeld D (2012) Human activity modeling and simulation with high fidelity. In: Interservice/industry training, simulation and education conference (I/ITSEC)
2. Santos WR, Braatz D, Tonin D, Menegon LZ, Luiz N (2016) Analysis of the integrated use of a motion capture system with a digital human modeling and simulation software for incorporation of future activity. Gest Prod 23(3)
3. Dai H, CAI B, Song J, Zhang D (2010) Skeletal animation based on BVH motion data. In: 2nd International conference on information engineering and computer science, pp 1–4
4. Blender Online Community (2015) Blender-a 3D modelling and rendering package
5. https://www.autodesk.com/products/maya/overview
6. https://www.autodesk.com/products/3ds-max/overview
7. Scataglini S, Truyen E, Perego P, Gallant J, Tiggelen DV, Andreoni G (2017) Smart clothing for human performance evaluation: biomechanics and design concepts evolution. In: 5th International digital human modeling symposium, Germany, Bonn
8. Badler NI (1997) Virtual humans for animation, ergonomics, and simulation. In: Proceedings IEEE non rigid and articulated motion workshop
9. Danckaers F, Huysmans T, Ledda A, Verwulgen S, Van Dogen S, Sijbers J (2014) Correspondence preserving elastic surface registration with shape model prior. In: International conference of pattern recognition, pp 2143–2148

10. Danckaers F, Huysmans T, Hallemans A, De Bruyne G, Truijen S, Sijbers J (2018) Full body statistical shape modeling with posture normalization. In: Cassenti D (ed) Advances in human factors in simulation and modeling. AHFE 2017. Advances in intelligent systems and computing, vol 591. Springer, Cham (2017)
11. Danckaers F, Scataglini S, Haelterman R, Van Tiggelen D, Huysmans T, Sijbers J. Automatic generation of statistical shape models in motion. In: AHFE 2018: advances in human factors in simulation and modeling (in press)
12. Danckaers F, Huysmans T, Lacko D, Sijbers J (2015) Evaluation of 3D body shape predictions based on features. In: 6th International conference on 3D body scanning technologies, Lugano, Switzerland, pp 258–265
13. https://yostlabs.com/
14. Villar O (2014) Learning blender: a hands on guide to creating 3D animated characters, 2nd edn. Addison Wesley professional, Boston
15. Meyer M, Desbrun M, Schröder P, Barr AH (2003) Discrete differential-geometry operators for triangulated 2-manifolds. In: Hege HC, Polthier K (eds) Visualization and mathematics III. Mathematics and visualization. Springer, Berlin, Heidelberg
16. Robinette KM, Daanen HAM, Paquet E (1999) The CAESAR project: a 3D surface anthropometry survey. In: Second international conference on 3-D digital imaging and modeling (Cat. No. PR00062), pp 380–386
17. Baran I, Popović J (2007) Automatic rigging and animation of 3D characters. ACM Trans Graph 26(3):72
18. Scataglini S (2017) Ergonomics of gesture: effect of body posture and load on human performance. Ph.D., Politesi. https://www.politesi.polimi.it/handle/10589/136840