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Shape processing for digital anthropometry

M.Annichini and R.Arena and M.Fanini and M.Fattorel and D.Pavei and D.Tasson and V.Garro and C.Lovato and A.Giachetti [1]

[1] VIPS-Shapelab, Department of Computer Science, University of Verona, Italy

Abstract

The recent diffusion of 3D acquisition devices and the increased computing power of PCs and portable devices offers several possibilities to develop interesting and innovative applications. Our group, in collaboration with the Department of Motor and Sport Sciences of University of Verona, focuses on the acquisition and analysis of human body shape, trying to connect the science of anthropometry with the fields of shape analysis and mesh processing. First results are encouraging and this approach seems to offer a mutual scientific enrichment to the involved disciplines. Compared to other kind of subjects, human body shape is an intrinsically complex subject to investigate, but provides a good outlet for the development of applications that can influence everyday life of people and prone to be transformed in useful commercial products.

Categories and Subject Descriptors (according to ACM CCS): I.3.8 [Computer Graphics]: Applications—

1. Introduction

With the diffusion of digital devices for body scanning, the science of anthropometry gained a new, powerful tool that allows to perform deeper investigations on human body shape. Anthropometric measurements, that traditionally are performed through tape and calipers, are implied in several biological and medical settings in order to obtain population reference data and carry out health surveys. Anthropometry is of use in forensic medicine to identify individuals, in the movie industry to make synthetic video and animations, in ergonomics to produce best-fitting objects and tools as well as in the clothing industry to realize optimized garment; a brief deepening on those applications is avaiable in [NZW09]. Digital shape analysis tools allows to rethink anthropometry science because in the digital environment possible measurements are not limited to the traditional 1-D ones, but complex geometrical features (such as curvatures and partial volumes) are simply derivable from body scanner data. The recent availability of low cost depth cameras allows to think at innovative healthcare and anthropometric applications not requiring high measurement accuracy.

2. Processing of whole body scanner data for antropometry

We started our research on digital anthropometry in collaboration with the Faculty of Motor and Sport Sciences of the University of Verona, processing data captured with a Breuckmann BodySCAN device. Output of body scanners are known to present missing parts (holes) mainly derived from occlusion problems, bad photometric properties or excessive complexity (i.e. hair) of the body surface. Moreover, depending on the acquisition time of the device, movement artefacts can be spotted. A pre-processing step on body scanner data is almost mandatory in order to reduce the influence of those problems and to remove unwanted objects present in the scene. Body scanner technology offers the possibility to perform fast and cheap acquisition of the body shape, so a huge quantity of data is becoming available. Those mass of data has to be processed in order to derive meaningful measurements. An automatic or semi-automatic pipeline for anthropometric analysis is required. Nevertheless proprietary body analysis systems are available, the developement of an open system for anthropometry is convenient to process body scanner acquisition not depending from a specific scanner manufacturer.

3. Human analyzer software

We developed a pipeline for anthropometric analysis of body models that, starting from body scanner data, automatically pre-processes them and perform anthropometric measurements. Pre-processing is realized by means of VCG-Meshlab script, while subsequent mesh analysis steps are performed through a dedicated C++ code that is compilable under Linux or Windows OS. Firstly, the developed algorithm extracts the skeletal tree of the acquired body shape.

The skeleton, obtained through a method based on voxel coding and active contours [LCG09] is cleaned and analysed in order to detect the position of the trunk and of the five limbs (head, arms and legs). Subsequent curve skeleton segmentation allows to find the position of limb joints. Obtained information is used to initialize a stick figure that is then refined with an optimization procedure, able to correct errors in case of topological noise (e.g. arms not completely detatched from trunk) and improving symmetry and accuracy of the estimated pose. Finally, the stick is used to perform geometrically defined automatic anthropometric measurements. Health-related applications of the pipeline (e.g. indirect measurement of body fat) are described in [LCF*09] and [LMP*11].

4. Web based interactive visualization

The possibility of interact with 3D objects in a browser window offered by WebGL is interesting for the purposes of our anthropometric laboratory in different ways. It potentially allows operators to view the output and interact online with the automatic mesh processing pipeline. Moreover, by means of this technoloy results of 3D anthropometric analysis could be furnished to the interested subjects directly on a web browser window accessible from home PCs or mobile devices. We implemented a WebGL application prototype able to load and display 3D body models with associated data, i.e the stick figure as computed by the Human Analyzer and a set of annotated 3D points (1). These points can indifferently be anthropometric landmarks or automatically computed salient points of the shape. The application lets the user navigate around the 3D body and show/hide interactively different structures (see *http://www.andreagiachetti.it/shapelab/humanDemo*). Interactive measurements and shape comparison features will be added in the future.

Figure 1: *WebGL visualization of annotated human scan.*

5. Kinect-based anthropometric applications

In those years are become extremely popular cheap 3D acquisition devices like the Microsoft Kinect. Even if they cannot capture a human body the precision of a full scanner, they can provide sufficient detail for several applications (e.g clothes or shoes sizing, indirect fat measurement, etc.) and can be used everywhere, even in subject's homes. We are actually developing anthropometric acquisition system based on the Kinect. A simple body measurement tool is composed by a PC and a single device positioned in front of the subject. The interface suggests the correct pose to the subject, giving a feedback on the correct positioning of the limbs. When the acquisition procedure is completed, a table of the anthropometric measurements is shown 2. Another tool is focused on the acquisition of foot scans using a single device rotating around the leg. The final surface is currently reconstructed by means of KinectFusion [IKH*11] and ad hoc postprocessing. The resolution obtained with this method seems sufficient to make it usable in the field of shoe manufacturing.

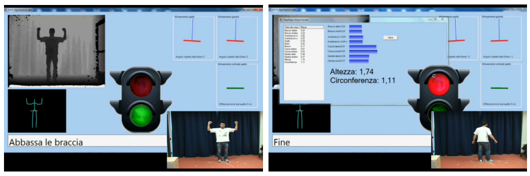

Figure 2: *A kinect-based human body measurement system.*

6. Discussion

It is reasonable to suppose that applications of human body shape analysis to data deriving from cheap 3D sensor have a real possibility to improve the public health in a society where obesity and related methabolic and cardiovascular risks are pandemic [BOGB07]. The rapidly expanding field that our team is exploring seems to offer concrete opportunities to apply scientific knowledge in various aspects of everyday life allowing the development of applications that can be useful and commercially interesting.

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