Anthropometric rigging for variable manikin appearance

This item was submitted to Loughborough University's Institutional Repository by the author.

Citation: LUNDSTROM, D., CASE, K. and HOGBERG, D., 2010. Anthropometric rigging for variable manikin appearance. Presented at 8th International Conference on Manufacturing Research (ICMR-2010), Durham, UK, 14-16th Sept., pp. 250-255

Additional Information:

- This is a conference paper.

Metadata Record: https://dspace.lboro.ac.uk/2134/31875

Version: Published

Rights: This work is made available according to the conditions of the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) licence. Full details of this licence are available at: https://creativecommons.org/licenses/by-nc-nd/4.0/

Please cite the published version.
ANTHROPOMETRIC RIGGING FOR VARIABLE MANIKIN APPEARANCE

Daniel Lundström
Keith Case

Mechanical and Manufacturing Engineering
Loughborough University
Loughborough
Leics, LE11 3TU, UK
D.C.Lundstrom@lboro.ac.uk

Dan Högberg

Virtual Systems Research Centre
University of Skövde
Skövde, 541 28, SWEDEN
Dan.hogberg@his.se

ABSTRACT

DHM (Digital Human Modeling) tools have increasingly become a contributor to human factors engineering and user-centered design. Sources report however that little attention has been paid to the appearance of DHM virtual human models, i.e. manikins. Aspects of visual appearance have considerable impact on conveying beliefs and attitudes, something often used in industrial design to motivate solutions. This work aims to synthesis the need of correct anthropometric representation in DHM with the artistic freedom available in visual art industries and address the need of more humanlike appearances of manikins.

1 INTRODUCTION

In the last decade, DHM (Digital Human Modeling) tools have increasingly become a contributor to human factors engineering and user-centered design (Duffy 2008). The aim of these tools is to support ergonomics throughout the entire design process by virtual analysis of human workplace and product interactions. DHM tools such as 3DSSPP (Chaffin 1969), SAMMIE (Case et al. 1990), Jack (Badler 1993), Ramsis (Seidl 1997) have successfully been introduced in industry to facilitate a more integrated, rapid and cost efficient design and development process (Lämkull et al. 2007). One reason why DHM tools might be effective in the development process is that they speak the same visual language as the designer (Högberg 2009). A 3D visualization is easier to understand and contains more information than a 2D sketch, which may improve the evaluation. Changes to the design can be also be performed quickly (Hanson et al. 1999, Comninos 1985).

The core of DHM tools is the virtual human model, or manikin, which visually and geometrically represents human anatomy in 3D. In the typical case these manikins are made up by anthropometrically scalable body segments connected through coupled kinematic joints. By allowing for controlled variability in anthropometry and kinematics these manikins can be used to provide information of subject/s reachability, field of view and clearances for arms, hands and tools, and serve as a basis for ergonomic evaluation and decision-making (Hanson et al. 1999, Lämklull et al. 2007).

Badler (1997) characterizes the state of virtual human modeling along five dimensions: Appearance (Cartoon Shape or Physiologically Accurate), Function (Cartoon actions or Human limitations), Time (Off-line generation or Real- time generation production), Autonomy (Direct animation or Intelligent), Individuality (Specific person or Varying personality). Current research is much focused on advancing most of these criteria. However, Yang et al. (2007) highlights that to date, most digital human development has concerned kinematic and dynamic functionality, with little attention being paid to the appearance of the manikin. This is concurrent with reports of requests from DHM users of manikins with more human like appearances made by Lämklull et al. (2007). Aspects of visual appearance have considerable
impact on how people assess one another and we are profoundly affected, in terms of beliefs and attitudes, by the body shape, facial looks and clothing of others (Gulz and Haake 2005). Baylor and Plant (2005) argue that, in general, people are more persuaded by models that are similar to themselves, or similar to how they would like to be.

In visual art industries, such as cinema, computer gaming and graphical/industrial design, focus on human modeling mainly concerns the visual and esthetic appearance of the manikin. Capturing the right mood or feeling in visualization is likely to be more of a priority than to accurately portray human limitations and anthropometric variability. In these industries human modeling is thus carried out beyond of the context of ergonomic science and proper kinematic modeling as well as anthropometrical scaling are secondary considerations. Currently there are several commercial computer programs available supporting human modeling and visualization in these industries. Two of the more novel approaches to human modeling are Poser (Smith Micro Software) and MakeHuman (MakeHuman) which, given a few basic parameters, assist the artist/designer by automatically creating human models through scaling, morphing and texturing base models.

This work aims to synthesis the need for anthropometric control in DHM manikins with the artistic freedom available in visual art industries to address the need for more humanlike appearances of manikins through the possibility of user defined manikin appearances in DHM.

2 METHOD
The human model created in this work finds its inspiration in what is in 3D animation commonly referred to as ‘character rigging’. Character rigging, or rigging, is the connection of a motion controlling skeleton to a character surface, or skin. In a ‘rig’ a skin can be represented by various rendering methods, such as triangle or quad meshes, NURBS or patch surfaces and is connected to the bone by skin weighting. Skin weighting is the process of connecting a vertex, surface control point, to one or more controlling objects. This is achieved through relating the transformation matrix of the vertex to that of the controlling object. By this, a small number of geometries can control the movement of a larger set of vertices. In this work an ‘anthropometric rig’ is created to control anatomy as well as function as a motion rig.

The software 3ds Max (Autodesk) is used as the main development and visualization platform as it allows the use of MAXScript, a simple, well documented and easy to learn scripting language. Moreover, using 3ds Max as a platform allow the use of other vital inherent functions such as skin weighting, kinematic coupling, animation, modeling etc.

2.1 Anthropometry
Anthropometrical measurements controlling the ‘anthropometric rig’ are derived from the ANSUR database compiled by Gordon et al. (1988). This data is well documented and is by containing large sets of subjects (1773 men and 2208 women) well suited for regression modeling. Moreover, using this data allows for the unaltered implementation of a hierarchical regression model developed by You et al. (2005) for the purpose of estimating missing measurements. According to You et al. (2005), most current DHMs use ‘flat’ estimation models, meaning they use only stature and/or weight as regressor/s to estimate other anthropometrical measurements. The hierarchical model instead ‘switches’ regressor/s when a better one is available thus keeping the errors to a minimum.

The regression model of You et al. (2005), covers 60 anthropometrical measurements of the ANSUR database. In the regression model for the manikin developed in this research we make use of over 80. For time saving purposes missing measurements are derived using traditional ‘flat’ regression modeling.

2.2 Anthropometric Parameterization
Most of the anthropometrical data derived from regression modeling do not directly translate into usable manikin data. The reason for this is that the external landmarks of the ANSUR survey do not directly correspond to manikin segment local frames, i.e. joints, and that width, length and circumference data does
not always give a full description of flesh distribution and/or proportion. In the ‘anthropometric rig’ being
developed flesh distributions are controlled by parametric elliptical cross sections, much inspired by the
ANSUR collection methodology. The width and length ratio in relation to circumferences is derived from
the approximation of Ramanujan (Almkvist and Berndt 1988). In relation to anthropometric data the
equality of this equation is not always met, as width, length and circumference describing the ellipsis do
not always match the correct sectional shape i.e. the section is in fact not an ellipse. In these cases width
and length are given priority over circumference (this measurement is however not excluded from the re-
gression model). There are also cases where either width and/or length measurements are missing. In
these cases the proportions of the cross sectional ellipsis are estimated.

Throughout this work, models proposed by Reed et al. (1999) are mainly used to derive segment local
frames. As hand and feet frame data are not available in Reed et al. (1999) x-ray imaging is used to esti-
mate general proportions of hand and feet as well as joint locations. Other exceptions from the sole use of
Reed et al. (1999) are the shoulder complex (Clavicle, Scapula and Humurus) where frames are derived
from Schneider et al. (1983) by regression and the spinal segments, where an ‘average’ spine geometry of
Keller et al. (2004) was fitted to the data of Reed et al. (1999). Some of these are exemplified below:

2.2.1 Hands and Feet

As mentioned, hands and feet are parameterized by relating proportions of x-rays to ANSUR anthropome-
try. Simply, bone lengths are related by estimated/measured ratios to the ANSUR measurement nr. 59 and
finger flesh thicknesses are estimated as ratios in relation to ANSUR measurement nr. 57, Figure 1.

![Figure 1: Ratio of x-ray in relation to ANSUR anthropometry.](image)

2.2.2 Shoulder Complex

Reed et al. (1999) proposes a shoulder joint position related to the acromium landmark according to Fig-
ure 2. However, for the purpose of this research, the definition of Reed et al. (1999) is incomplete as it
does not offer a location for the sternoclavicular joint. Hence, in this work this joint location is modeled
by a simple regression relationship from data proposed by Schneider et al. (1983).

![Figure 2: Creation of ‘anthropometric rig’ shoulder complex.](image)
2.2.3 Spine

As not all landmarks, required by Reed et al. (1999), to establish a spinal column are available in the ANSUR data set an average spine proposed by Keller et al. (2005) is fitted between the L5/S1 and C7/T1 discs. Through this a three joint spine model is represented with joints between L5/S1, T12/L1 and C7/T1 corresponding to Lumbar and Thoracic regions of the spine.

2.3 Kinematic Coupling

As mentioned previously, one of the reasons why 3ds Max is used in this work is the availability of other useful functions. The ability to create kinematic structures/chains by linking segments is imperative for the creation of a manikin as it allows the segments to be linked and constrained to each other much as they appear in a real human. In 3ds Max this is achieved by building a hierarchical structure to which the inherent ‘bone tools’ function applied. This allows for a workflow that includes easy interactive posturing and animation through direct kinematics, or DK, for hierarchically structured segment motions. 3ds Max also carries the functionality of defining inverse kinematic, or IK, segment chains on top of the previously defined hierarchical structures allowing joint limit settings restricting the interactive movement of the manikin to match those of a human. Inverse kinematics also increases the interactive workflow by letting a link chain follow its child, or end effector.

2.4 Skin Model

A quad mesh skin model is created through modeling in 3ds Max. Due to lack of high performance hardware, the model is kept low polygonal but still with the aim to retain sufficient anatomical resolution. The skin is then attached to the cross sections through the inherent skin weighting function allowing for rigid but also weighted skin deformations. That means that a vertex skin weight can be divided by the ratio between two segments allowing the skin to conform more naturally to human movement.

3 RESULTS

The resulting manikin consists of approximately 53 segments and 89 degrees of freedom and carries the ability of an exchangeable as well as a more natural and deformable skin model.

![Figure 3: ‘Anthropometric rig’ with skin.](image)

A small visual investigation was carried out comparing the ‘anthropometric rig’ to two currently available commercial DHM manikins, RAMSIS (HumanSolutions) and Delmia V5 Human (Dassault Systemes). In this investigation models were regressed from ANSUR male 50 percentile data of stature and weight. A visual inspection of the skeleton representation displays strong similarities with the Delmia V5 Human manikin in relation to, foot, leg, pelvis, spin, neck and head segments. Representation of the
shoulder complex is however more in conformity with the RAMSIS manikin. As the RAMSIS manikin is derived from actual human surface scan data, which neither of the other manikins are, it functions in this investigation as a relative reference for the comparison of flesh distributions. This inspection display overestimation of flesh distribution in the thoracic region for the Delmia V5 Human manikin and an underestimation of the buttocks region for the ‘anthropometrical rig’.

![Figure 4: Comparison of RAMSIS, Delmia V5 Human and ‘anthropometric rig’ 50%-ile men.](image)

4 DISCUSSION

The purpose of this work is to accommodate artistic freedom and thus introduce variation to DHM stretching beyond sole anthropometric representation/s. With the suggested approach the designer has the option to adapt the manikin/s to fit the design situation/s. As mentioned in the introduction, aspects of visual appearance have considerable impact on how we as people assess one another in terms of beliefs and attitudes; virtual humans are no exception. By making the manikin appearance to more realistically represent the product or workplace user/s, it is believed that designers will understand and eventually satisfy users’ requirements and expectations to a larger degree by the design.

Moreover, the ability for artistic freedom in DHM manikin appearance might be in line with the usual tools of the industrial designer, such as mood charting, story boarding and scenario building in allowing the designer to carry part of this into ergonomics simulation. One possible addition to realistic manikin appearance is to assign personality traits (characters/personas) to the manikin to ever further making the manikin representing a “living user”. This as an attempt to enhance the DHM tools’ ability to assist in the design process, related to issues typically considered within ergonomics and in industrial design. Also, the objective is that the tools shall be able to assist in both the “exploration/understanding”, “generation/creation” and “evaluation” related activities of the design process, just not the evaluation part, which is believed to be the main contribution of today’s DHM tools. This approach of creating “DHM Personas” is exemplified and discussed in Högberg et al. (2009) and may in the future be an natural extension of the research reported here.

REFERENCES


