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The Magic of Virtual Presence

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Abstract: *The paper shows the procedures of construction and animation of high-quality virtual human bodies, employing automated and traditional hand methods of 3D-character designing and construction. The use of modern automated 3D digital body scanners and motion capture systems is presented, as well as the art of traditional key-frame animation. It is found out that the author-developed software systems of static bodily anthropometry "ErSABA" and dynamic bodily ergometry "VatoSABA" considerably contribute to graphic personalisation of real human models, offering exact dimensions, appearance and movements of the virtual characters thus based. Using the above systems and software applications, it is also possible to create internet-based virtual characters, animated on the basis of real persons or custom-designed cyber actors, based on personal preferences and requirements of the user. The authors believe that the implementation of the existing technology can result in the construction of virtual 3D characters characterised by adequate virtual identity. The paper also shows that using computerised 3D graphic environment modelling it is possible to create photo-realistic virtual interactive miraculous synthetic worlds with an unlimited number of themes and their variations.*

Key words: *3D digital body scanners, 3D motion capture systems, virtual characters, virtual environment.*

1. INTRODUCTION

The first virtually constructed human model appeared in the thirties of the last century in research and development laboratories of military, aeroplane and car industries. Computerised models of the time had relatively simple internal kinematic structure, and were developed for the purpose of simulation in the course of ergonomic properties and relations between the human body and relevant surroundings. The models were presented employing quite primitive and relatively big and rough surfaces of the elements such as blocks, cylinders, ellipsoids and spheres. Virtual model dynamic movements in a 3D space were performed using interpolation techniques of the conventional key-frame animation.

Contemporary procedures of designing and constructing virtual characters, together with computer-generated environment, are completely automated, reducing in this way the time necessary to design them and enhancing the quality of the product. Modern personalised 3D Virtual Characters, with highly developed internal structural chains in the initial body and position in the 3D environment, using sophisticated motion capture techniques and high-end computer hardware, make it rather easy to join real movements to real characters, including facial animation and speech of every kind.

Digital characters are distinguished by their ability to create virtual identities. Using photos, outer body contours, as well as a schematic dynamics of the real model inner locomotive system, it is possible to create a virtual 3D interactive character, based on the initial model, and able to speak, move around, show feelings and emotions. Dynamic and static changes on virtual character models can be made at any time and in any conceivable extent, while 3D character models can be transferred quickly and easily from one virtual environment into the other.

Contemporary virtual models are able to promote products and services, offer information on new products and lines of business, take part in scientific simulations of bio-mechanical analyses, etc., all of this for 24 hours a day, 365 days a year, with no fatigue, no reduced effectiveness, or holidays.

Computer-generated 3D characters and their virtual environments have been used extensively – in science, education, sports, in video-games production, movie and TV production, advertising, Internet-oriented virtual applications, etc.

2. STATIC VIRTUAL 3D HUMANS

The aim of constructing a realistic 3D virtual human is to come, using 3D computer graphic modelling, as close to the dimensions of the initial human model as possible, as well as to get photo-realistic textures of human body, so as to construct as complete and as accurate virtual 3D clone of the initial model as possible

Human body is characterised by three main planes and directions, the planes crossing in the centre of the body gravity. Sagital plane divides the body into left and right halves, frontal one into front and back half and transversal into upper and lower part, Fig. 1. [1].

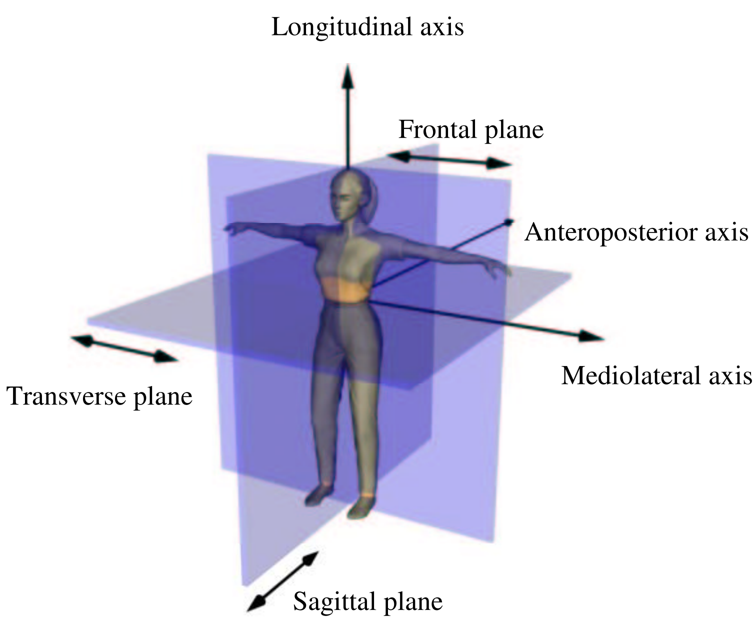


Fig. 1. *Basic planes and directions of human body*

Applying contemporary technology and 3D computer software, a prototype can be substituted with 3D models, on which it is possible to interactively perform, in real time, all the necessary shaping and alterations. Computerised 3D model that is used in research should be comprehensively studied and checked, since each disadvantage and error is reflected in the project final elements realised. Biomechanical modelling of a human body asks for a thorough preparation and analysis of each individual segment constituting the body. It means that the accuracy of the body presentation depends upon pre-defined number of cross-sections, where human body segments should be divided into smaller constituting parts. Body symmetry is assumed in constructing body segments, so as to obtain symmetrical values of loading left and right limbs [2].

2.1. Automatic determination of anthropometric measures employing the "*ErSABA*" software application

Conventional determination of anthropometric measures for each individual, employing conventional methods, is a complex and time-consuming job. New computerised methods offer fact and accurate determination of all the key bodily measures. A software application "*ErSABA"* has been developed, of the 4.2. version at the moment, which can, using the input data on body height, weight and gender, together with the necessary accuracy of position at work, determine 22 characteristic anthropometric measures [3]. Fig. 2 shows a pictorial and alpha-numerical on-screen presentation of characteristic anthropometric measures for a standing female person, while the Fig. 3 shows alpha-numerical on-screen view of the whole of the characteristic anthropometric measures for the person measured. Measuring data are at the moment available for the persons that are actually measured and for those that know their height. After processing, the anthropometric data are automatically stored into so-called anthropometric database, so that they are available for further "off - line" analyses [4].

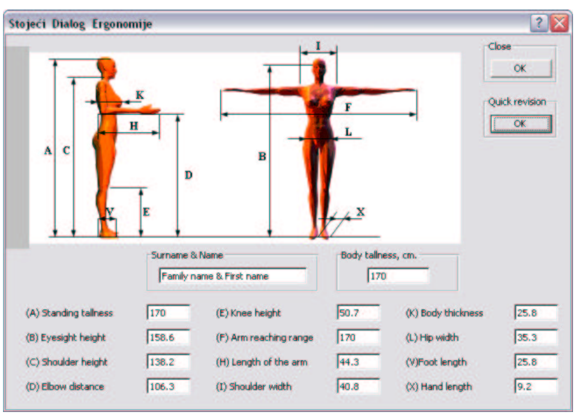


Fig. 2. *On-screen presentation of characteristic anthropometric measures for a standing female person*

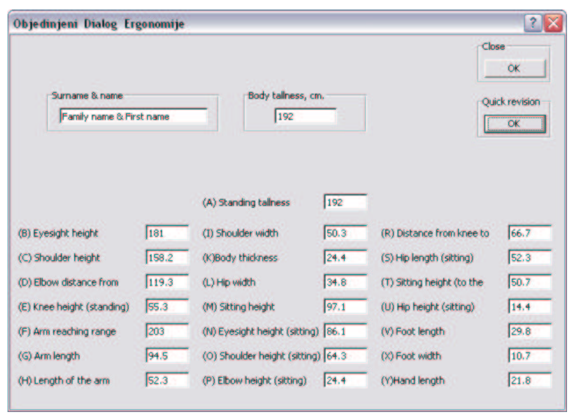


Fig. 3. *On-screen view of the whole of the characteristic anthropometric measures for a female person*

2.2. 3D Digital Body Capture and Measurement System "*BodySABA*"

Most investigators, in constructing a geometrical model of a human body, focus on the procedure of taking a series of surfaces bordered with co-ordinate points of a 3D measuring cloud, obtained by modern 3D scanners, Fig. 4 and 5. The procedure offers precisely the same model of the bodily construction of the person, associated with a particular dotted cloud, and describing bodily measures of a particular character. The whole of the construction of the virtual human model is based on knowing the volume and cross-section of the body, as well as its mechanical behaviour in the performing dynamic movements [5].

Fig. 4. *Digital Body Measurement System with Enclosure*

Fig. 5. *Individual Views of 3D Data Points*

Project Cyber Fashion Group (*CFG*) by S. Baksa has developed and offered a three-dimensional digital body scanning with 3D Body Measurement system, "*BodySABA*" of the actual version 0.2., Fig. 6. Body Capture System "*BodySABA* 0.2." is in an initial phase of its development. However, as can be seen at the digital 3D presentation in Fig. 7., its applicability even in its present form is quite obvious for contemporary CG techniques of digital scanning.

Fig. 6. *Scanning with digital Body Capture System "BodySABA 0.2."*

Fig. 7. *Digital 3D presentation of the object scanned*

Body Capture System "*BodySABA*" is intended for spatial 3D scanning of objects, with the purpose of constructing virtual 3D models. The system can be used for garment and footwear design, garment and footwear industry, car industry, development of video games, construction of virtual bodies, creation of internet-oriented characters, doing business on the Internet, anthropologic research, ergonomic studies, healthcare applications, sports analyses etc.

3. DYNAMIC VIRTUAL 3D HUMAN MODELS

Digital character animation of a 3D human movement and behaviour simulation is a challenging branch of CG engineering. Animation of virtual, computer-generated 3D characters is divided into two basic groups: virtual character limbs and torso macro animation, yielding basic bodily movements; and micro animation, most often facial animation (fac anim) and/or speech animation (lip sync). Cyber persons can thus speak, sing or communicate in some other way with similar virtual characters or with our real world.

Macro animation of biomechanical mechanisms included in human movements is a highly complex and requiring procedure, most so when analysing the branching of construction entities and when synthesising the movements, as in these phases definition of mobility and directing the system in question should be performed, and perform the same tasks for the group of systems as well. The structural scheme of human skeleton offers a number of degrees of movement. Human skeleton consists of 95 joints with a single possible direction of movement, 80 joints with two possible directions of movement, and 75 joints with three possible directions of movement, which means 250 degrees of free movement. Having this in mind, the complexity of kinematic and dynamic investigation of human skeleton becomes quite obvious. It is of utmost importance, as the mobility of the computer-generated 3D character depends upon the number of degrees of free movement of the elements it is composed of [6].

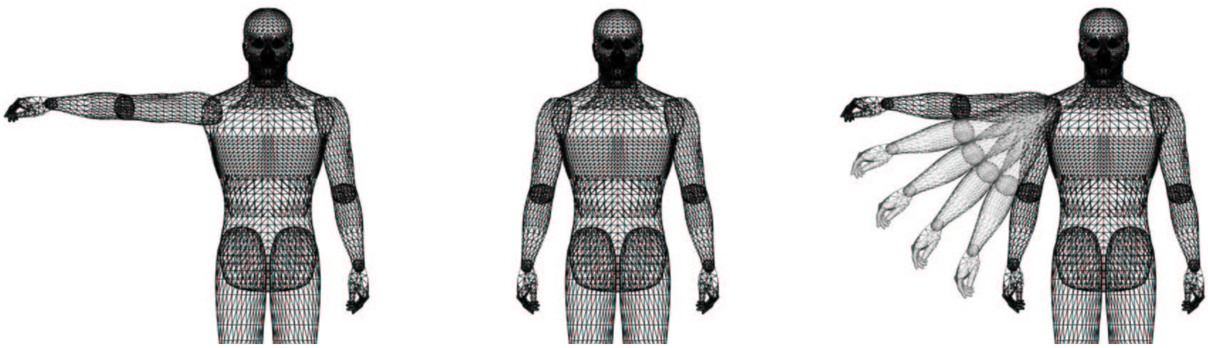
Facial micro animation contains complex movements of various groups of muscles that constitute recognisable facial expressions. There are over 30 groups of muscles responsible for facial movements. They constitute a basis of movements that yield phonemes, emotions or various facial expressions [7].

Traditional approach in animating virtual 3D characters consists of implementing key-frame animation. It asks for relatively modest investment and a lot of working time, yielding rather acceptable animation results. More modern, popular, fast and accurate, but financially more demanding animation approach is based on the implementation of a "Motion capture (mocap)" system. These systems are able to detect automatically movements of real human actors [8].

3.1. Traditional key - frame animation

This phrase in CG engineering includes computer-generated interpolation of various static postures between two key frames. Its aim is to offer natural and smooth transition between two key frames. However, despite a lot of effort and time invested in it, and various animation techniques, it is quite easy to detect and recognise anomalies, especially so in virtual human body movement simulation and visualisation.

Fig. 8 shows the procedure of obtaining computer-generated interpolation of a virtual human arm position between two key frames, x and y, as shown in Figures 8 a and 8 b.



a) b) c)

Fig. 8. The procedure of traditional key-frame animation

a) Upper position of the arm in the key frame x
b) Lower position of the arm in the key-frame y
c) Computer-generated position of the arm between the key-frames x and y

3.2. Motion Capture System of the "VatoSABA" computerised movement animation

Motion Capture System "*VatoSABA* 1.2." for Computerised Movement Analysis digitises real human movements recorded into corresponding virtual 3D character behaviour. It is a new and original approach to computerised character animation of virtual 3D humans, offering both minimal investment and ease of work, as with key-frame animation, as well as accuracy and speed of automatic motion capture digital systems.

Fig. 9 shows recording biomechanical movements of a real model, employing the *VatoSABA* 1.2. motion capture system in a movie studio. Fig. 10 shows a section of a computerised virtual human figure animation, based on real behaviour of a real human model from the Fig. 9, recorded using the *VatoSABA* 1.2. motion capture system.

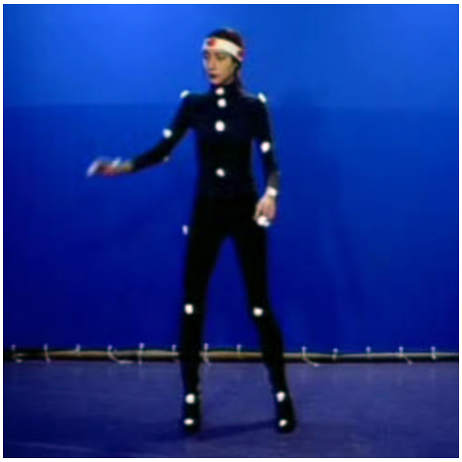


Fig. 9. *Studio recording with VatoSABA 1.2. motion capture system*

Fig. 10. *Section of a computerised virtual character animation based on the input data acquired by the VatoSABA 1.2. mocap system*

4. VIRTUAL 3D ENVIRONMENTS

Application of the investigations in the overall workplace design and design of environment for free time offers the possibility to determine a harmony of the environment elements and human body, as well as a proper body posture at work and in free time, reducing energy consumption to a minimum. It also makes possible to influence worker fatigue in a manufacturing process, as well as to make work more humane, increase productivity and product quality [9].

Systems of virtual environment open the door to the adventure of entering various computer-generated virtual 3D worlds. The authors have the freedom of choice in creating variants of digitally constructed 3D environments. Fig. 11 shows a photograph of a real dwelling, while Fig. 12 offers a frame of a computerised animation, constructed on the basis of the photograph from Fig. 11.

Fig. 11. Photograph of a real dwelling

Fig. 12. *A frame of virtual 3D computerised animation constructed on the basis of a real dwelling*

Users are now able to visualise computer-generated virtual environment through the eyes of their virtual human figures. There is also a possibility of interactive movements of their virtual bodies through a number of bodily digitised controls. Human-like virtual 3D models are even created possessing varying degree of interaction with their virtual environments [10].

5. CONCLUSIONS AND FUTURE WORK

The aim of this paper is to present computerised CG hand and automatic procedures of virtual 3D character construction and animation, together with the accompanying environments.

In the course of developing 3D virtual humans and environments the authors have found that the CFG described offers the construction of 3D virtual human actors, with realistic appearance and articulations. The actors exhibit similar appearance and behaviour as real humans. It has also been concluded that it is possible to design, create and construct any imagined Cyber Actor or Digital Creature, needed for a particular purpose. It is also possible to associate recognisable real identity to virtually created characters.

Obvious conclusion is that it is possible to construct interactive virtual character web sites with created and animated high-quality virtual human bodies.

Future research will be directed towards human modelling and animation for the purpose of constructing integrated highly developed synthetic humans from animation design and communication and the interaction between real and virtual humans.

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