HUMAN MOTION ANALYSIS AND SYNTHESIS USING GRAPHICAL BIOMECHANICS MODELS IN SPORTS ACTIVITIES

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In many applications the study of human movement using a computer is very useful. One such application is the three-dimensional reconstruction of the structure of the human body and its movement using sequences of images and graphic models. For this reconstruction to be accurate and precise the person analyzed and the virtual human (humanoid) must have similar anthropometric characteristics. A process is therefore defined that attempts to adjust the humanoid to the morphology of the person, a process which can be very laborious and subjective if done manually or by selection of points. This article presents a process of semiautomatic matching between person and humanoid. Once this process is carried out we are ready to analyze and represent the movements under study. The study is adapted to specific sports activities. In these cases the adjustment process can be assisted by the computer. At present, it is used in indoor spaces, but its use in outdoor spaces is also intended. The system requires no markers or special clothing to be worn by the athlete or sports participant, and its range of application is therefore very wide. Also very important are its portability into domestic environments using VRML 2.0 and the H-anim standard for specification of virtual humanoids. This advantage is very important because experts can visualize movements on any personal computer with a commercial Internet browser.

KEY WORDS: humanoid, real and synthetic Images, VRML, matching, calibration, graphic model, sports motion, internet

INTRODCUTION: The general process of the system were divided into four stages:

1. Image capture. Images of the person from different points of view and of the background were captured. The humanoid with characteristics most similar to the original individual was selected. A semiautomatic process with which obtained the humanoid adjusted to the person's measurements was applied. The captured images and the generated humanoid was combined to verify the result of the process and study the values that interest us.

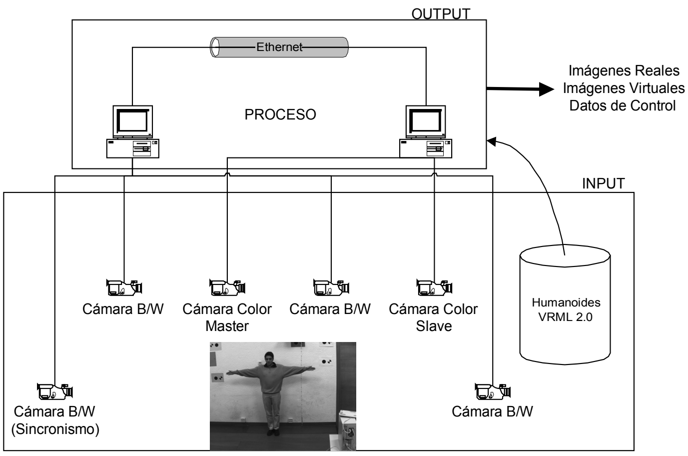
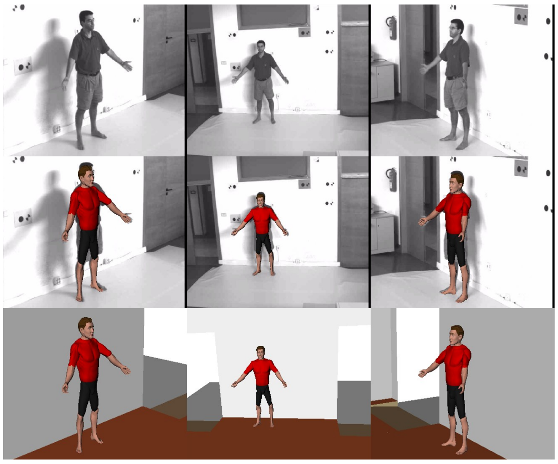


Figure 1 – The setting of 6 configurable points of view.

2. Capture process. The capture can be carried out from 6 configurable points of view (figure 1), with two color and four greyscale cameras. The hardware is two PCs with Pentium II processors. One has the four greyscale cameras connected to an IC-ASYNC board, synchronized so that the capture is simultaneous and in real time. The other has the two color cameras and two acquisition boards, also synchronized to each other. In the performance tests carried out, to be able to capture at 30 images per second it is necessary to capture to memory, thus limiting the capture time to 10 s (384 Mb at a resolution of 768x574, 8 bits per pixel). The synchronization between computers is via network. The



cameras are calibrated using Tsai's classic algorithm (Tsai, 1986). The libraries are those of the boards although all the development is done in C++, defining independent classes among capture, user interfaces, and image and graphics models, with the idea of maximizing portability.

3. Humanoids. There are various specifications (Badler, Phillips, & Webber, 1993) for humanoids; we have chosen the one created by the group h-anim in VRML format for its portability and adaptability to different applications.The humanoid is composed of a collection of joints and segments structured in the form of a tree. Each joint corresponds to an anatomical joint (knee, shoulder, vertebrae), for example with each vertebra hanging from the one above, and the wrist joint hanging from the elbow joint. Each joint has associated with it a segment it represents, for example the elbow has the upper arm as its segment. Each segment may have sites and displacers. A site corresponds to an endpoint, such as the fingertips, while a displacer corresponds to an effect applied to the segment.

4. Matching. Matching of the humanoid is currently done semimanually; we are working on automatic processes (Yáñiz, Rocha, & Perales, 1998). The information captured is from the greyscale cameras, in three positions following specific anthropometric criteria, from which we obtain the desired parameters. We use a data-base of predefined movements and models to help the matching process. Also we can use this knowledge to estimated new movements, that are not previously recorded.

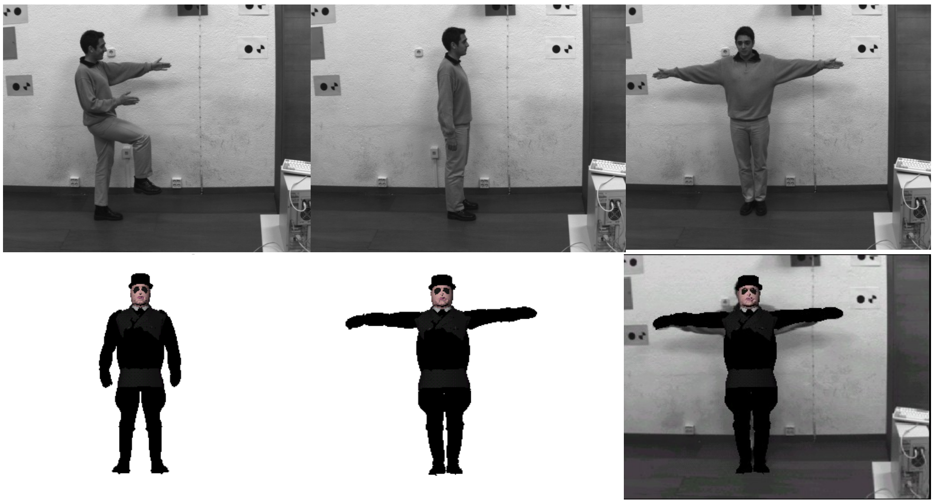


Figure 2 - Six corresponding images.

The color images assist in the segmentation of the parts of the body (Wren, Azarbayejani, Darrell, & Pentland, Pfinder: Real-Time, 1997). The color cameras allow us to capture part of the infrared spectrum, which facilitates working with low light levels and/or considering processes of fusion of information (fusion vision). The semiautomatic matching process has certain limitations of precision according to the models and the calibration of the cameras. In figure 2 we have six corresponding images, the first three in the positions selected for the collection of information, then the humanoid in default position, and in the last two the

humanoid adapted to the measurements and to the position of the human in one of them superimposed on the general image.
In figure 3 we can see a position of the individual seen from three cameras and their corresponding adjustments and virtual scene. We then present a person kicking a ball (figure 4.) and graphics of joint values of the biomechanical model.

Figure 3 - Position of the individual seen from three cameras and their corresponding adjustments and virtual scene.

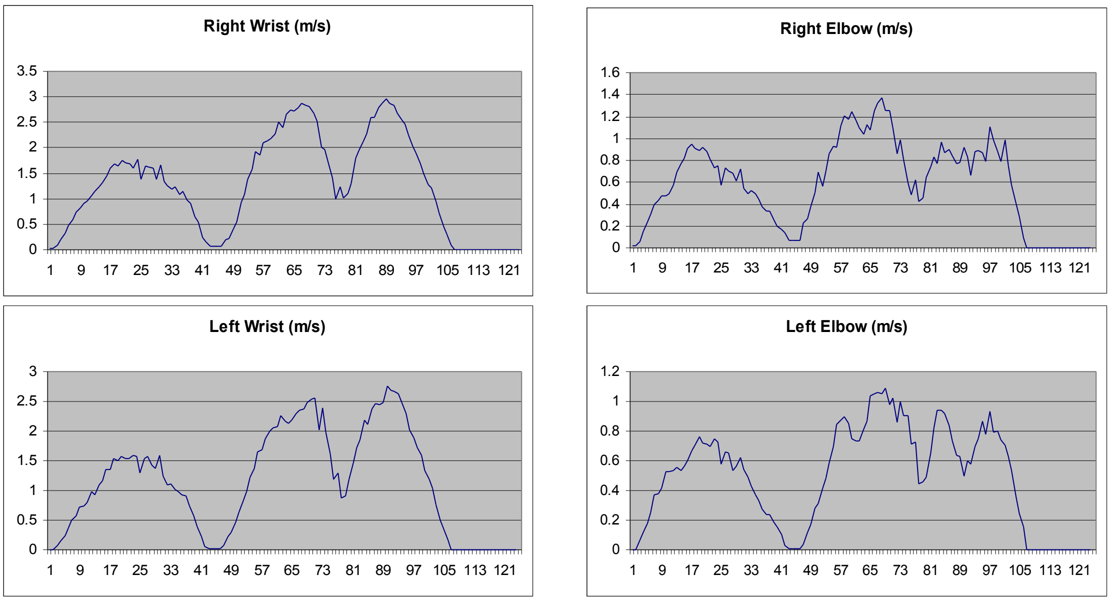


Figure 4 - Graphics of joint values of the biomechanical model.

5. 3D representation. When editing the humanoid it is useful to have the person as a reference and vary the measurements of the humanoid interactively, so we have placed the captured image in the background.
We create the 3D representation of the humanoid, with the captured image in the background, in OpenGL[1] with the aid of the library OpenInventor[2]. As the definition of objects and their parameters in VRML is very similar the conversion of the h-anim humanoid to OpenInventor is quite easy. One of the principal objectives is the portability of representations and animations.
In parallel the whole scene or laboratory is modeled in VRML, which allows us to mix real objects with virtual scenes or vice versa.

CONCLUSION: We have developed an application for capturing and matching real images and synthetic images of humanoids with the object of making a precise analysis of human movement. In general the final system should allow us to detect, follow, and recognize the activities of one or more persons in a scene (Yáñiz, Rocha, & Perales, 1998). The part presented allows editing of the humanoid only under supervision, but a possible extension would be obtaining cinematic and dynamic means with a view to more sophisticated applications. In fact a determined level de precision will be defined according to the application.
This work is framed within a more general project of analysis and synthesis of human movement using techniques of digital image processing and computer vision. Is very important to remark that the system proposed is non-invasive and no use markers on the persons, so occlusions are avoided and we can use it in any environment. Also the biomechanical model is overplaced on real images and we don't need manual digitalization and interactively feedback with the model is possible in real time processing.
The last part presents the adaptation of the proposed system to the analysis of sports motion in all possible variations. Obviously each discipline has its parameters of interest, which the user or specialized technician will define. The precision of the system is adequate for infoor sequences. We plan in near future study specific type of sports motions like soccer and single person disciplines like martial arts.

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[2] Open Inventor is a registered trademark of Template Graphics Software, Inc