Interactive Environment for Human Motion Analysis

I.H. Hilal, S. Van Sint Jan, M. Rooze
University of Brussels,
Department of Human Anatomy (CP 619),
808 Lennik Street,
1070 Brussels, Belgium
e-mail: Isam.Hilal@ulb.ac.be
http://www.ulb.ac.be/project/vakhum

Abstract
Three-dimensional (3D) visualization is becoming increasingly advantageous in both qualitative and quantitative biomechanical studies of anatomical structures, involving multiple data sources (e.g. morphological data and kinematics data). For many years, this kind of experiment was limited to the use of bi-dimensional images due to a lack of accurate 3D data. However, recent progress in computer science and the development of new programming languages has opened new perspectives. Indeed, language such as Virtual Reality Modeling Language (VRML) allows for the development of an interactive interface for the simulation of human motions combining data from both the medical imaging (i.e., morphology) and biomechanical studies (i.e., kinematics). This paper presents such interface developed for the study of human gait analysis.

Methods
The simulator presented in this document shows virtual representation of biomechanical models of movements, where kinematics data was obtained from in vitro study and 3D bone morphology from medical imaging. The implementation of the simulator using VRML language, allowed the development of a study tool in a completely interactive environment, where the 3D visualization of both anatomical surfaces and associated motions can be represented separately or combined.

Kinematically, the human body can be considered as a complex structure constituted by a group of interconnected segments linked to each other by means of joints. Joint motions are the results of position changes occurring for each of the segments involved in the movement. The kinematical changes of adjournment and/or rotation generated in each joint determine the position of the segments. This definition is the idea that allowed the creation of our simulator of human movement.

Results
The user interface of the joint motion simulator was conceived with the idea of allowing an improved understanding of the human motions. The interface is divided in two regions (Fig. 1). One region shows the 3D representation of the physical model, while the second region displays the kinematics curves. Each graph is actually also a motion trigger. Clicking on one of the graphs start the simulation of the related motion. This allows a user to select either a particular motion component (i.e., a rotation around a particular axis), or a combination of all components (e.g., prono-supination) or even a combination leading to the simulation of complex motions (e.g. flexion-extension of the elbow simultaneously with prono-supination of the forearm).

Each one of the kinematics functions is programmed independently to allow the above flexibility in the motion selection. Each one of the illustrated curves can be activated so that the model executes only specific movements. There are three levels of activation. The first level corresponds to the primitive movement of each one of the segments; the user has the opportunity to examine rotations occurring about the axes x, y or z independently. The second level allows the study of the joints; the user can observe the relative motions of the bone for a particular joint motion. The third level the combination of several motions to simulate complex tasks.
Conclusion

We described in this paper a method to visualize 3D morphological and kinematics data in a fully interactive environment. VRML language was adopted to develop the interface. This allows end-users to access the virtual environment using standard web browsers (e.g. Netscape®, Microsoft Explorer®). Only a VRML viewer plug-in must be previously installed on the user system (e.g. Cosmo Player®). These specifications allow visualisation of Joint Simulator interface on most standard multi-media computers. We found the first results encouraging.

First version of systems similar to the one described in this paper are now integrated within the anatomy classes of the Faculty of Medicine at ULB. We are now studying the impact of such system for the understanding of Functional Anatomy by our students. First feedbacks from medical students were positive. We are planning surveys among students to try quantifying these preliminary responses. From a scientific point-of-view the system also proved to be useful. Indeed, results of motion analysis are classically analysed using motion graphs only. This is not always an easy task. The system presented here brings some improvements. Indeed, results interpretation is greatly improved thanks to the simultaneous display of the above motion graphs together with the “physical” models of both bone segments and motion. The scientist has a very good feeling about the meaning of her/his data. Also, experimental errors are dramatically enhanced: simulation shows collision or separation of the bone segments during the motion simulation.

References


**Acknowledgements**
This study is part of the VAKHUM project (www.ulb.ac.be/project/vakhum), which is funded by DG XIII of the European Commission (contract # IST-1999-10954). Special thanks to C. Chao and J-L Sterckx for their technical assistance. Also to the Radiology Department of the Bordet Institute (Belgium) and to New England Miniature Ball Inc. (USA) for providing the balls used as fiducial landmarks in this study.