Computing the Virtual Human

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1 Introduction

Compelling computer graphics will increasingly require realistic physics based modelling to allow us to simulate the virtual human characters in movies, computer games, education and medical simulation.

The IUPS (International Union of Physiological Sciences) Physiome project is developing the framework and science required for simulating human anatomy and physiology.

2 Anatomically and Biophysically Based Models

To simulate the complex processes within a human, models of the organs comprising a human are being developed. As well as accurate geometry these models include physiology to represent chemical, electrical, mechanical and fluid based processes. For a model representing the heart all these processes are coupled together. The cellular processes are modelled on a cellular spatial scale, which is very different from the scale for solving the mechanics or electrical activation of the whole heart organ. The methods for coupling these different scales are being developed.

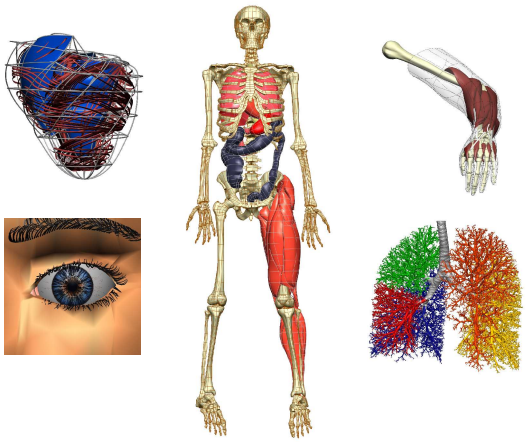

Figure 1: The geometry of some of the models.

Some of the processes that are being modelled are heart myocyte activation, heart ventricular mechanics, heart tissue electrical activation, gut electromechanics, eye lens circulation, leg muscle mechanics, lung airways, lung mechanics and lung blood transport. The geometry of many of these models is shown in Figure 1.

To facilitate the communication of these models and the building of databases containing representations of them several XML file formats are being developed. CellML (refer to www.cellml.org) is able to specify the mathematics representing the physiology. Many cellular processes and some material constitutive laws have been coded in CellML. FieldML is being developed to allow the generalised description of interpolating fields. Ontological classification allows the models to be stored in an extensible database that is well connected with other existing bioinformatic databases.

To match a particular character in a movie or a particular patient in a surgical analysis the highly detailed models of the parts of human anatomy need to be individually customised. This can be done with Free Form Deformation. This fitting method allows the customised model to match the measured characteristics of the individual while maintaining the complexity and topology of the original model.

3 Facial Animation

This system of creating detailed, biophysically based generic models and then using Free Form Deformation to customise them to a particular individual has been successfully applied to facial animation. LifeFX, using software and technology from the Bioengineering Institute, demonstrated this at ACM SIGGRAPH (ACM SIGGRAPH Electronic Theatre 1999 and 2000)

4 Surgical Simulation

Creating these models requires an increasing understanding of the fundamental processes that are occurring. Once a computer representation exists it can be used to investigate novel interventions, to facilitate education or to allow surgical training.

5 Conclusion

As the capabilities of computer rendering systems and graphics cards continue to advance it will be possible to incorporate more and more physics based simulation into movies and computer games. These advances could allow computer simulation of processes such as the response to disease, exercise or injury. The IUPS Physiome Project is advancing the science that will enable this to happen.