3D Anatomical Modelling and Simulation Concepts

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Abstract

Nowadays, a large panel of medical acquisitions devices are made available producing a large amount of information such as high-resolution volumes, temporal sequences or functional images. Although this information helps scientists and physicians better understand the human anatomy and physiology, it becomes more-and-more difficult to analyse and visualise it. In this context, anatomical and functional models that combine multi-modal information are highly demanded. These models are successfully used in medical simulations such as virtual surgical interventions (e.g., bone, liver surgeries) or physiological process analysis (e.g., tumour growth, cartilage degeneration). They improve the diagnosis and assist the physicians. In this tutorial, we will present the current research issues towards the creation of patient-specific anatomical models and their functional simulation. Various topics in medical modelling/simulation will be addressed, focusing on computer-graphics based approaches, such as deformable models in image segmentation, data fusion, interactive physically-based simulation and cost-efficient visualisation. Examples will be given in the musculoskeletal, cardiac and vascular domains. All speakers are partners of the EU project "3D Anatomical Human" led by MIRALab - University of Geneva.

Categories and Subject Descriptors (according to ACM CCS): Computer Graphics [I.3.3]: Viewing algorithms—Computer Graphics [I.3.5]: Physically based modeling—Image Processing and Computer Vision [I.4]: Segmentation—Life and Medical Sciences [J.3]: Health—

1. Introduction

The objective of this tutorial is to train students and researchers in the various domains involving the modelling and simulation of the human body for medical purposes. Nowadays, a large panel of medical acquisitions devices are made available producing a large amount of information such as high-resolution volumes, temporal sequences or functional images. Although this information helps scientists and physicians better understand the human anatomy and physiology, it becomes more-and-more difficult to analyse and visualise it.

In this context, anatomical and functional models that combine multi-modal information are highly demanded. These models are successfully used in medical simulations such as virtual surgical interventions (e.g., bone, liver surgeries) or physiological process analysis (e.g., tumour growth, cartilage degeneration). They improve the diagnosis and assist the physicians. For instance, the EU project

"3D Anatomical Human" and the Swiss Project "Co-Me" are projects that bridge complementary approaches for modelling and simulating the human musculoskeletal system.

In this tutorial, we will present the current research issues towards the creation of patient-specific anatomical models and their functional simulation. The generation of patient-specific model is very challenging but of paramount importance in the domain of Health. In fact, generic anatomical and physiological models cannot express the variability that exist among individuals and that lead to different diagnosis and treatments. The tutorial is divided in three main parts: (i) anatomical modelling from medical data, (ii) Physically-based simulation of biological tissues and (iii) medical visualization and related applications. Various examples will be given to illustrate the challenges of modelling, simulation and visualization. It will be shown in particular how computer graphics techniques can play an important role in the medical field.