Department of Mechanical Engineering

THE UNIVERSITY OF MELBOURNE

SEMINAR SERIES 2011

Dr Karol Miller

Intelligent Systems for Medicine Laboratory
The University of Western Australia

Thursday 24th November, 1.30pm

Lecture Theatre
Level 3, Building 170
Mechanical Engineering
Grattan St, Parkville

Real-time finite element analysis and meshless methods for computational biomechanics for medicine.

Abstract:

Mathematical modelling and computer simulation have proved tremendously successful in engineering. Computational mechanics has enabled technological developments in virtually every area of our lives. One of the greatest challenges for mechanists is to extend the success of computational mechanics to fields outside traditional engineering, in particular to biology, biomedical sciences, and medicine. By extending the surgeon's ability to plan and carry out surgical interventions more accurately and with less trauma, Computer-Integrated Surgery (CIS) systems could help to improve clinical outcomes and the efficiency of health care delivery. CIS systems could have a similar impact on surgery to that long since realized in Computer-Integrated Manufacturing (CIM).

However, before this vision can be realized the following two challenges must be met:

Challenge 1. Real-time (or near-real-time) computations.

Rationale: In surgical simulation interactive (haptic) rates (i.e. at least 500 Hz) are necessary for force and tactile feedback delivery. In intra-operative image registration one needs to provide a surgeon with updated images in less than 40 seconds. To achieve these, highly non-linear models with ca. 50 - 100 thousand degrees of freedom must be solved in close-to-real-time on commodity computing hardware.

Challenge 2. Efficient generation of computational grids from medical images of human organs.

Rationale: In clinical workflow 3D images (e.g. magnetic resonance images) are acquired. In order for biomechanical computations to be practical, a computational grid must be obtained from these images (semi-)automatically and rapidly.

At Intelligent Systems for Medicine Laboratory we have addressed Challenge 1 by developing Total Lagrangian Explicit Dynamics finite element and meshless algorithms and implementing them on Graphics Processing Units.

We are also addressing Challenge 2 by developing a concept of "an image as a computational model". We discretise the entire medical image volume with the cloud of points for the solution interpolation, insert an underlying regular cubic grid for volumetric integration and assign mechanical properties to integration cells based on probabilistic tissue classification algorithms. This approach leads to almost instantaneous computational model generation.

We have successfully applied the techniques mentioned above to modelling brain deformations during surgery and intra-operative neuroimage registration.

MORE INFORMATION

For more Mechanical Engineering seminar information contact:

Professor Ivan Marusic
Department of Mechanical Engineering
E: imarusic@unimelb.edu.au