Challenges for computational biomechanics for medicine

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Mathematical modelling and computer simulation have proved tremendously successful in engineering. 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 realised the following four challenges must be met:

Challenge 1. Efficient generation of computational grids from medical images of human organs.

Challenge 2. Real-time (or near-real-time) computations on commodity hardware.

Challenge 3. Real-time simulation of cutting, damage and propagation of discontinuities.

Challenge 4. Mathematical formulations that are weakly sensitive to uncertainties in mechanical properties of tissues.

In this lecture I describe how the Intelligent Systems for Medicine Laboratory addresses these challenges by using explicit dynamics and dynamic relaxation algorithms implemented on GPU and developing a concept of an "image as a model".