Computational Mathematics Colloquium

Computational mathematics meets medicine: Formulations, numerics, and parallel computing

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Abstract: We will discuss computational methods that integrate imaging data with (bio)physics simulations and optimization in an attempt to aid decision-making in challenging clinical applications. In particular, we will focus on PDE-constrained formulations for diffeomorphic image registration, a classical inverse problem, which seeks to find pointwise correspondences between two or more images of the same scene. In its simplest form, the PDE constraints are the transport equations for the image intensities. We will augment these equations with a model of brain cancer progression to enable data assimilation in brain tumor imaging. We will see that our formulation yields strongly coupled, nonlinear, multiphysics systems that are challenging to solve in an efficient way. We will discuss the formulation, discretization, numerical solution, and the deployment of our methods in high-performance computing platforms. Our code is implemented in C/C++ and uses the message passing interface (MPI) library for parallelism.

We will showcase results for clinically relevant problems, study numerical accuracy, rate of convergence, time-to-solution, inversion quality, and scalability of our solver. We will see that we can solve clinically relevant problems (50 million unknowns) in less than two minutes on a standard workstation. If we use 512 MPI tasks we can reduce the runtime to under 2 seconds, paving the way to tackle real-time applications. We will also showcase results for the solution of registration problems of unprecedented scale, with up to 200 billion unknowns.

Thursday, February 1, 2018, 4:00 pm
Mathematics and Science Center: W301

Mathematics and Computer Science
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