LMS Seminar

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Mechanically Consistent Regularization for Large Motion Tracking

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ABSTRACT

Equilibrated Warping is a motion tracking approach based on the finite element method and the equilibrium gap regularization. The finite element method is used to formulate the motion tracking problem, i.e., to find the displacement field that best match the source and target images, allowing to ensure some regularity to the solution. However, because of limited image resolution and noise, this problem is ill-posed, and requires regularization. The equilibrium gap regularization essentially penalizes any deviation from the solution of a hyperelastic body in equilibrium with arbitrary loads prescribed at the boundary, thus representing a regularization with strong mechanical basis.

In the presentation, I will first describe the image-based motion tracking problem and provide some literature review on mechanical regularization. I will then introduce a novel generalization to the nonlinear finite strain framework of the equilibrium gap principle, as well as a new regularization term for the boundary tractions, and describe proper finite element discretization of both terms. I will also show how the full regularized motion tracking problem can reformulated into a proper mechanics inverse problem. Finally, I will illustrate the tracking performance of the method, and provide various elements of validation based on synthetic and real images.

BIOGRAPHY

Dr. Genet is currently a Professor in the Mechanics Department of École Polytechnique, Palaiseau, France, with research posting within the M3DISIM team, which belongs to both the French National Laboratory for Mathematics and Informatics (INRIA) and the Solid Mechanics Laboratory of École Polytechnique. Previously he obtained his PhD from École Normale Supérieure, Cachan, France, in 2010, and was then a postdoctoral fellow at the Lawrence Berkeley National Laboratory, California, USA, from 2010 to 2012. In 2012 he obtained a Marie-Curie International Outgoing fellowship to work on patient-specific cardiac modeling, at the University of California at San Francisco, USA, and Stanford University, Palo Alto, USA, from 2012 to 2014, and at the Swiss Federal Institute of Technology (ETH), Zurich, Switzerland, from 2014 to 2015. Over the past few years, he has been involved in many aspects of the research on soft tissue biomechanics and biomedical engineering, including multiscale (in space, i.e., cell/tissue/organ levels, and time, i.e., functioning/remodeling scales) and multiphysics (mechanics/biology coupling, poromechanics, etc.) computational modeling, model-data interaction computer methods (mechanics-regularized motion tracking, parameter estimation, uncertainty quantification, etc.), in silico analysis of various diseases and potential treatments using personalized models/digital twins. For his work, he received multiple grants from the French National Research Agency (ANR), Swiss National Science Foundation (SNF), European Innovation Council (EIC), etc., and was awarded the Young Investigator Award from the Francophone Society of Biomechanics.