

TriCAMS 2022 Poster Information

September 16, 2022

Title: Rule-based Definition of Muscle Bundles in Patient-Specific Models of the Left Atrium

Author: Laryssa Abdala, *University of North Carolina, Chapel Hill*

Abstract: Patient-specific computer models of the atria can facilitate personalized risk assessment and treatment planning of Atrial Fibrillation. However, a challenge faced in creating such models is the complexity of the atrial fiber architecture. This work proposes a semi-automated rule-based algorithm to generate the local fiber orientation in the left atrium. A notable advantage of our approach is the ability to reconstruct the main LA fiber bundles in a variety of morphologies.

Title: Effective Thermal Equilibrium for Switching Polymer Model of Chromosome Dynamics

Author: Anna Coletti, *University of North Carolina, Chapel Hill*

Abstract: To be added later.

Title: Backing Yourself into a Corner: Emergent Effects of Self-Avoidant Memory in Curvature Statistics of Particle Paths.

Author: Katherine Daftari, *University of North Carolina, Chapel Hill*

Abstract: Chemically induced swimming of microdroplets motivates a model for self-avoidant particles which exhibit novel trajectory statistics at long timescales. As the particles stochastically explore the domain, they often turn in on their own past history and create concentration “traps” which are revealed by areas of extremely high path curvature. We explore the shortcomings of traditional models in explaining this behavior and suggest a new technique to better quantify this emergent effect.

Title: A Computational Fluid Dynamics Model of Embryonic Heart Chick Heart Development Under Perturbed Flow Conditions

Author: Kristen Giesbrecht, *University of North Carolina, Chapel Hill*

Abstract: I present a whole heart and vasculature computational fluid dynamics model of the embryonic chick anatomies at many development stages elucidating the role of abnormal blood flow in heart development.

Title: Geodesic Properties of a Generalized Wasserstein Embedding for Time Series Analysis

Author: Shiyang Li, *University of North Carolina, Chapel Hill*

Abstract: Transport-based metrics and related embeddings (transforms) have recently been used to model signal classes where nonlinear structures or variations are present. Here we study the geodesic properties of time series data with a generalized Wasserstein metric and the geometry related to their signed cumulative distribution transforms in the embedding space. Moreover, we show how understanding such geometric characteristics can provide added interpretability to certain time series classifiers, and be an inspiration for more robust classifiers.

Title: To Correctly Classify Imbalanced Data, Find the Best Model Data

Author: K. Medlin, *University of North Carolina, Chapel Hill*

Abstract: Most datasets are difficult to correctly classify because (i) they contain an imbalance of classes, and (ii) classifiers are trained to deliver accurate results only on the “majority” class. In other words, the classification of data is biased. Preliminary findings of a new classification method based on the data itself instead of the model show promising results.

Title: Well-Balanced Scheme for the Shallow Water MHD Equations with a New Divergence-Free Treatment of the Magnetic Field

Author: Michael Redle, *North Carolina State University*

Abstract: PDEs constrained by a divergence-free magnetic field provide mathematical models to many complex physical systems. A close examination of the nature of such PDEs typically reveals their deep mathematical structure, and thus, typically require a very fine and computationally expensive mesh. To ensure these structures are preserved exactly in simulations on a coarser mesh, a careful algorithmic construction is required. We present a new method that exactly preserves both the divergence-free constraint and equilibrium states of the shallow water MHD system. The design scheme is successfully tested on several examples.

Title: A Fast, Semi-Implicit, 2-Field Formulation for Modeling the Dynamics of Incompressible and Nearly-Incompressible Hyperelastic Solids

Author: Edward Terrell, *University of North Carolina, Chapel Hill*

Abstract: Dynamic models of incompressible elastic solids often require implicit time stepping. The featured method updates volumetric strain implicitly while updating momentum explicitly.

Title: A Nodal Immersed Finite Element-Finite Difference Method

Author: David Wells, *University of North Carolina, Chapel Hill*

Abstract: The immersed finite element-finite difference (IFED) method is a computational approach to modeling interactions between a fluid and an immersed structure. The IFED method uses a finite element (FE) method to approximate the stresses and forces on a structural mesh and a finite difference (FD) method to approximate the momentum of the entire fluid-structure system on a Cartesian grid. The fundamental approach used by this method follows the immersed boundary framework for modeling fluid-structure interaction (FSI), in which a force spreading operator prolongs structural forces to a Cartesian grid, and a velocity interpolation operator restricts a velocity field defined on that grid back onto the structural mesh. Constructing the coupling operators also requires determining the locations on the structure mesh where the forces and velocities are sampled. We show that sampling the forces and velocities at the nodes of the structural mesh is equivalent to using lumped mass matrices in the IFED coupling operators. If these approaches are combined, the IFED method permits the use of lumped mass matrices derived from nodal quadrature rules for standard interpolatory elements. Our theoretical results are confirmed by numerical benchmarks, including standard solid mechanics tests and examination of a dynamic model of a bioprosthetic heart valve.

Title: Examining the human response to endotoxin challenge variations using dynamical systems modeling

Author: Kristen Windoloski, *North Carolina State University*

Abstract: We develop a model describing interactions between inflammation components, hormones, and cardiovascular markers during an endotoxin challenge. We study the effects of changes in timing, total dose, and administration methods.

Title: A novel simultaneous plan quality and sparsity optimization for spot-scanning proton arc (SPArc) therapy

Author: Lewei Zhao, *Beaumont Health System, Michigan*

Abstract: “Background: Proton arc therapy is a new treatment modality that delivers proton beams while continuously rotating the gantry. However, it takes significant time to deliver the plan due to numerous spots in the proton arc plan. At meanwhile, reducing the treatment delivery time might degrade the treatment plan quality because of less degree of freedom in the optimization. Since the technological advancement in the energy layer selection system, spot switching time dominates the total irradiation time in the modern pencil beam scanning system. The previous study reported that the number of the spot is directly correlated to the delivery time. To the best of our knowledge, there is no planning framework can address this issue simultaneously.

Purpose: This study proposed a regularized l0-minimization primal dual active set with continuation (PDASC) algorithm to search the proton arc spot sparsity solution. This framework paved the first proton arc simultaneously optimization of the plan quality and the beam delivery time (BDT).

Methods: We used a non-convex l0-norm to control the sparsity level of the regularized solution and l2-norm for the clinical objectives. The algorithm couples the primal dual active set method with a continuation strategy on the regularization parameter. Two representative clinical cases, including an intracranial and a lung target, were used for testing purposes. l2-norm value is calculated for evaluating the clinical objective and dose-volume histogram (DVH) was analyzed. Both the objective value and optimization time are compared with the original Spot-Scanning Proton Arc algorithm (SPArc-original).

Results: The results show that PDASC can optimize both spot sparsity and plan quality simultaneously. This new planning framework could effectively improve the optimization speed by a factor of about three hundred on average (8.8 times to 536.5 times from 20).

Conclusions: This study introduced the first and fast proton arc optimization framework to simultaneously optimize the plan quality and BDT through PDASC, which is a critical step forward in the era of proton arc therapy.”
