**Poster #24 - Title:** Validation of Large Fluid Dynamic Simulations of Complex Geometries with 3D Printing

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**Abstract:**

Computational fluid dynamics (CFD) plays an increasing important role in circulatory disease modeling. Advances in high performance computing have made it possible to simulate fluid flow through complex geometries at high resolutions. However, for these simulations to impact clinical care, detailed validation of the simulation must be conducted with realistic data sets.

A standard method for validation of a CFD application is the simulation of flows for which the incompressible Navier-Stokes equations have a well-known result. Yet, for a CFD application focus on simulating blood flow in vascular geometries, standard flows may not fully reflect the challenges of the specific problem and provide a comprehensive assessment of the CFD application's stability and validity. For instance, a simulation of flow through a coarcted aorta must accurately resolve the narrow branches of the aortic arch and handle the high Reynolds numbers in the coarctation. A comparison with experimental results for a physiological relevant flow in a vascular geometry resolves this deficiency. 3D-printing allows the same geometry to be used for computation and experiment.

HARVEY is a parallel hemodynamics application based on the lattice Boltzmann method. We compare the results from HARVEY with particle image velocimetry (PIV) results for flow in a patient-specific aorta with a coarctation. Focusing on the coarctation, our results indicate that HARVEY accurately resolves the flow through the geometry. For this comparison, HARVEY simulations used as many as 32768 cores of a Blue Gene/Q supercomputer.

**Poster #25 - Title:** Bayesian model of microbial population growth

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**Abstract:**

Microbial population growth curves are ubiquitous in microbiology, and can be used to study differential effects of media, genetics and stress on cell populations. Consequently, many modeling frameworks exist for microbial population growth measurements. However, the most common models are limited to a small subset of experimental conditions (e.g., single substrate with a large main effect). In order to model the diverse effects of genetics and stress on microbial population growth, we developed a completely general model of growth curves using Gaussian process (GP) regression. We apply GP regression to a set of growth experiments for $27$ transcription factor mutant strains in the hypersaline-adapted archaeon \hsal{} under normal growth, oxidative stress, and heat shock. GP regression performs comparably to classical growth models under normal conditions and significantly outperforms other models for non-standard conditions (e.g. stress). GP regression accurately identifies transcription factors in \hsal{} that are significant in one or more stress response pathways.
Our GP models are flexible and accurate models of population growth under all experimental conditions.

**Poster #26 - Title:** Can Massively Parallel Fluid Simulations Guide Coronary Stenting Procedures?

**Authors:** Madhurima Vardhan, John Gounley, Darshana Jaint, Jane Leopold, Andy Kahn, Amanda Randles

**Abstract:**

Coronary stent implantation remains the leading percutaneous intervention to treat coronary artery disease with an estimated 454,000 patients undergoing this procedure annually. In stent restenosis occurs in 12-15% of stents and is associated with an increase in adverse cardiovascular events and healthcare costs. This pathophysiological phenomenon arises when neointimal hyperplasia progressively obstructs the vessel lumen at the edges and/or within the body of the stent. Stents alter coronary artery geometry and increase rigidity leading to areas of perturbed (i.e., low) shear stress; low shear stress promotes neointimal formation. In this study, we are investigating the role computational fluid dynamics in surgical planning and clinical decision-making for coronary stenting procedures.

Our hypothesis is that access to patient-specific wall shear stress data derived from computational fluid simulations would influence where a clinician would place the stent and potentially reduce the likelihood of stent restenosis. Accurate 3D representations of left and right coronary arteries are reconstructed from anonymized CT data of 35 patients. Each patient CT data sets consists of approximately of 2000 Dicom slices, coronary arteries were segmented on each slice using Mimics. Reconstructed 3D coronary geometries after smoothing are validated by cardiologists.

Wall Shear Stress (WSS) in these anatomically validated models is calculated using HARVEY - a massively parallel computation fluid dynamics application. It is a C++ code that uses Message Pass Interface for parallelization and has been shown to scale efficiently to 1.6 million cores of the IBM Blue Gene/Q supercomputer. To determine WSS physiological input parameters such as inlet velocity and fluid viscosity are derived from averaged patient data. The WSS results are then used in a formal quantitative user study with experts in the field of interventional cardiology across different geographical regions. The statistically significant results from the user study would demonstrate that the knowledge of low WSS regions in coronary arteries could guide stent placement. Modified stent configurations could potentially help reduce in stent restenosis and thereby translate to improved surgical outcomes.