Workshop on Applied Mathematics and Scientific Computing

Shiinoki Cultural Complex, Kanazawa City, Japan

January 28 (Wednesday), 2026

Program and Abstracts

Time	Title, Speaker, Affiliation, and Abstract
09:25–09:30	**Opening Remarks** Hirofumi NOTSU, Kanazawa University, Japan
09:30–10:00	**Modeling of rheology in blood flow, coagulation and hemolysis** Tomáš BODNÁR, Czech Technical University in Prague, Czech Republic *Blood flow modeling and simulations are quite challenging from both the physical and mathematical point of view. This is even more complicated when the problems of blood hemolysis or thrombosis are considered. The associated numerical simulations are thus very demanding, leading to additional costs or need to reduce the spatio-temporal resolution of the simulations. The present talk will introduce some of the rheological models typically used for blood flow and discuss their possible combination with the models of blood coagulation and hemolysis. Focus will be not just on the generalized Newtonian models, but also on the viscoelastic models of the differential type, with shear-thinning properties. Special attention will be paid to the effects of convected time derivative in rheological constitutive laws.*
10:00–10:30	**Design and numerical assessment of axial blood pumps using a parametric CAD–CFD workflow** Anna LANCMANOVÁ, Czech Technical University in Prague, Czech Republic *A computational workflow for the development of axial rotary blood pumps will be presented, combining parametric CAD generation with automated numerical simulations and optimization workflow. The framework is intended to support iterative design loops, allowing geometry modifications to be rapidly tested, assessed, and documented without repeated manual preprocessing or reporting. Rotational modelling approaches will be addressed, as the representation of rotating components influences the reliability of predicted pump performance. Steady-state simulations using the Multiple Reference Frame (MRF) method will be compared with fully transient rotating mesh simulations, and differences will be discussed.*
10:30–11:00	**Break**
11:00–11:30	**Revealing the energy transfer mechanism from muscle contraction to blood ejection using a heart simulator** Takumi WASHIO, The University of Tokyo and UT-Heart Inc., Japan *A normal human left ventricle ejects 60% of the end-diastolic cavity volume with 15% fiber shortening. When changes in deformation energy and viscous energy loss are negligible, all of the energy from muscle contraction is transformed into blood ejection energy. During the ejection phase, the direction of contraction stress is parallel to the inner wall surface, where the blood is pushed inward. To achieve highly efficient energy transfer with minimal fiber shortening, the fiber orientation must be well-organized, and contraction forces must be generated to ensure uniform fiber shortening. In this talk, first, I will discuss what we have learned about the aforementioned energy transfer mechanism from our numerical models. Second, I will introduce numerical schemes that facilitate fluid-structure interactions in whole heart models, including heart valves. Finally, I will demonstrate some practical applications of our heart simulator in clinical settings.*
11:30–12:00	**Finite element simulation of thermal convection in the human eye** Takehiro MATSUMOTO, Tohoku University, Japan *Aqueous humor flow in the anterior segment of the eye is strongly linked to glaucoma, but observing the flow is very difficult because the fluid is transparent. In this study, we constructed a patient-specific geometry and simulated a three-dimensional time-dependent aqueous humor flow with thermal convection using the finite element method. To validate the simulation results, we used optical flow analysis to estimate the velocity field of aqueous humor from anterior segment video data and compared it with the simulated velocity field. The results showed qualitative agreement between the two flow fields, supporting the effectiveness of the proposed method. Furthermore, our results indicate that eyelid conditions and posture have significant effects on aqueous humor dynamics.*
12:00–14:00	**Lunch Break**

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14:00–14:30	**Shape optimization problem for turbulent flow** Takashi NAKAZAWA, Kanazawa University, Japan *Shape optimization in turbulent flows is generally extremely challenging because it requires exploring a large-scale, highly nonlinear solution space. In this talk, the speaker presents an approach that tackles this difficulty by applying Snapshot POD to reduce the dimensionality of the solution space, enabling more efficient solution exploration. The presentation will also introduce results from applying this method to several turbulent flow cases.*
14:30–15:00	**Shape identification in fluid flows via shape optimization** Julius Fergy RABAGO, Kanazawa University, Japan *This talk provides an overview of numerical workflows based on shape optimization for shape identification problems in fluid flows. Prototypical examples from free boundary problems, geometric inverse problems, and optimal shape design are considered. The presentation focuses on how shape derivatives are formulated and incorporated into numerical algorithms. Representative examples illustrate how shape optimization methods can be implemented in practice to address shape-related problems governed by fluid flow models.*
15:00–15:30	**Break**
15:30–16:00	**Adaptive Lagrange-Galerkin methods for incompressible flow problems** Hirofumi NOTSU, Kanazawa University, Japan *We present adaptive Lagrange–Galerkin (LG) finite element schemes with pressure stabilization and level set techniques for two-fluid flow and fluid–structure interaction problems. Owing to their characteristic-based formulation, LG schemes are robust for convection-dominated problems and free of CFL-type restrictions, making them well-suited for adaptive mesh refinement. A second-order stabilized LG scheme for the incompressible Oseen equations is introduced as a theoretical foundation, and its stability and error estimates are established. The proposed framework is then extended to two-fluid flow and fluid–structure interaction problems, with numerical results in multiple dimensions demonstrating its effectiveness.*
16:00–16:05	**Closing Remarks** Hirofumi NOTSU, Kanazawa University, Japan