The 3rd Workshop on Applied Mathematics and Scientific Computing

Online, Kanazawa University, Kanazawa City, Japan, August 10 (Monday), 2026

Time	Schedule Overview: Speaker / Affiliation
10:00–10:20	Radek RICHTR, Czech Academy of Sciences and Czech Technical University in Prague, Czech Republic
10:20–10:35	Vinsensia FERREN, Bandung Institute of Technology, Indonesia, and Kanazawa University, Japan
10:35–10:45	Break
10:45–11:05	Petr PAUŠ, Czech Technical University in Prague, Czech Republic
11:05–11:20	Chayanon WANNARAT, Chulalongkorn University, Thailand, and Kanazawa University, Japan

Instructions for Speakers (Please keep your presentation within the allotted time.)

- **20-minute talk:** 15 min presentation + 5 min moderator's introduction and Q&A.
- **15-minute talk:** 12 min presentation + 3 min moderator's introduction and Q&A.

Schedule and Abstracts

Time	Title of Talk / Speaker / Affiliation / Abstract
09:55–10:00	*Opening Remarks*
10:00–10:20	*Dynamic Texture Similarity: From Spectral Representation to Segmentation and Human Perception*

Radek Richtr
Institute of Information Theory and Automation, Czech Academy of Sciences, and
Faculty of Information Technology, Czech Technical University in Prague, Czech Republic

Dynamic textures are visual processes whose appearance is determined jointly by spatial structure and temporal evolution. Typical examples include water, smoke, fire, foliage, and grass [1]. This talk presents a mathematical approach to dynamic-texture similarity that focuses on the organization of change rather than on pixelwise correspondence.

The central method is the Dynamic Texture Similarity Criterion (DTSM) [2]. It selects significant spatial-frequency components, follows their trajectories over time, and compares the resulting temporal Fourier spectra. This construction provides an interpretable account of spectral energy that is lost or newly introduced between two videos. At the same time, its pair-dependent representation means that DTSM is a useful similarity or dissimilarity criterion, but not a metric in the strict mathematical sense.

We also investigated whether the original inner L_1 comparison should be replaced by another distance between the temporal Fourier-magnitude curves associated with selected spatial frequencies. With the rest of the segmentation pipeline fixed, 35 alternatives were screened, including Bray–Curtis [4], Canberra, Wasserstein/EMD, cosine-angle, dynamic time warping, soft-DTW, and multiscale spectral comparisons. Bray–Curtis gave the strongest balanced inner-spectral result and improved the local full-sequence *Dynamic A* diagnostics over L_1, although it did not outperform the frozen 32-dimensional RMS–L_2 hybrid. These are local, in-sequence development results, not official or held-out benchmark scores.

The talk then considers advanced variants based on fixed spectral signatures, local descriptors, and distributional distances. Their use in dynamic-texture segmentation is illustrated on the UTIA Mosaic *Dynamic A* benchmark [3], including its formal partitioning problem, evaluation criteria, and qualitative video results. Finally, computational similarity is related to human judgements of grass textures and to edited videos in which object removal and inpainting may preserve, suppress, or introduce characteristic spatio-temporal frequencies.

[1] G. Doretto, A. Chiuso, Y. N. Wu, and S. Soatto, *Dynamic Textures*, International Journal of Computer Vision, vol. 51, no. 2, pp. 91–109, 2003,

[2] R. Richtr and M. Haindl, *Dynamic Texture Similarity Criterion*, Proceedings of the 24th International Conference on Pattern Recognition (ICPR), 2018, pp. 904–909,

[3] S. Mikeš and M. Haindl, *Texture Segmentation Benchmark*, IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 44, no. 9, pp. 5647–5663, 2022,

[4] J. R. Bray and J. T. Curtis, *An Ordination of the Upland Forest Communities of Southern Wisconsin*, Ecological Monographs, vol. 27, no. 4, pp. 325–349, 1957,

10:20–10:35	*Numerical Optimization of Friction-Based Wave Attenuation in the Shallow Water Equations*

Vinsensia Ferren
Bandung Institute of Technology, Indonesia
Kanazawa University, Japan

Bottom friction is a key mechanism for wave-energy dissipation in shallow-water models, yet it is commonly prescribed empirically and assumed to be spatially uniform. This thesis instead treats the friction coefficient as a spatially distributed control variable and develops an adjoint-based framework for optimizing its distribution to attenuate waves governed by the one-dimensional shallow water equations (SWEs). The problem is formulated as a PDE-constrained optimization in which the SWEs serve as the state constraint and a cost functional measuring wave activity, augmented by Tikhonov regularization, is minimized over bounded friction profiles.

A weak formulation of the state system is established for two classes of boundary conditions, and Lipschitz continuity of the control-to-state map is proved using an energy estimate and Grönwall's inequality. The state equations are discretized using piecewise-linear finite elements in space and a Lagrange–Galerkin scheme in time, which treats the nonlinear advection term through characteristic tracing and avoids the CFL-type restriction of conventional Galerkin discretizations.

The main theoretical contribution is the derivation of a linear backward-in-time adjoint system and an explicit gradient formula for the reduced cost functional through a Lagrangian formulation. The resulting gradient is used in a projected gradient-descent algorithm that maintains the prescribed bounds on the friction coefficient. Numerical experiments verify the accuracy of the forward solver using manufactured solutions and demonstrate that wave attenuation depends strongly on the spatial distribution of friction. The optimized friction profile substantially suppresses persistent wave oscillations compared with the uncontrolled case, demonstrating the potential of distributed friction optimization as a wave-attenuation strategy in shallow-water models.

This is a joint work with Prof. Hirofumi Notsu (Kanazawa University, Japan) and Julius Fergy Rabago (Kanazawa University, Japan).

10:35–10:45	*Break*
10:45–11:05	*Deterministic and Probabilistic Approach to Cross-Slip in Dislocation Dynamics*

Petr Pauš
Czech Technical University in Prague, Czech Republic

This contribution deals with the numerical simulation of dislocation-precipitate interaction in copper crystals by means of discrete dislocation dynamics. We consider a dislocation gliding in a slip plane under an external stress field and a precipitate located in the same slip plane also generating a stress field. The precipitate stress field forces the dislocation to perform a cross-slip mechanism (i.e., change the slip plane). We present a comparison of the deterministic approach to the cross-slip mechanism with a probabilistic approach governed by a normal distribution of probability.
This work is based on [1, 2, 3]. This is a joint work with Michal Beneš and Miroslav Kolář (both Czech Technical University in Prague, Czech Rep.).

[1] Petr Pauš, Michal Beneš, *Direct approach to mean-curvature flow with topological changes.*, Kybernetika 45(4) (2009), 591–604.

[2] Petr Pauš, Michal Beneš, Jan Kratochvíl, *A dislocation dynamics analysis of the critical cross-slip annihilation distance and the cyclic saturation stress in fcc single crystals at different temperatures.*, Acta materialia 61.20 (2013), 7917–7923.

[3] Marc Verdier, Marc Fivel, István Groma, *Mesoscopic scale simulation of dislocation dynamics in fcc metals: Principles and applications*, Modelling and Simulation in Materials Science and Engineering 6.6 (1998), p. 755.

11:05–11:20	*Analysis of Singular Perturbation Problems in Differential Equations and Related Topics in Atmospheric Modeling*	

Chayanon Wannarat
Chulalongkorn University, Thailand
Kanazawa University, Japan

Singular perturbation problems arise when a small parameter causes a system's qualitative behavior to change abruptly as it tends to zero, typically producing thin boundary layers where solutions vary rapidly. This work develops a unified perspective on such problems, spanning ordinary differential equations and a fundamental model in geophysical fluid dynamics. We begin with linear singularly perturbed ODEs, constructing classical inner and outer asymptotic expansions and proving their uniform convergence to the exact solution as the perturbation parameter vanishes. We then extend this analysis to a broader class of nonlinear problems by introducing a new tilted coordinate transformation. This transformation reformulates the problem so that the Arzelà–Ascoli theorem yields a simple and robust framework for establishing uniform convergence of the transformed solutions, circumventing some of the technical difficulties of classical matched asymptotics. For a distinguished class of nonlinear equations, we go further and explicitly identify the limiting profile, proving uniform convergence to this limit. Finally, we apply the singular perturbation framework to the three-dimensional Boussinesq equations governing incompressible, buoyancy-driven flow. Taking the aspect ratio $\varepsilon = H/L$ as the small parameter, we nondimensionalize the system and perform an anisotropic rescaling of the vertical coordinate. This formally derives the primitive equations as the thin-domain limit, connecting rigorous ODE asymptotics to a physically significant PDE reduction widely used in ocean and atmospheric modeling.

This work is based on [1, 3].

This is a joint work with Kimura Masato (Kanazawa University, Japan).

[1] Chongsheng Cao and Edriss S Titi, *Global well-posedness of the three- dimensional viscous primitive equations of large scale ocean and atmo- sphere dynamics*, Annals of Mathematics, pages 245–267, 2007.

[2] Philip Hartman, *Ordinary differential equations.*, SIAM, 2002.

[3] Xueke Pu and Wenli Zhou, *Rigorous derivation of the full primitive equa- tions by the scaled boussinesq equations with rotation.*, Bulletin of the Malaysian Mathematical Sciences Society, 46(3):88, 2023.

[4] William C Skamarock, Joseph B Klemp, Jimy Dudhia, David O Gill, Zhi- quan Liu, Judith Berner, Wei Wang, Jordan G Powers, Michael G Duda, Dale M Barker, et al., *A description of the advanced research wrf version 4*, NCAR tech. note ncar/tn-556+ str, 145(10.5065), 2019.

11:20–11:25	*Closing Remarks*

Organizers

Masato KIMURA	Kanazawa University, Japan
Hirofumi NOTSU	Kanazawa University, Japan
Julius Fergy RABAGO	Kanazawa University, Japan