2024 Workshop on Nonlinear Analysis and Applications

School of Mathematical and Statistical Sciences (SMSS)
The University of Texas Rio Grande Valley (UTRGV)

Date: March 19, 2024
Location: UTRGV Stem Center (EMAGC 2.412), Edinburg

Organizers:

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Invited Speakers:

Thomas Chen	University of Texas-Austin
Qing Nie	University of California-Irvine
Dmitry Rachinskiy	University of Texas-Dallas
Libin Rong	University of Florida

Workshop Description:

The SMSS of UTRGV is hosting a single day workshop devoted to nonlinear analysis and computation with interdisciplinary applications. We wish to build a workshop series which will provide a forum for mathematics motivated by applications in natural and social sciences to biology and epidemiology. The workshop series will bring together researchers across all career stages and across different research areas. Our goal is to foster and enhance communication and collaboration among faculty and students, and to promote the incorporation of young researchers into these fields. The workshop series will feature a panorama of current research in nonlinear analysis and computation (and related differential equations and dynamical systems), with a clear view towards applications in math-physics, engineering, biology, and other domains.

This workshop series is sponsored by the Carlos and Stephanie Manrique de Lara Endowment Grant and the School of Mathematical and Statistical Sciences at the University of Texas Rio Grande Valley.

Please contact Dr. Zhaosheng Feng (zhaosheng.feng@utrgv.edu) if you have any questions or need more information.

WORKSHOP PROGRAM

- 13:00 pm-13:10 pm, Opening remarks
  Timothy Huber, Director of School of Mathematical and Statistical Sciences, University of Texas Rio Grande Valley

  Chair of Talk I: Zhaosheng Feng

- 13:10 pm -14:00 pm, Thomas Chen, Department of Mathematics, University of Texas at Austin,
  Title: *Explicit construction of global L^2 minimizers in underparametrized Deep Learning networks*

  Chair of Talk II: Erwin Suazo

- 14:05 pm-14:55 pm, Qing Nie, Department of Mathematics, University of California at Irvine
  Title: *Spatiotemporal learning of high-dimensional cell fate*

  Chair of Talk III: Jasang Yoon

- 15:00 pm -15:50 pm, Dmitrii Rachinskii, Department of Mathematical Sciences, University of Texas at Dallas
  Title: *Multiple Lyapunov functions in analysis of stability of systems with hysteresis: SIR model with Preisach operator as a case study*

  Chair of Talk IV: Bingyuan Liu

- 15:55 pm-16:45 pm, Libin Rong, Department of Mathematics, University of FLorida
  Title: *Recent developments in modeling HIV infection and treatment*

  Chair of Discussions Session: Michael Lindstrom

- 16:50 pm-18:00 pm, Group discussions

ABSTRACTS OF TALKS

- Thomas Chen, Professor and Chairman of Department of Mathematics
University of Texas, Austin, Texas 78712

  Title: Explicit Construction of Global L^2 Minimizers in Underparametrized Deep Learning Networks

  Abstract: In this talk, we present some recent joint results with Patricia Munoz Ewald (UT Austin) in which we provide an explicit construction of global minimizers of the L^2 cost function in underparametrized Deep Learning networks, in the context of supervised learning and ReLU activation functions; no use of gradient descent is made here. Moreover, a geometrically adapted gradient descent flow is presented for the overparametrized case which exhibits a uniform exponential convergence rate, under a rank condition; links of this construction with sub-Riemannian geometry are pointed out.

- Qing Nie, University of California Presidential Chair
Department of Mathematics and Developmental & Cell Biology, University of California, Irvine, California 92697

  Title: Spatiotemporal Learning of High-dimensional Cell Fate

  Abstract: Cells make fate decisions in response to dynamic environments, and multicellular structures emerge from multiscale interplays among cells and genes in space and time. The recent single-cell genomics technology provides an unprecedented opportunity to profile cells for all their genes. While those measurements provide high-dimensional gene expression profiles for all cells, it requires fixing individual cells that lose many important spatiotemporal information. Is it possible to infer temporal relationships among cells from single or multiple snapshots? How to recover spatial interactions among cells, for example, cell-cell communication? In this talk I will present our newly developed computational tools that are mostly based on dynamical models and machine-learning methods, with a focus on inference and analysis of transitional properties of cells and cell-cell communication using both high-dimensional single-cell and spatial transcriptomics, as well as multi-omics data for some cases. Through their applications to various complex systems in development, regeneration, and diseases, we show the discovery power of such methods in addition to identifying areas for further method development for spatiotemporal analysis of single-cell data.

- Dmitrii Rachinskii, Professor of Mathematics
  University of Texas, Dallas, Texas 75080

  Title: Multiple Lyapunov functions in analysis of stability of systems with hysteresis: SIR model with Preisach operator as a case study

  Abstract: In engineering applications, a variety of non-smooth operators are used to model hysteresis phenomena in constitutive relations of plastic, magnetic, piezoelectric, porous materials and contact dynamics. We discuss this method of modeling in the context of social interaction and population dynamics using an SIR model with the Preisach hysteresis operator as a case study. Due to hysteresis, the system has a continuum of equilibrium states. To analyze stability, we interpret the model as a switched system with infinitely many subsystems (vector fields) and a history-dependent switching rule imposed by the Preisach operator. As is well-known, switching can lead to instability even if each subsystem is stable. We adapt the method of multiple Lyapunov functions to obtain sufficient conditions for global stability and discuss some instability scenarios.

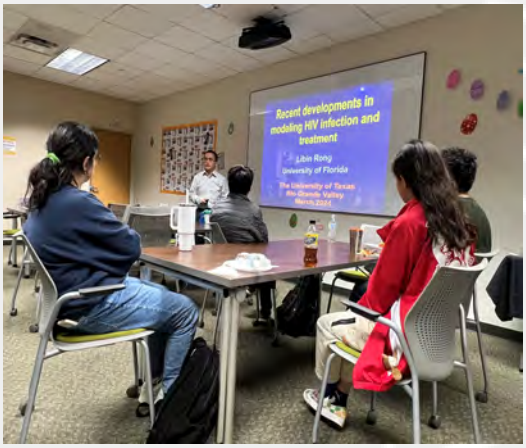
- Libin Rong, Professor and Chairman of Department of Mathematics
  University of Florida, Gainesville, Florida 32611

  Title: Recent developments in modeling HIV infection and treatment

  Abstract: HIV infection remains a significant global public health challenge. While highly active antiretroviral therapy effectively controls viral replication, complete eradication of the virus remains elusive. Mathematical models, when integrated with experimental data, offer valuable insights into HIV infection, drug treatments, and immune responses. However, several key questions persist unanswered: Are some drugs more effective than others? Does treatment intensification yield benefits? What factors contribute to multiple infections? Are there additional sources, aside from latent infections, that sustain HIV persistence during long-term therapy? In this talk, I will outline recent modeling advancements aimed at addressing these questions and discuss their implications for HIV infection management.







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