Biomedical Informatics Grand Rounds
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The Interplay of Curvature and Control from Vison-Based Autonomy, Networks, to Economics

Romeil Sandhu, Ph.D.
Assistant Professor
Stony Brook University
Departments of Bioinformatics and Computer Science
Department of Applied Mathematics & Statistics

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Bio: Romeil Sandhu is currently an Assistant Professor at Stony Brook University with appointments in Biomedical Informatics, Applied Mathematics & Statistics Departments, and Computer Science. He is the recipient of the 2018 AFOSR YIP Award for work on 2D3D feedback control and machine learning for autonomous systems and 2018 NSF CAREER Award for work on geometric optimization of time-varying networks. Romeil first received his B.S. and M.S, and Ph.D. degrees from the Georgia Institute of Technology in Electrical Engineering. His research interest focuses on the broad area of intelligent systems with a particular emphasis in geometry & control towards the understanding of faltering autonomous agents in an unknown environment where ambiguity often arises.

Abstract: This talk will focus on recent advances in geometry and control with a specific emphasis on how curvature (a measure of "flatness" in Riemannian geometry) is intimately tied to rate functions with applications in areas of vision-based autonomy, graph theory and complex networks, systems biology, to seemingly disparate areas in economics. To motivate our discussion, the first part of this talk will focus on the fundamental chicken-and-egg robotic vison problems of 2D image segmentation and 3D attitude (pose) estimation from a single and/or multiple 2D observations. We show that these two problems can be intrinsically coupled in a single 2D3D PDE by leveraging geometric constructs and further, how one can generalize such concepts beyond the image domain in a "post-vision" spectrum whereby we invert radar signal information (bypassing image formation) for shape reconstruction. In doing so, we are then able to show, from a feedback control perspective, that a particular form of curvature is positively correlated to convergence rates of stability in the Lyapunov sense. In the second half of this talk, we will relate how this result fits into a broader thematic result due to Lott, Villani, and Sturm whereby another form of curvature, namely Ricci curvature, is intimately connected to Boltzmann entropy. In turn, we reexamine the open problem of developing Ricci curvature over discrete metric spaces and how such advances that leverage coarse geometry can be employed to exploit network functionality. Specifically, by placing a probability structure on a graph as opposed to dealing directly with the discrete space, the graph can be treated as a Riemannian manifold for which there exists a richness of tools and advantages that will be discussed. Lastly and time permitting, we will close with several applications in systems biology (i.e., cancer and stem-cell biology) to economics in a motivating attempt to stylize the interplay of control and curvature. This talk is designed to be accessible to a general audience with an interest in any of the above domains with a specific interest in control and dynamical systems.

Educational Objects: Upon completion, participants should be able to:
- Mathematical Theory: Introduce Geometry as a Form of Uncertainty in (any) Dynamical Systems
- Biological Relevance: How Such Theory Can Be Used in Biological (Stem-Cell/Cancer) Systems
- Interdisciplinary Applications: How Such Theory Can Be Applied to Autonomy to Economic Applications.

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