

**CRUNCH Seminars at Brown, Division of Applied Mathematics**

**Friday - June 4, 2021**

**Physics-infused Machine Learning and Evolutionary Learning Approaches to Design Intelligent Robotic Systems**

**Amir Behjat, University at Buffalo**

**Recent years have seen significant progress and promising success in the ability of data-driven learning methods to perform state prediction and (behavior) policy generation for intelligent robotic systems. However, the black-box nature of some of these approaches, the need for overtly large or data-hungry models, and poor generalizability and scalability when applied to complex settings (e.g., swarm learning and robot design) continue to plague the performance of such methods. One potential broad vision towards alleviating these barriers calls for the integration of accumulated knowledge in the form of physics equations and laws, human domain knowledge, and control theory, into machine learning processes (as opposed to simply depending on data).**

**This talk will go over some of the early successes that we have had in implementing this vision. As a first example, we will discuss Physics-Infused Machine Learning (PIML) architectures that integrate imperfect-but-fast physics models with neural networks to provide significantly better generalizability and extrapolability. Then we will touch upon a new Neuroevolution framework that exploits fundamental genetic operator and graph theory concepts to provide better convergence and competitive performance in learning controllers for benchmark OpenAI problems and unmanned aerial system problems. Finally, we will end with some insights into our recent work in applying this neuroevolution algorithm along with control theory concepts to perform morphology/behavior co-design of unmanned aerial vehicles, and how this concept could in the future make it significantly easier to perform co-design of new and/or multi-functional robotic systems.**