Schedule of Workshop

Thursday Aug 17

9:30-10:20 Chethan Pandarinath (GT BME)

10:20-10:40 coffee break

10:40-11:30 Daniel Goldman (GT Physics)

11:30-12:20 Sam Brown (GT Bio Sci.)

12:20-1:50 lunch break

1:50-2:40 Matthew McDowell (GT ME)

2:40-3:30 Jorge Laval (GT CE) CANCELLED

3:30-3:50 coffee break

3:50-4:40 Martin Short (GT Math) CANCELLED

Friday Aug 18

9:30-10:20 Eric Feron (GT AE)

10:20-10:40 coffee break

10:40-11:30 Kaivalya Bakshi, Evangelos Theodorou (GT AE)

11:30-12:20 Fumin Zhang (ECE)

12:20-1:50 lunch break

1:50-2:40 Panos Tsiotras (GT AE)

2:40-3:30 Marcus J. Holzinger (GT AE) CANCELLED

3:30-3:50 coffee break

3:50-4:40 Martha Grover (GT Chem Bio Eng)

Chethan Pandarinath (GT BME)

Title: High performance brain-machine interfaces through innovations in control algorithm design

Abstract: Brain-machine interfaces (BMIs) aim to restore function for people with disabilities by directly interfacing with the nervous system to control external assistive devices. A key challenge in advancing these systems is developing frameworks to accurately estimate and perturb the state of the brain in real-time. I will demonstrate the development and application of such frameworks to an intracortical motor prosthesis for people with paralysis. As part of the BrainGate2 pilot clinical trial, we developed advances in neural signal processing, systems design, and algorithms and demonstrated the highest performance 2-dimensional control and communications rates ever achieved by people with paralysis controlling a BMI. Moving forward, I will highlight recent results in using deep learning approaches to precisely understand the dynamics of neural population activity. By modeling neural population activity as a reflection of an underlying dynamical system, we dramatically increase our ability to extract information and intention from populations of neurons in the brain. The insights gained from these studies motivate interdisciplinary approaches towards the control of complex end effectors (e.g., dextrous robotic arms) that leverage innovations across neuroengineering and systems neuroscience.

Daniel Goldman (GT Physics)

Title: The geometry of self-propulsion in (and on) frictional fluids

Abstract: Certain animals and robots contend with flowable terrestrial environments like sand. We have developed a granular resistive force theory (RFT) that accurately models locomotion in dry granular media (Zhang & Goldman, PoF, 2014) in the "frictional fluid" regime; however, this theory gives limited insight into the character of locomotion. Geometric mechanics (e.g. work of Shapere, Wilczek, Marsden, Kelly, and others) is a powerful framework relating position and orientation changes of a body to shape changes. Advances by Hatton and Choset (Eur. Phys. J. 2015) now enable application to large self-deformations; in previous collaboration we demonstrated the power of the combination of geometric mechanics and RFT through study of a three-link robot (two active, controllable degrees of freedom) swimming in granular media (Hatton et al, PRL, 2013). In this talk I will present our continued collaborative work extending these tools to describe the locomotion of animals and robots with considerably more than two degrees of freedom. I will show that the cyclic self-deformations of sandfish lizards, shovel nosed snakes, sidewinder rattlesnakes, salamanders and mudskipper fish (and corresponding robophysical models) that make continuous or intermittent contacts with granular substrates can be represented as a linear combination of two shape bases functions -- the shape configuration space can be described with two variables. With these approximations we gain insight into optimal self-deformation of high-DoF locomotors in laboratory settings which approximate certain natural environments. These tools facilitate the search for locomotor templates (see e.g. Full & Koditschek, JEB, 1999)—low dimensional neuromechanical control targets which can enable animals to perform tasks quickly, efficiently or with minimal sensing and control.

Sam Brown (GT Bio Sci.)

Title: Effective and evolutionarily robust infection control

Abstract: Infection medicine currently faces two major and growing crises that impact the ability of MDs to treat bacterial infections with our current arsenal of antibiotics. The first is widely recognised – the evolution of antibiotic resistance. The second receives less attention – chronic and life-threatening infections where appropriate antibiotics often fail to resolve infections. By building a multi-scale predictive understanding of microbial dynamics both within and among patients, I aim to develop novel patient-specific control strategies that effectively treat patients now and into the future.

Matthew McDowell (GT ME)

Title: In situ Characterization of Dynamic Processes in Materials for Electrochemical Energy Storage

Abstract: Dynamic materials processes, such as phase transformations, mechanical degradation, and ion motion, play a major role in determining the lifetime and performance of next-generation electrochemical energy storage systems. To develop batteries with improved safety, energy density, and lifetime, it is critical to understand transformation mechanisms and degradation processes across length scales within these devices. In my research group, multiscale in situ experimental techniques are used to reveal reaction mechanisms and interfacial transformations in energy storage materials to guide the development of better batteries. Our recent work has used a combination of in situ transmission electron microscopy (TEM) and in situ x-ray diffraction (XRD) to elucidate transformation pathways when high capacity electrode materials react with lithium vs. sodium. Cu2S-based electrodes, for instance, show similar global transformations during reaction with lithium and sodium, but the nanoscale reaction pathways differ significantly, which influences the electrochemical behavior. Other sulfide materials also show divergent behavior. Additional research to be presented is focused on i) using x-ray spectroscopic methods to understand reaction mechanisms at solid-state interfaces, and ii) using x-ray diffraction and imaging methods to investigate strain evolution within individual battery particles. Together, these results demonstrate the importance of utilizing in situ techniques to understand atomic-to macroscale dynamic processes in energy materials.

Jorge Laval (GT CE)

Title: TBA

Abstract: TBA

Martin Short (GT Math)

Title: Modeling and predicting urban crime – How data assimilation helps bridge the gap between stochastic and continuous models

Abstract: Data assimilation is a powerful tool for combining mathematical models with real-world data to make better predictions and estimate the state and/or parameters of dynamical systems. In this talk I will give an overview of some work on models for predicting urban crime patterns, ranging from stochastic models to differential equations. I will then present some work on data assimilation techniques that have been developed and applied for this problem, so that these models can be joined with real data for purposes of model fitting and crime forecasting.

Eric Feron (GT AE)

Title: The growing need for proofs in Aerospace Information systems

Abstract: Since its inception, aerospace engineering has been the fertile grounds for nice results in dynamical systems, including those related to optimal control, dynamical system stability, filtering theory etc., reaching an all-time high during the Apollo program. On the other hand, the growing importance of computers and computer science in all aerospace applications poses new and somewhat different challenges that bring back the need for mathematical rigor, not only for the sake of elegance and personal gratification, but also as key elements towards the certification of embedded real-time software applications.

The nature of the problems encountered during software and system analysis to support system certification will be reviewed and various approaches to their solution will be outlined. The very strong need for engineering students familiar with the notion of proof (and mathematics students with a taste for engineering) will be discussed.

Kaivalya Bakshi, Evangelos Theodorou (GT AE)

Title: Fully Nonlinear P(I)DEs and stochastic control: SDEs with control multiplicative noise and ensemble control of jump diffusions

Abstract: Application of the Dynamics Programming Principle (DPP) to continuous space stochastic control problems leads to a PDE problem in most practical cases. The deep relationship between stochastic control and PDE theory has led to several interesting algorithmic and analytical developments over the past few decades. Probabilistic representation of PDEs arising from the control framework lies at the heart of this relationship.

In this talk we discuss our ongoing and recent works on PDE based stochastic control in two specific subtopics. It is well known that in case a nonlinear stochastic control problem leads to semilinear parabolic PDE problem, one may transform it to a linear PDE or use the first order forward backward SDEs representation of the semilinear PDE. In the first subtopic discussed in this talk, a second order forward backward SDEs framework is built to solve a fully nonlinear parabolic PDE. Such problems arise in systems with control multiplicative noise which have been used successfully in the past. In our second subtopic, an ensemble control problem of jump diffusions will be considered. This is inherently a PIDE control problem. We select the Infinite Dimensional Minimum Principle (IDMP) approach to solve this problem. A close resemblance is observed in the structure of the control frameworks resulting from application of Stochastic Dynamic Programming (SDP) and IDMP. We explore the fundamental connection of SDP applied to control of SDEs with the IDMP applied to control of P(I)DEs. Finally, we conclude by alluding to some questions relating to the stability properties of PDE based control frameworks and their importance in possible future applications.

Fumin Zhang (ECE)

Title: Learning and Predicting Human Intentions Through Interactions

Abstract: One of the most challenging problems for robot to effectively interact with human is the lack of predictive models for human Intentions. The research community is making tremendous effort in developing learning algorithms and feedback control methods that are able to adapt to individual differences and, at the same time, to tolerate temporary abnormalities. This talk will focus on how to recognize and predict human intentions when a robot may have an opportunity to trigger reactions from a human subject repeatedly. We will discuss models for human pointing motion, human feature detection, and a class of expert based learning algorithms that have been applied to human robot interaction in experiments. We develop the Georgia Tech Miniature Autonomous Blimp (GT-MAB) as flying vehicles for indoor experiments that supports safe interaction between human and flying robots. The GT-MAB has relatively long flight duration up to two hours per battery charge. Furthermore, the blimps are naturally cushioned and do not cause any pain when collide with human. It offers a fun experience that often encourage physical contacts with humans.

Panos Tsiotras (GT AE)

Title: Computing Optimal Trajectories: From Continuous to Discrete and from Deterministic to Stochastic and Back

Abstract: Since its inception in the late 1950's optimal control theory has been the cornerstone of many major technological developments in aerospace engineering and related fields. Despite six decades of continuous advances in this area, real-time optimal trajectory generation remains the elusive ``holy grail'' of control theorists. The recent emergence of autonomous robotic systems has brought along with it challenges that are beyond the capabilities of traditional trajectory optimizers. In this talk I will give an overview of some recent results for computing optimal trajectories for autonomous systems that leverage multi-scale and sampling-based methods in order to compute efficiently and robustly optimal trajectories for highly nonlinear, realistic systems. We expedite convergence using ideas from approximate dynamic programming, thus bridging the gap between these recent methods and the more traditional methods based on optimal control. Finally, we discuss a new class of trajectory optimization methods for stochastic systems based on the solution of forward-backward stochastic differential equations.

Marcus J. Holzinger (GT AE)

Title: TBA

Abstract: TBA

Martha Grover (GT Chem Bio Eng)

Title: Crystallization Control using Dynamic Programming

Abstract: The organization of a large collection of particles into an ordered crystalline array is needed for many applications, including pharmaceutical separations, nuclear waste disposal, and optoelectronic metamaterials. Due to improvements in sensing technology, it is now becoming possible to monitor the crystalline state in real time during the crystallization process, and this sensor technology opens up new possibilities for feedback control. Here we monitor the crystalline state and use this data to build an empirical model. An optimal feedback policy is then calculated using the empirical model along with dynamic programming. Alternatively, the empirical model can be calculated from simulation “data” coming from a detailed particle-level simulation. Experimental results demonstrating the method will be presented for molecular crystallization and colloidal crystallization.