Meeting Information

Registration

Registration is free and all meeting attendees must register. All presenters have been automatically registered. Non-presenting attendees can register by emailing Siddhartha Mehta at siddhart@ufl.edu or Michael McCourt at mccourt@ufl.edu with your name and affiliation. Registration material can be picked up on Monday-Friday 8:30-4:15 in the UF-REEF lobby. Note a slightly different schedule of sessions and breaks on Friday (see below).

Coffee Breaks

Coffee breaks will be held 9:45-10:00am and 2:30-2:45pm on Monday-Thursday, 10:30-10:45am and 2:45-3:00pm on Friday in the UF-REEF lobby.

Luncheon

Lunch will be provided to the registered meeting attendees from 11:30am-1:00pm on Monday-Thursday, 12:15-1:15pm on Friday in the UF-REEF lobby.

Internet Access

Internet access is available free of charge.
Network SSID: ufvisitor

Meeting Rooms

Monday/Wednesday/Friday:
Sessions A and B - Auditorium
Sessions C1 and D1 - Auditorium
Sessions C2 and D2 - Studio 110

Tuesday/Thursday:
Sessions A and B - Auditorium
Sessions C1 and D1 - Auditorium
Sessions C2 - Studio 110
Sessions D2 - Conference Room
Monday, July 27th

8:55-9:00 Opening Remarks by Vladimir Boginski (Auditorium)

9:00-9:45 Plenary Session A (Auditorium)

Finding Groups with Maximum Betweenness Centrality
Oleg Prokopyev, Associate Professor, University of Pittsburgh

9:45-10:00 Coffee Break

10:00-11:30 Session B (Auditorium)

Applications of Multi-Vehicle Path Planning Using Indirect Optimization Methods
Michael J. Grant, Purdue University

The Impact of Intervention Timing on Maximizing Bayesian Evidence Spread in Social Networks
Alexander Nikolaev, University at Buffalo (SUNY)

Randomized Alternating Direction Method of Multipliers for Distributed Optimization
Yuyuan (Lance) Ouyang, Clemson University

11:30-1:00 Luncheon

1:00-2:30 Session C1 (Auditorium)

The Graph Laplacian: What Does It Tell Us About the Network Structure?
Alexander Veremyev, University of Florida

An Analysis of Viral Advertisement Re-posting Activity in Social Media
Alexander Semenov, University of Jyväskylä, Finland
1:00-2:30 Session C2 (Studio 110)

Ana**lytics for Task Allocation Under Uncertainty**
Monali Malvankar, University of Western Ontario, Canada

A Generalized Adaptive Chebyshev–Picard Iteration Method for Solution to Two–Point Boundary Value Problems
Thomas Antony, Purdue University

High Quality Hypersonic Concept Design Using Indirect Methods
Michael Sparapany, Purdue University

2:30-2:45 Coffee Break

2:45-4:15 Session D1 (Auditorium)

Nonlinear Dimensionality Reduction for Classification of EEG Records
Anton Kocheturov, University of Florida

Labeling Aerial Images Through Patch-Wise Classification
Hao Zhang, University of Florida

Accelerated Method for Dynamical Network Learning
Wei Zhang, University of Florida

Fast Computation of Stationary - Sparse Causality Network Learning
Xianqi Li, University of Florida

2:45-4:15 Session D2 (Studio 110)

Synchronization of Uncertain Euler-Lagrange Systems with Uncertain Time-varying Communication Delays
Zhen Kan, University of Florida

On the Hierarchical Optimal Control of a Chain of Distributed System
Getachew K. Befekadu, University of Florida

Stabilization of an Underactuated Parallel System with a Single Input
Chau Ton, Air Force Research Laboratory / National Research Council
Tuesday, July 28th

9:00-9:45 Plenary Session A (Auditorium)

*UF Research on Assured Communications for Hostile Environments*
John Shea, Professor, University of Florida

9:45-10:00 Coffee Break

10:00-11:30 Session B (Auditorium)

*Cognitive Radio at GTRI: Spatial, Spectral, and Signal Processing*
Brian Beck, Georgia Tech Research Institute

*The DARPA Spectrum Challenge Ramblin’ Wreck Waveforms and FROST, a Distributed SDR Testbed*
Sean Nowlan, Georgia Tech Research Institute

*Approximate Cheap Localization with FM*
Piyush Kumar, Florida State University / CompGeom, Inc.

11:30-1:00 Luncheon

1:00-2:30 Session C1 (Auditorium)

*A Formal Approach to Preventing Malignant / Corrupt Activity of Networked Agents*
Abhinav Perla, University at Buffalo (SUNY)

*Decentralized Network Structure Formation for Robust Information Spread*
Christopher Diaz, University at Buffalo (SUNY)

*Sequential Stochastic Assignment with the Uncertainty in Worker Survival*
Siddhartha Nambiar, University at Buffalo (SUNY)

*Numerical Comparison of Novel Search and Greedy Algorithms for the Multidimensional Assignment Problems*
Alexander Pevtsov, New Mexico State University
1:00-2:30 Session C2 (Studio 110)

Path Planning for Cooperative Navigation with Inter-Agent Range Measurements
Adam J. Rutkowski, Air Force Research Laboratory

Bio-inspired Magnetic Field Sensing and Processing
Brian K. Taylor, Air Force Research Laboratory

Network Delay Modeling for Assisted GPS
Grant Huang, Air Force Research Laboratory / National Research Council

2:30-2:45 Coffee Break

2:45-4:15 Session D1 (Auditorium)

On Biconnected and Fragile Subgraphs of Low Diameter
Oleksandra Yezerska, Texas A&M University

S-Plex and S-Defective Clique Numbers of a Graph
Vladimir Stozhkov, University of Florida

On Decomposition of Connectivity Constraints in Integer Programs
Yiming Wang, Texas A&M University

Characterizing and Detecting Independent Union of Cliques
Zeynep Ertem, Texas A&M University

2:45-4:15 Session D2 (Conference Room)

A Framework for Dynamically Fusing Human and Robotic Decisions in Urban Target Tracking
Michael McCourt, University of Florida

A Relative Estimation Framework for Multi-sensor UAV State Estimation
Daniel Koch, Brigham Young University

Reputation Based Reliability Estimation for Sensor Networks
Zack Bell, University of Florida
Wednesday, July 29th

9:00-9:45 Plenary Session A (Auditorium)

Buffered Probability of Exceedance: Methodology and Software
Stan Uryasev, Professor, University of Florida

9:45-10:00 Coffee Break

10:00-11:30 Session B (Auditorium)

High-throughput Materials Discovery and Development: Breakthroughs and Challenges in the Mapping of the Materials Genome
Marco Buongiorno Nardelli, University of North Texas

Improved Bounds on the Overall Properties of Composite Materials with Randomly Oriented Fibers
Pavlo Krokhmal, University of Iowa

Comparison of Thermal Conductivity and Its Anisotropy of Various Polytypes of Silicon Carbide at Low and High Temperatures from First Principles Calculations
Anna Kuznetsova, Air Force Research Laboratory / National Research Council

11:30-1:00 Luncheon

1:00-2:30 Session C1 (Auditorium)

Multidimensional Buffered Probability of Exceedance: Application to Multi-Commodity Flow Capacity Constraint Relaxation
Alexander Mafusalov, University of Florida

Soft Margin Support Vector Classification as Buffered Probability Minimization
Matthew Norton, University of Florida

Support Vector Machines with Risk Constraints
Victoria Zdanovskaya, University of Florida
A Bi-level Decision Dependent Stochastic Programming Model for Generation Investment Planning in Power System
Yiduo Zhan, University of Central Florida

1:00-2:30 Session C2 (Studio 110)

Vision-Based Control with Unknown Time Varying State Delay and Known Time Varying Input Delay
Indrasis Chakraborty, University of Florida

A Potential Function Approach to Maintaining Line of Sight
Anup Parikh, University of Florida

Experimental Validation for Visual Servo Control of an Unmanned Ground Vehicle via a Moving Airborne Monocular Camera
Hsi-Yuan Chen, University of Florida

2:30-2:45 Coffee Break

2:45-4:15 Session D1 (Auditorium)

A Hierarchical Model for Optimal Recovery in Stochastic Network Systems
Juan Borrero, University of Pittsburgh

Robustness of Solutions to Critical Node Detection Problems Under Conditions of Imperfect Data
Colin P. Gillen, University of Pittsburgh

Robust Spanners and Minimum Edge Compact Spanners: Overview and Algorithms
Tathagata Mukherjee, Florida State University

Discrete Time Dynamic Assignment Models for Evacuation Planning with Boundedly Rational Evacuees
Guanxiang Yun, University of Central Florida

2:45-4:15 Session D2 (Studio 110)

An Inverse Containment Control-Based Approach to Solving the Herding Problem
Ryan Licitra, University of Florida

Spatial Control of Linear Multiagent Systems
Dzung Tran, Missouri University of Science and Technology
Active-Passive Distributed Consensus Filtering with Reduced Communication and Dynamic Agent Roles
J. Daniel Peterson, Missouri University of Science and Technology

Decentralized Cooperative Control Methods for the Modified Weapon Target Assignment Problem
Kyle Volle, Georgia Institute of Technology
Thursday, July 30th

9:00-9:45 Plenary Session A (Auditorium)

*The Influence of Single Crystal Plastic Deformation Mechanisms on Damage Distribution in Porous Materials*
Oana Cazacu, Professor, University of Florida

9:45-10:00 Coffee Break

10:00-11:30 Session B (Auditorium)

*Metal-Ceramic Composites in Extreme Environments: Complex Microstructures, Effective Properties, and Thermo-Mechanical Behavior*
Olesya Zhupanska, University of Iowa

*Deformation of Exotic Metallic Materials under Extreme Environments*
Benoit Revil-Baudard, University of Florida

*Turbulence Generation and Energy Transfer Mechanism in Boundary Layer Transition using Direct Numerical Simulation*
Shanti Bhushan, Mississippi State University

11:30-1:00 Luncheon

1:00-2:30 Session C1 (Auditorium)

*Materials Data Requirements for Design of an Expendable Hypersonic Airbreathing Airframe*
Lynn Neergaard, Leidos / Air Force Research Laboratory

*Entropy Constrained Flux Reconstruction for Robust High Order Fluid Simulation*
Andrew B. Shelton, Leidos / Air Force Research Laboratory

*Fluid-Thermal-Structural Interaction Effects in Preliminary Design of High Speed Vehicles*
Zachary Witeof, Leidos / Air Force Research Laboratory
1:00-2:30 Session C2 (Studio 110)

Globally Asymptotically Stable Distributed Control for Distance and Bearing Based Multi-Agent Formations
Kaveh Fathian, University of Texas at Dallas

Tracking and Spatial Control of Multiagent Formations with Multiplex Information Networks
Dzung Tran, Missouri University of Science and Technology

Distributed Task-Allocation in Multi-Agent Systems with Limited Dynamic Communication and Agent Attrition
Johnathan Votion, University of Texas at San Antonio

2:30-2:45 Coffee Break

2:45-4:15 Session D1 (Auditorium)

Nonlinear Thermal Reduced-Order Models for a Hypersonic Vehicle
Ryan Klock, University of Michigan

Aeroelastic Modeling and Simulation of Very Flexible Vehicles
Ryan C. Kitson, University of Michigan

Rapid Loads Prediction for Hypersonic Vehicles Using CFD Surrogates
Emily Dreyer, The Ohio State University

Rapid Loads Prediction for Supersonic Vehicles Using CFD Surrogates
Dianne Zettl, The Ohio State University

2:45-4:15 Session D2 (Conference Room)

Projection Methods in p-Order Cone Programming
Alexander Vinel, Auburn University

Robust Sensitivity Analysis in the Optimal Value of Linear Programming
Guanglin Xu, University of Iowa

Stochastic Accelerated Alternating Direction Method of Multipliers with Importance Sampling
Chenxi Chen, University of Florida
Friday, July 31st

9:00-10:30 Session A (Auditorium)

Rapid Characterization of Munitions Using Neural Networks
Mark Carpenter, Auburn University

Optimization of Value-at-Risk: Computational Aspects of MIP Formulations
Konstantin Pavlikov, University of Florida

A Simple Scenario Decomposition Algorithm for Stochastic Programming Problems with a Class of Downside Risk Measures
Maciej Rysz, Air Force Research Laboratory / National Research Council

10:30-10:45 Coffee Break

10:45-12:15 Session B (Auditorium)

Continuous Approaches to Optimization Problems in Graphs
Sergiy Butenko, Texas A&M University

Directed and Parameterized Networks and their Applications in Combinatorial Optimization, Cooperative Control, and Social Networks
Alla Kammerdiner, New Mexico State University

Loss-constrained Minimum Cost Flow Under Arc Failure Uncertainty with Applications in Risk-aware Kidney Exchange
Qipeng Phil Zheng, University of Central Florida

12:15-1:15 Luncheon

1:15-2:45 Session C1 (Auditorium)

Thermo-Mechanical Response of Metal-Ceramic Composites for High Temperature Applications
Phillip Deierling, University of Iowa

Modeling of Thermal Ablation in Fiber-reinforced Polymer Matrix Laminated Composites
Yeqing Wang, University of Iowa
A Stochastic PDE-Constrained Optimization Approach to Vibration Control of a Composite Plate Subjected to Mechanical Load and a Piecewise-linear Current
Dmitry Chernikov, University of Iowa

1:15-2:45 Session C2 (Studio 110)

Map Merging of Rotated, Corrupted and Different Scale Maps Using Rectangular Features
Jinyoung Park, Auburn University

A Quaternions Formulation for Relative Pose and Structure from Five General Feature Points
Kaveh Fathian, University of Texas at Dallas

Bi-Directional Cooperative Obstacle Avoidance for Heterogeneous Unmanned Vehicles
Jonathan Lwowski, University of Texas at San Antonio

2:45-3:00 Coffee Break

3:00-4:30 Session D1 (Auditorium)

Understanding the Aeroacoustic Radiation Sources and Mechanisms in High-Speed Jets
Michael Crawley, The Ohio State University

A Parametrized Framework for Modeling and Control of a Vehicle Family
Austin Brockner, University of Florida

Numerical Study of Synthetic-Jet Actuation Effect on Airfoil Leading and Trailing Edge Noise
Marco Sansone, Embry-Riddle Aeronautical University

Effect of Flow-Acoustic Resonant Interactions on Aerodynamic Response of Transitional Airfoils
Joseph Hayden, Embry-Riddle Aeronautical University

3:00-4:30 Session D2 (Studio 110)

Optimal Placement for a Limited Range Binary Sensor
J. Pablo Ramirez-Paredes, University of Texas at Dallas

System Level Design and Optimization of LQR Flight Controllers
Sandor Valenciaga, University of Florida
Differential Drag-Based Guidance for Spacecraft Relative Maneuvering Using Spatial Information in Atmospheric Density Prediction
Dave Guglielmo, University of Florida

4:30 Closing remarks by Vladimir Boginski (Auditorium)
Finding Groups with Maximum Betweenness Centrality

Oleg Prokopyev
University of Pittsburgh

In this talk we consider the problem of identifying the most influential (or central) group of nodes (of some predefined size) in a network. Such group has the largest value of betweenness centrality or one of its variants, e.g., the length-scaled or the bounded-distance betweenness centralities. We demonstrate that this problem can be modeled as a mixed integer program (MIP) that can be solved for reasonably sized network instances using off-the-shelf MIP solvers. We also discuss interesting relations between the group betweenness and the bounded-distance betweenness centrality concepts. In particular, we exploit these relations in an algorithmic scheme to identify approximate solutions for the original problem of identifying the most central group of nodes. Furthermore, we generalize our approach for identification of not only the most central groups of nodes, but also central general groups of graph elements (either nodes or edges exclusively, or their combination according to some prespecified criteria) satisfying, if necessary, some additional cohesiveness properties (e.g., the targeted group should form a clique or a k-club). Finally, we conduct extensive computational experiments with different types of real-life and synthetic network instances to show the effectiveness and flexibility of the proposed framework. Even more importantly, our experiments reveal some interesting insights into the properties of the influential groups of graph elements that are modeled using the maximum betweenness centrality concept or one of its variations. This is a joint work with Alexander Veremyev and Eduardo L Pasiliao.
Applications of Multi-Vehicle Path Planning Using Indirect Optimization Methods

Michael Grant
Purdue University

Traditionally, path planning is performed through discretization and solving the corresponding optimization problem using pseudospectral or other collocation methods. The designer is often tasked to assess the quality of the numerical, computer-generated solutions based on experience and post-processing analyses. For problems that involve many complex interactions, a detailed assessment often cannot be performed, and the generated paths often exhibit numerical artifacts that mask optimal behavior. The use of indirect optimization methods to construct high quality optimal paths associated with the interaction of multiple vehicles is described. The ability to construct such high quality solutions is made possible by leveraging additional mathematical information made available by indirect methods. The features and trends observed within the numerical indirect solutions are guaranteed to be associated with optimality. This characteristic ensures that no better solution exists in the vicinity and that no improvement to the solution would be achieved with additional computational time. The application of indirect methods to multi-vehicle path planning is shown, and examples in robust reference trajectory generation and timed cooperative engagements illustrate the speed and fidelity of the approach.
The Impact of Intervention Timing on Maximizing Bayesian Evidence Spread in Social Networks

Alexander Nikolaev and Mohammadreza Samadi
University at Buffalo (SUNY)

The influence maximization problem, as defined in social network science, lies in finding a set of seeds that can initiate a diffusion-driven cascade in an optimal way. We explore flexible, time-dependent seed activation solutions for long-term intervention/campaign planning on networks. We model influence propagation as parallel Bayesian evidence cascades. The investigations with the model shed light on the phenomena of belief reinforcement and viral spread of innovations, rumors, opinions, etc., in social networks. This talk highlights the impact of the timing of ejecting the external evidence on the solution to the NP-Hard problem of generating a maximal cascade of “positive” subjective evidence (in support of a hypothesis claim preferred by the decision-maker).
Randomized Alternating Direction Method of Multipliers for Distributed Optimization

Yuyuan (Lance) Ouyang
Clemson University

We consider a multi-agent optimization problem, in which a network of agents minimize cooperatively a convex objective function. In particular, the objective function is the sum of several local functions that are privately possessed by the corresponding agents, and the constraint describes the coupling of decision variables. We present a randomized alternating direction method of multipliers to solve the problem in a decentralized and asynchronous manner. The complexity results of the proposed method are reported, in terms of both the objective function value and the feasibility residual. Potential applications and extensions of the proposed work will also be discussed.
The Graph Laplacian: What Does It Tell Us About the Network Structure?

Alexander Veremyev†, Vladimir Boginski, Eduardo L. Pasiliao
†University of Florida

The Laplacian of a graph, which is defined as the difference between its diagonal degree matrix and the adjacency matrix, received significant attention during the last decades due to its relations to many important problems arising in combinatorial optimization, data clustering, machine learning, etc. The aim of this talk is to provide intuitive interpretation of the Laplacian concept and its relation to various graph characteristics. Specifically, a couple of physics-based models will be presented to illustrate relationship between graph structure and its Laplacian. We will also consider two very important concepts of graph Laplacian spectra, namely, the second smallest eigenvalue (algebraic connectivity) and the corresponding eigenvector (Fiedler vector) and discuss their applications to spectral clustering, network synchronization, consensus and convergence analysis of multi-agent networked systems. Finally, we provide an explicit characterization of Laplacian spectra of some classes of optimal strongly attack-tolerant networks and mention other notable applications of graph Laplacian.
An Analysis of Viral Advertisement Re-posting Activity in Social Media

Alexander Semenov†, Alexander Nikolaev, Alexander Veremyev, Vladimir Boginski
†University of Jyväskylä, Finland

More and more businesses use social media to advertise their services. Such businesses typically maintain online social network accounts and regularly update their pages with advertisement messages describing new products and promotions. One recent trend in such businesses’ activity is to offer incentives to individual users for re-posting the advertisement messages to their own profiles, thus making it visible to more and more users. A common type of an incentive puts all the re-posting users into a random draw for a valuable gift. Understanding the dynamics of user engagement into the re-posting activity can shed light on social influence mechanisms and help determine the optimal incentive value to achieve a large viral cascade of advertisement. We have collected approximately 1800 advertising messages from social media site VK.com and all the subsequent reposts of those messages, together with all the immediate friends of the reposting users. In addition to that, approximately 150000 other messages with the reposts were collected, amounting to approximately 4.5M of reposts in total. In this presentation, we summarize the results of the analyses based on these data. We then formulate and solve the problem of maximizing a repost cascade size under a given budget.
Analytics for Task Allocation Under Uncertainty

Monali Malvankar-Mehta
University of Western Ontario, Canada

The use of unmanned aerial vehicles (UAVs) or drones in the U.S. military is escalating from 5% in 2005 to 31% in 2012. Human-integrated approach in the context of UAV route planning is necessary for performance of key activities like “weapon release”. UAVs are assigned geographically-dispersed priority-based task to be completed within a pre-specified time window and a ground crew is required to supervise performance of each task. Crew - based on their training and experience - have varying efficiencies to perform assigned task. Additionally, a crew assigned to controlling multiple UAVs may experience heavy workload. Based on importance of each task, cost, and human involvement, task allocation needs to be determined. This research considers varying hybrid task, associated costs, operator efficiencies and their cognitive workloads in the complex human-machine interaction system with the objective to minimize cost and maximize effectiveness of the overall system by developing a Stochastic Integer Programming Model.
A Generalized Adaptive Chebyshev-Picard Iteration Method for Solution to Two-Point Boundary Value Problems

Thomas Antony and Michael Grant
Purdue University

A Generalized Adaptive Chebyshev-Picard Iteration (GACPI) method for solution to two-point boundary value problems is presented. The state trajectories are approximated using Chebyshev polynomials and constraining the coefficients of the polynomials enforces the boundary conditions. The method is a generalized version of an existing Modified Chebyshev-Picard Iteration (MCPI) method, which could be used only to solve a specific class of boundary value problems with linear boundary conditions. Unlike MCPI, the method presented here makes no assumptions about the nature of the boundary conditions and can also solve for free parameters in the problem. The GACPI method consists of highly parallelizable matrix operations and uses computationally intensive gradient information only for solving free parameters in the problem. The addition of a damping methodology improves the convergence characteristics of the method. The order of the Chebyshev polynomials is dynamically calculated based on the error tolerance required and the nonlinearity of the problem. When executed on a single processor, GACPI is shown to have convergence and performance characteristics similar to or better than MATLAB’s bvp4c in solving two-point boundary value problems arising from indirect trajectory optimization methods. The GACPI method is expected to enable rapid trajectory optimization on highly parallel computational environments such as the DoD’s High Performance Computing platform.
Traditionally, hypersonic mission conceptual design has been performed in an iterative process using direct optimization methods. The introduction of modern computing has facilitated this and many analytical models governing the system have been lost. Optimization through indirect methods leverages these analytics and yield high quality trajectories while reducing the dimensionality of the overall problem. Historical limitations of indirect methods include deriving equations of motion, convergence, and constraints. These historical limitations can be overcome through modern computational software.

Due to the fact that a hypersonic system is governed by a system of differential equations, effectively using parallel computational infrastructures provides a unique challenge. For dimensionally large hypersonic systems where integration time is large, the multiple shooting method provides a means to take full advantage of parallel computational resources. Combined with a continuation process, the multiple shooting method can increase robustness of a solver while simultaneously reducing the time to solution.
Nonlinear Dimensionality Reduction for Classification of EEG Records

Anton Kocheturov
University of Florida

Nowadays trained neuroscientists can tell a lot about the state of the brain of a particular patient using electroencephalography (EEG) or other tools. They can detect epileptic seizures and other mental diseases or brain traumas. They can distinguish different states of a brain such as for example, alertness and drowsiness. But a large amount of data to be analyzed and monitored is a very huge obstacle because it requires a lot of time to manage it. In other cases potential problems must be detected on the spot: for instance, if a pilot of an aircraft has lost his or her consciousness or alertness it should be detected as soon as possible and even on-line in order to prevent negative consequences.

The automated tools for tackling these problems exist. There is a number of approaches based on machine learning techniques such as Support Vector Machine (SVM) or Artificial Neural Networks (ANN) which are good in classification of different states of a brain. But they have a very fundamental problem: they require the training part, or collecting and analyzing of the data by neuroscientists.

To avoid these obstacles we suggest using Nonlinear Dimensionality Reduction techniques for the analysis of EEG records. We introduced a very simple measure based on the distance of points in 3-dimensional space from the coordinates of the electrodes on the scalp which has shown a good classification power.
Labeling Aerial Images through Patch-Wise Classification

Hao Zhang
University of Florida

Aerial images are referred to photographs taken from fixed-wing aircraft, helicopters and UAV etc. Since being invented, aerial images found many of their applications in military such as reconnaissance and aerial mapping. Thanks to the rapid development of technology, huge amounts of aerial images are produced over time which greatly raises the need of automatic processing of them. Labeling aerial image is one of the most fundamental and key aspects of understanding and processing images. Similar to other image classification problems, the difficulty of this task mainly due to the highly variant configurations of objects: objects in aerial image could appear in different scales, orientations and could be affected by occlusions and different illuminations, etc. This work implements a Convolutional Neuron Network trained on UC Merced land use dataset to label given aerial images into pre-determined classes.
Accelerated Method for Dynamical Network Learning

Wei Zhang
University of Florida

In this talk, I will present learning the linear dynamical network with the technique of joint association graph screening and decomposition. The corresponding optimization problems are non-convex, an accelerated algorithm for solving multi-convex problems is introduced. Some convergence result and numerical experiments would also be presented.
Fast Computation of Stationary - Sparse Causality Network Learning

Xianqi Li
University of Florida

Recently, researchers have an increasing interest in identifying network dynamics and topologies in network science. Many approaches have been proposed to identify network topologies underlying various dynamical systems modeled by multivariate time series. In this talk, the network structure of interest is assumed to be sparse. The time series we consider are stationary. With these assumptions, we propose several modified accelerated gradient methods to improve the computational efficiency. Some of our methods are able to improve the detection and estimation compared to the existing approaches.
Synchronization of Uncertain Euler-Lagrange Systems with Uncertain Time-varying Communication Delays

Zhen Kan
University of Florida

A decentralized controller is presented for leader-based synchronization of communication-delayed networked agents. The agents have heterogeneous dynamics modeled by uncertain, nonlinear Euler-Lagrange equations of motion acted by heterogeneous, unknown, exogenous disturbances. The developed controller requires only one-hop (delayed) communication from network neighbors and the communication delays are assumed to be heterogeneous, uncertain and time-varying. Each agent uses an estimate of communication delay to provide feedback of estimated recent tracking error. Simulation results are provided to demonstrate the improved performance of the developed controller over other popular control designs.
On the Hierarchical Optimal Control of a Chain of Distributed System

Getachew K. Befekadu† and Eduardo Pasiliao
†University of Florida - REEF

In this talk, we consider a chain of distributed system governed by a degenerate parabolic equation, which satisfies a weak Hörmander type condition, with a control distributed over an open subdomain. In particular, we consider two objectives that we would like to accomplish. The first one being of a “controllability” type that consists of determining the reachable target set from a given initial condition; while the “second one” is keeping the state trajectory of the overall system close to a given reference trajectory on a finite, compact time intervals. We introduce the following method. First, we partition the control subdomain into two subdomains that are conformable to the leader’s and follower’s strategies, respectively. Then, using the notion of Stackelberg’s optimization (which is a hierarchical game theoretic framework), we provide a new result which amounts to the uniqueness of density theorem – where the follower (which corresponds to the second criterion) is required to respond optimally, in the sense of best-response correspondence to the leader’s strategies (that are associated to the controllability type criterion) so as to achieve the overall goals. Finally, we remark on the implication of our result in assessing the influence of the leader’s reachable target set on the follower’s strategies in relation to the direction of “leader-follower” and “follower-leader” information flows.
Stabilization of an Underactuated Parallel System with a Single Input

Chau Ton
Air Force Research Laboratory / National Research Council

This paper presents a novel sliding mode control (SMC) strategy for a class of parallel underactuated nonlinear systems, where multiple states are simultaneously affected by a single scalar control input. The main challenge in the control design for this class of systems is that the standard backstepping-based approaches cannot be applied. This difficulty is mitigated through innovative selection of sliding surfaces through the notion of equivalent control, along with a novel sequential control design procedure. For a particular class of system, the proposed control law achieves asymptotic regulation of system states using a single scalar control input. For a larger class of underactuated system, we are able to show stable results with specified boundary layer using discontinuous feedback. Stability analysis is provided to prove the theoretical result, and numerical simulation with experimental results using wheeled mobile robots (WMRs) are provided to validate the effectiveness of the proposed control algorithm.
Ensuring communications during US Air Force missions may require the contested use of communication spectrum. The spectrum utilized by the US Air Force assets may also be utilized by domestic users or enemy forces. Both teams have incentives to use the spectrum for communication while simultaneously blocking the other team from communicating; however, each team must make tradeoffs in its use of the spectrum for communication, jamming, and sensing. Under this program, our team is developing and demonstrating systems that contain autonomous vehicles that are cognitive and agile in how they use the radio spectrum and the positioning of the vehicles in space to achieve assured communications. In this presentation, we will give an overview of the proposed work and then demonstrate some of the concepts using a system of mobile robots equipped with embedded software-defined radios.
Cognitive Radio at GTRI: Spatial, Spectral, and Signal Processing

Brian Beck
Georgia Tech Research Institute

Software Defined Radios (SDRs) have been increasingly employed in the field of cognitive radio research. The Software Defined Radio Lab (SDRL) at the Georgia Tech Research Institute (GTRI) seeks to utilize SDRs for enhancing communications, spectrum access, and remote sensing applications. Our talk first highlights a new direction for SDRs, which we term spatial cognitive radio. In this research area, we seek to exploit or derive spatial information from the signals gathered by networks of mobile SDRs and other radios. Examples of current research results include spectrum mapping, relay node optimization, precise ultra-wideband (UWB) localization, and UWB tomographic imaging. We present results of our work in these areas using our unique Cognitive Spectrum Operations Testbed, or CSOT.

Additionally, we will present the waveforms and software that enabled our GTRI team to become a finalist at the DARPA Spectrum Challenge. Our innovations include adaptive modulation, jamming-resistant waveforms, fast spectrum-sensing techniques, and rate-less coding. Finally, we will present the design and operation of a distributed, reconfigurable SDR testbed for field use. This distributed network of SDR systems enables large-scale, real-time testing of wireless PHY and MAC protocols with an emphasis on supporting many modulation schemes, precise transmission timing, and command and control (C2) services.
The DARPA Spectrum Challenge Ramblin’ Wreck Waveforms and FROST, a Distributed SDR Testbed

Sean Nowlan
Georgia Tech Research Institute

First, we will present the waveforms and software that enabled our GTRI team to become a finalist at the DARPA Spectrum Challenge. Our innovations include adaptive modulation, jamming-resistant waveforms, fast spectrum-sensing techniques, and rate-less coding. Second, we will present the design of the Field-ready, Reconfigurable, Operational, SDR Testbed (FROST), an enabling tool for field experimentation of wireless signals and protocols. This distributed network of SDR systems enables large-scale, real-time testing of wireless PHY and MAC protocols with an emphasis on supporting many modulation schemes, precise transmission timing, and command and control (C2) services.
In this paper, we present a coarse and passive localization system for GPS-denied environments. Our system is based on a cheap software defined radio (SDR) costing less than $25, which is used to listen to broadcast signals from local FM Radio stations. We show that the hardware and associated algorithms are capable of localizations with average errors of less than 5 miles, without requiring a fingerprinting or crowd sourcing approach. The algorithm is based on a large-scale simulation pre-processing phase, which estimates the power spectrum received in small rectangular cells (geohashes) from various FM towers in the locality. Our query phase first runs our peak detector on the power spectrum and then solves a subset query problem to compute proposed geohashes to be analyzed. Finally, it uses a simple Euclidean nearest neighbor search to localize the power spectrum received by the SDR. Our current simulation spans the entire USA. We use 924 power spectra distributed over more than 200 miles for experimentally validating our query algorithm. Our average localization error is less than 5 miles.
A Formal Approach to Preventing Malignant / Corrupt Activity of Networked Agents

Abhinav Perla and Alexander Nikolaev
University at Buffalo (SUNY)

The development of connections between malignant agents can be a major hindrance to the productivity of a network, when the agents have limited capabilities or resources for monitoring each other’s activity. In this talk, we outline a model that captures some aspects of how corruption emerges. We assume that agents can be strategically embedded into a directed supervisor-worker reporting network, and a rotation policy for each agent can be defined. Then, corruption can only occur when an agent and all their supervisors are ready to go corrupt and identify each other as such, which takes time. An ensuing optimization problem lies in optimizing the reporting structure and rotation timing so as to maximize the expected long-time revenue generated by the whole network. We consider scenarios with no supervisor, one and two supervisors as the feasible policies and find the optimal rotation timing under each policy. We then analyze the impact of the model parameters (proportion of malignant agents in the work, productivity rate, costs, etc.) on the choice of an optimal policy.
Decentralized Network Structure Formation for Robust Information Spread

Christopher Diaz and Alexander Nikolaev
University at Buffalo (SUNY)

Stochastic actor-oriented models, developed for Social Network Analysis, describe the dynamics of longitudinal network formation. In their conventional application, agents build connections to achieve a satisfactory structure of their local networks. This talk presents an extension of this line of work to the case where agents are concerned not with network structure per se, but instead, their ability to hear and spread rumors. The agents assess their network position quality by the number of messages they receive from their peers; each agent periodically sends such messages, which propagate through the network as random walks of random length. The agents work to revise their local connection structure, while taking into account the cost of adding the connections; to this end, they solve local optimization problems, the objective functions of which are informed by their own history and feedback from directly connected peers. The convergence of these objective functions is expected to give insights on the methods for strategically building networks in a decentralized way.
Sequential Stochastic Assignment with the Uncertainty in Worker Survival

Siddhartha Nambiar and Alexander Nikolaev
University at Buffalo (SUNY)

The Sequential Stochastic Assignment Problem (SSAP), introduced by Derman et al. (1972), lies in anticipatively assigning workers with given success rates to sequentially arriving tasks to maximize the total expected reward; every task’s value follows a given distribution and remains unknown until the task presents itself to the workers. This work presents an optimal policy for GSSAP - a Generalized SSAP - that extends the original problem simultaneously in two ways: first, the uncertainty in worker survival is introduced, and second, the number of tasks is allowed to be random. GSSAP has practical significance in multiple applications including healthcare (organ allocation) and military operations (target assignment). We prove the existence of and specify an optimal assignment policy for GSSAP as a deterministic threshold policy, compute the total expected reward under this policy, and explain a rule under which the workers can optimally assign themselves to tasks in a decentralized way, with minimal communication.

References

Numerical Comparison of Novel Search and Greedy Algorithms for the Multidimensional Assignment Problems

Alexander Pevtsov and Alla Kammerdiner
New Mexico State University

Multisensor systems provide enormous amount of data for the detection and localization of objects. In military applications, a need arises to associate the sensors with the objects being detected. These data association problems can be formulated as a linear Multidimensional Assignment Problem (MAP). This problem is NP-hard, and for large numbers of sensors, \(d\), and objects, \(n\), both the memory needed to store the input and the time needed to find the global optimal solution increases quickly. In this study we compare the Greedy algorithm for the MAP by Krokhmal with the novel large-scale neighborhood search proposed by Kammerdiner. The new search explores exponentially large neighborhoods in polynomial time by solving the respective two-dimensional Linear Assignment Problems (LAPs) using the Hungarian algorithm. We generate the instances of the MAP using Grundel-Pardalos generator and compare the performance of two algorithms on these test instances. Our results show promising performance of the new method on moderate-size problem instances. We also study and compare four multi-start strategies for the new algorithm on larger sized problems.
Path Planning for Cooperative Navigation with Inter-Agent Range Measurements

Adam J. Rutkowski†, Brian K. Taylor, Martin J. Eilders, Kevin M. Brink, Clark N. Taylor, Jamie E. Barnes †Air Force Research Laboratory

In this work, we consider the problem of guiding a pair of autonomous vehicles from known initial locations to desired goal locations. The objective is to plan trajectories so that the vehicles reach their goals as accurately as possible when access to external navigation aids such as the Global Positioning System (GPS) is not available. In many navigation scenarios, it is known that navigation accuracy depends on the path traveled by the vehicle. For the scenario considered in this study, each vehicle has an onboard odometer for measuring relative changes in position and heading. The vehicles also have sensors for measuring range between vehicles.

In order to find a set of paths that result in good navigation performance, and to avoid the curse of dimensionality associated with searching an infinite dimensional space of possible trajectories, the trajectories were restricted to a class described as pseudo-zigzagging. An exhaustive search of all possible trajectory pairs revealed that, in the best case, the estimated final position standard deviation can be reduced by a factor of 5 when compared with the worst cases. Those trajectories that excite the range measurement tend to have better position estimation accuracy than trajectories that maintain a constant inter-vehicle range. However, range excitation alone is not enough to guarantee good performance, since less than 0.1% of the trajectory sets with non-constant range had final estimated standard deviation within 10% of the best case. This suggests that appropriate path selection is critical to achieving good navigation performance.
Bio-inspired Magnetic Field Sensing and Processing

Brian K. Taylor, Adam J. Rutkowski
Air Force Research Laboratory

Several animals use the Earth’s magnetic field in concert with other sensor modes for local and continental-scale navigation tasks. Simultaneously, Earth’s magnetic field offers a signal that engineered systems can leverage for navigating in environments where GPS is unavailable or unreliable. In addition, many animal sensory systems use a distributed sensing paradigm where a number of sensors are used to collect data, while the animal’s nervous system processes and fuses data to generate behavioral commands in a robust manner. Building on these notions and existing biological studies, our work investigates biologically-inspired distributed magnetic sensing to use Earth’s magnetic field for navigation. We use biologically derived and inspired methods such as neuronal population models to process and interpret the distributed data. In addition to bio-inspired methods, we explore using engineering-based methods to process and interpret data for the purposes of reference and comparison. As expected, with all methods, an increase in the number of sensors provides enhanced robustness to sensor noise. Preliminary work indicates that neuronal population models offer potential benefits in terms of noise removal from a signal. Our goal is to leverage neuronal models to agilely and robustly fuse data from multiple sensors and sensor modes for enhanced navigation performance.
Network Delay Modeling for Assisted GPS

Grant Huang
Air Force Research Laboratory / National Research Council

Currently, conventional Global Positioning System (GPS) receivers work well in open-sky environments. However, location finding in weak-signal conditions, such as urban canyons and indoors, is challenging and has been the subject of extensive research. Assisted GPS (A-GPS) is one of the concepts that help receivers acquire weak signals by receiving assistance data from wireless networks, such as orbital parameters, and coarse time and location references. A-GPS also improves Time-to-First-Fix (TTFF) through faster delivery of information that is recovered from navigation data broadcasted by GPS satellites. Receiver technology developers rely on signal simulators for testing real-world scenarios. While A-GPS support has been integrated in many simulators, probabilistic models of delays occurring during assistance data delivery have not been studied properly. This presentation provides a methodology of A-GPS network delay modeling that is applicable to various simulation environments. Particularly, a testbed is designed to collect delay data, model them statistically and integrate the model in a simulator. The testbed employs Secure User Plane Location (SUPL) architecture in two modes, Mobile Station (MS) based (MS-based) and MS-assisted, where data channels are used to communicate A-GPS assistance data. Measurement campaigns are conducted and network delay models are derived for various representative distances between assistance servers and receivers, and for various networks that users connect to, such as LAN, WLAN, third-generation mobile telecommunication (3G), high-speed downlink packet access (HSDPA), and fourth-generation Long Term Evolution (4G LTE), with the Transmission Control Protocol and the Internet Protocol (TCP/IP) connection between a server and a receiver.
On Biconnected and Fragile Subgraphs of Low Diameter

Oleksandra Yezerska
Texas A&M University

An s-club is a subset of vertices inducing a subgraph with a diameter of at most s. It is commonly used to characterize network clusters in applications for which easy reachability between group members is of high importance. We study two special cases of the 2-club model – a biconnected 2-club, and a fragile (not biconnected) 2-club, respectively. We investigate certain properties of both models and develop solution approaches for their corresponding optimization problems.
S-Plex and S-Defective Clique Numbers of a Graph

Vladimir Stozhkov
University of Florida

Degree-based clique relaxations are the best up-to-date concept of dense clusters, especially when cliques are overrestrictive and not easy to model in practice. The presentation is dedicated to two clique relaxation models: s-plex and s-defective clique, which have appeared in various fields such as social network analysis, bioinformatics, etc. Theoretical properties of the specified objects are investigated. Analytical and computational bounds for the related optimization problems are provided. The extensions of the Motzkin-Straus formulation for s-plex and s-defective clique are derived. The outline of the general procedure for solving the corresponding maximization problems in large sparse graphs is given.
On Decomposition of Connectivity Constraints in Integer Programs

Yiming Wang
Texas A&M University

In many network applications, one searches for a connected subset of vertices that exhibits other desirable properties. To this end, we study the connected subgraph polytope of a graph, which is the convex hull of subsets of vertices that induce a connected subgraph. Following the fact that any network can be decomposed into smaller networks with higher connectivity, we develop a scheme to decompose valid inequalities in the original polytope to valid inequalities in the polytopes of smaller networks, or to combine valid inequalities in smaller polytopes to one that valid for the original one. We also present examples to show how it benefits in generation of tight valid inequalities of general connected subgraph polytope.
Characterizing and Detecting Independent Union of Cliques

Zeynep Ertem
Texas A&M University

This paper explores a novel mathematical model called the maximum independent union of cliques problem, for which, as the name suggests, the solution consists of independent cliques. It is an interesting problem for which both the maximum clique and maximum independent sets are feasible solutions and individually their corresponding sizes are lower bounds for the size of the IUC solution. After presenting the structural properties as well as the complexity results of different graph types (planar, unit disk graphs and claw-free graphs), an integer programming formulation is developed, followed by a branch-and-bound algorithm and several heuristic methods to approximate the maximum independent union of cliques problem. The developed methods have been empirically evaluated on many benchmark instances.
A Framework for Dynamically Fusing Human and Robotic Decisions in Urban Target Tracking

Michael McCourt
University of Florida

In this talk, we will discuss a framework for dynamically fusing sensor measurements and decisions using Bayesian fusion. While the framework is applicable to multiple application domains, we will discuss its application to target tracking in urban environments. In target identification and localization, human spotters and autonomous sensors provide complementary information that can be fused to improve the quality of estimation. This fusion approach also applies to decision making including retasking autonomous sensors and humans in the environment. A related experiment will be discussed that will test the ability of humans to make quick decisions in high consequence applications. Physiological data will be recorded to model the state of the human with respect to quality of decisions. This model can be used to dynamically allocate privilege between humans and machines in decision making.
A Relative Estimation Framework for Multi-Sensor Uav State Estimation

Daniel Koch
Brigham Young University

This work presents a relative estimation framework for small unmanned air vehicles that can incorporate measurements from multiple view matching algorithms such as visual odometry and laser scan matching. A relative framework provides several advantages over a global estimation scheme, including better filter consistency, a more accurate representation of uncertainty in the global pose estimate, and safer handling of global updates such as GPS. Incorporating measurements from multiple sensors makes the estimation scheme more robust to changes in the environment and degradation or failure of any one sensing modality.
Reputation Based Reliability Estimation for Sensor Networks

Zack Bell
University of Florida

Sensor networks generally assume that the reliability of information shared between neighbors is constant. However, in many environments this assumption is not always valid. For example, cameras with assumed constant reliability are used in heterogeneous sensor networks for urban target tracking. These cameras may be blocked by moving obstacles, have distorted images due to changes in lighting conditions, or have been tampered with or destroyed. As a result, the camera may give bad information with higher probability than expected. In these types of scenarios a framework is needed for continuous estimation of sensor reliability that does not inhibit working neighbors. This research proposes the development of such a framework to estimate the reliability of members of heterogeneous networks through a reputation algorithm based on sensed and communicated information. Using this reputation algorithm, it will be feasible to alleviate the need to check sensors in the network immediately or as often.
Buffered Probability of Exceedance: Methodology and Software

Stan Uryasev
University of Florida

This paper investigates a new probabilistic characteristic called buffered probability of exceedance (bPOE). bPOE counts tail outcomes averaging to some specific threshold value. Minimization of bPOE can be reduced to Convex and Linear Programming. We will explain the approach with a dynamic stochastic optimization problem. At every time moment, a supplier wants to supply some predetermined amount of product. Production costs are stochastic and produced amount of product is described by a linear dynamic equation with uncertain coefficients. We illustrate this general model with an application in finance, which is called Cash Matching of a Bond Portfolio. We minimize bPOE that liabilities exceed assets. We discuss both methodological and software issues for the considered problem.
High-Throughput Materials Discovery and Development: Breakthroughs and Challenges in the Mapping of the Materials Genome

Marco Buongiorno Nardelli
University of North Texas

High-Throughput Quantum-Mechanics computation of materials properties by ab initio methods has become the foundation of an effective approach to materials design, discovery and characterization.[1,2] This data driven approach to materials science currently presents the most promising path to the development of advanced technological materials that could solve or mitigate important social and economic challenges of the 21st century. In particular, the rapid proliferation of computational data on materials properties presents the possibility to complement and extend materials property databases where the experimental data is lacking and difficult to obtain.

Enhanced repositories such as AFLOWLIB, open novel opportunities for structure discovery and optimization, including uncovering of unsuspected compounds, metastable structures and correlations between various properties. The practical realization of these opportunities depends on the design efficient algorithms for electronic structure simulations of realistic material systems,[3,4] the systematic compilation and classification of the generated data,[5,6] and its presentation in easily accessed form to the materials science community, the primary mission of the AFLOW consortium.

References

Figure 1: AFLOWLIB
Improved Bounds on the Overall Properties of Composite Materials with Randomly Oriented Fibers

Pavlo A. Krokhmal, Y. Morenko, Olesya I. Zhupanska
University of Iowa

This work is concerned with evaluation of the overall elastic properties and development of the improved variational bounds on the overall elastic properties of fiber-reinforced composites with arbitrary orientational distribution of fibers.

The problem of finding the tightest bounds for the composites with non-aligned phases is formulated as a nonlinear semidefinite programming (SDP) problem, i.e., an optimization problem where the optimization variables are represented by symmetric positive semidefinite matrices. The tightest upper (correspondingly, lower) bounds are sought by minimizing (maximizing) orientation-dependent effective moduli tensor with respect to an arbitrary diagonally symmetric positive semidefinite tensor such that for any phase , properties of which are defined by a given (constant) tensor , the difference is positive (negative) semidefinite:

\[
\min_{L_0 \succeq 0} \{ C \cdot \bar{L}(L_0) \mid L_0 - L_r \succeq 0, \ r = 1, \ldots, k \}.
\]

Here is the number of phases and the (symmetric) matrix represents the “weights” or “costs” of the corresponding elements of the effective tensor , which is nonlinear in terms of the semidefinite matrix :

\[
\bar{L} = L(L_0) = \left( \sum_{r=1}^{k} f_r \{(L^*_0 + L_r)^{-1}\}_r \right) - L^*_0.
\]

Above, is the volume fraction of phase , such that , operator denotes orientational averaging of phase (in the case of isotropic matrix one simply has ), and matrix is an overall constrain tensor and is a nonlinear transformation of . The proposed formulation immediately guarantees that any solution of the SDP problem represents a valid tensor of elastic material properties. The problem is solved by an interior point method, and an optimal solution produces bounds for the overall elastic properties of the multiphase composites with orientational distribution of phases. The computational results show that the obtained solution improves the Hashin-Schtrikman-Walpole bounds [1], which are the only known bounds for the composites with non-aligned microstructures and are only valid for the case of uniform random distributions of microstructure.

References

Comparison of Thermal Conductivity and Its Anisotropy of Various Polytypes of Silicon Carbide at Low and High Temperatures from First Principles Calculations

Anna Kuznetsova
Air Force Research Laboratory / National Research Council

The design of high-performance airframes for the next generation of maneuverable hypersonic vehicles operating at extreme environments requires multifunctional materials that are able to simultaneously resist high thermal, mechanical and oxidation loads as well as immense thermal gradients developed at the leading edge of hypersonic vehicles. In order to mitigate the excessive oxidation and mechanical stresses caused by extreme conditions at the hypersonic leading edge it is essential to efficiently reduce these thermal gradients by dissipating the heat along the surface of the vehicle without heating of the interior. This could be achieved by using high performance materials which have both high thermal conductivity and high thermal conductivity anisotropy.

Silicon carbide (SiC) is among the best candidates for such applications due to its high thermal conductivity and substantial thermal conductivity anisotropy as well as other superior properties, such as, low density, low thermal expansion, high strength, high elastic modulus and superior chemical inertness. Thermal conductivity tensor of SiC is highly dependent on its crystal structure and polytype. Consequently, new SiC-based material with thermal properties specifically tailored to a particular application can be created by gradually changing SiC crystal structure through combination of various SiC polytypes, element doping and using ab initio calculations to predict the resulting thermal conductivity tensor of the designed material.

We present calculations of the thermal conductivity of the various polytypes of silicon carbide at various temperatures and ambient pressure (temperatures range is 300-1200 K) from first principles in the framework of density functional theory and solution of the Boltzmann Transport Equation (BTE). Local density approximation (LDA) and generalized gradient approximation (GGA) produce similar thermal conductivities, with differences accounted by the known overbinding and underbinding of the LDA and GGA, correspondingly. Thermal conductivities at all considered temperatures are found to be consistent with the results of previous molecular dynamics simulations based on classical 2-body Tersoff potential. However, they are not consistent with recent experimental findings. Possible reasons for this disagreement are discussed.
Multidimensional Buffered Probability of Exceedance: Application to Multi-Commodity Flow Capacity Constraint Relaxation

Alexander Mafusalov
University of Florida

Buffered probability of exceedance (bPOE) was applied to network flow problems to minimize the number of overloaded vertices. This paper proposes three versions of multidimensional bPOE and studies their mathematical properties. The multi-commodity flow problem is viewed as an optimization over multiple random variables. Capacity constraints are assumed to be non-strict and the problem is relaxed to minimizing the number of capacity violations, which is reformulated as MILP problem. M-bPOE functions provide more conservative objectives and produce alternative LP formulations to the relaxed problem.
Soft Margin Support Vector Classification as Buffered Probability Minimization

Matthew Norton, Alexander Mafusalov, and Stan Uryasev
University of Florida

In our research, we provide theoretical insights into the nature of the popular C-SVM, soft-margin support vector classifier. We prove that the C-SVM, formulated with any regularization norm, is equivalent to minimization of Buffered Probability of Exceedance (bPOE). This equivalence allows us to gain new insights into the C-SVM. For example, along with insights inspired by bPOE, we show that the choice of regularization norm implies a distance metric for ‘margin maximization’. To help provide such theoretical insights, we introduce a new SVM formulation, the Extended Soft Margin Support Vector Machine (EC-SVM), named in this way to emphasize its relation to the Extended v-Support Vector Machine (Ev-SVM). We derive the EC-SVM as a bPOE minimization problem and show that the C-SVM is equivalent to the EC-SVM. Throughout, we utilize bPOE and the EC-SVM to interpret the C-SVM in a new, surprising way. We also connect the EC-SVM with the Ev-SVM, showing that they produce the same set of optimal solutions, helping to fully connect soft margin support vector classification with superquantile and bPOE concepts.
Support Vector Machines with Risk Constraints

Victoria Zdanovskaya and Konstantin Pavlikov
University of Florida

We consider a particular class of data-mining algorithms for classification called Support Vector Machines (SVMs). SVMs are used in a wide range of applications such as fraud detection, medical diagnostics, handwriting recognition, credit scoring, etc. In this research we introduce risk constraints to standard SVM formulations for the purpose of controlling their risk management characteristics.
A Bi-level Decision Dependent Stochastic Programming Model for Generation Investment Planning in Power System

Yiduo Zhan
University of Central Florida

This research focuses on the generation investment planning problem in power systems. The investment decisions must be made with the consideration of some lower-level optimization problems with uncertainty. We propose a two-stage bilevel decision dependent stochastic model (TBDDS) that consists of two levels of optimization problems. The upper-level problem is formulated as a facility investment planning problem. The lower-level problem represents an electricity pricing problem that addresses the market clearing consideration with local transmission network. We also employ transformation techniques to convert the non-linear bilevel stochastic programming problem to a mixed-integer linear programming (MILP). Several case studies are conducted.
Vision-Based Control with Unknown Time Varying State Delay and Known Time Varying Input Delay

Indrasis Chakraborty
University of Florida

The objective of this research is to design a controller for a vision based system with state and input delay. Time delay is a broad class of problem, mainly subcategorized in to state delay (delay comes from the dynamics of the system) and input delay (delay comes from the application of input in any dynamic system). Vision based system, for example, in missile navigation and guidance system, can experience state delay resulting in the time taken between the image captured using the camera and getting realized for tracking the target. Input delay is a common occurrence in most of the autonomic systems, as there is an inherent time lag between the actual application of the control force on the system and the moment it’s applied. Dealing with vision based system with delay is important as time delays can significantly affect the system performance depending on the magnitude of the delay. In this work, visual servo control over a communication network is considered, where the objective is to control a dynamic system (e.g., a robot) using images obtained over the network. State and Input delay are assumed to be slowly varying, with the magnitude of the state delay to be unknown unlike the input delay. This assumption is justified as the state delay depends on several parameters, all of those can’t be taken into account (e.g., network delays), unlike input delay, which depends on the latency of the system and can be considered to be known. Extensive Lyapunov stability analysis is done for a generalized image-based visual servo controller with unknown time-varying system delay and both with and without time-varying known input delay. Simulations are performed to validate the robustness of the designed controller, which shows a significantly small tracking error for state delay value as high as 200 ms.
A Potential Function Approach to Maintaining Line of Sight

Anup Parikh
University of Florida

A potential function based controller is developed for maintaining line of sight between a camera and a moving target in an environment with many obstacles. Superellipsoids of nth order are used to approximate the parallelepiped obstacles, and a virtual potential field developed based on the distance to the superellipsoid. Additional potential fields are added to keep the camera above the ground and within a prespecified range to the target. Finally, a controller is developed to keep the target in the camera FOV and the camera facing up. Simulation results are presented, and extensions for maintaining line of sight with multiple targets are also discussed.
Experimental Validation for Visual Servo Control of an Unmanned Ground Vehicle via a Moving Airborne Monocular Camera

Hsi-Yuan Chen, Zachary Bell
University of Florida

An experimental validation of a daisy-chaining based visual servo controller is performed. Specifically, the cooperative daisy-chaining controller is implemented with the objective to regulate an unmanned ground vehicle (UGV) to a desired pose utilizing the feedback from a moving airborne monocular camera system. In contrast to typical camera configurations used for visual servo control problems, the daisy-chaining controller is developed using a moving on-board camera viewing a moving target. Multi-view photogrammetric methods are used to develop relationships between different camera frames and UGV coordinate systems. In this experiment, a remote laptop, a Turtlebot (mobile robot), a stationary reference object (e.g., a building), and an AR.Drone (quadrotor) with a 720p resolution camera are used. The images received from the camera on-board AR.Drone are processed using OpenCV to extract and track features. The tracked feature points are fed into the controller implemented in MATLAB. The velocity control commands are broadcasted to the Turtlebot via Robotic Operating System (ROS) to achieve regulation to a desired pose. For performance verification, data collected from motion capture system is used as ground truth and plotted against the desired pose.
A Hierarchical Model for Optimal Recovery in Stochastic Network Systems

Juan Borrero†, Oleg Prokopyev, Pavlo Krokhmal
†University of Pittsburgh

We consider a network whose nodes are under attack by an external source. The nodes can recover either on their own, by receiving support of neighboring recovered nodes, or by receiving support from outside the network. A decision-maker has to determine how to invest his/her budget on these three options in order to minimize the time until all nodes are recovered. To address this question we propose a novel hierarchical and stochastic optimization model based on Markov processes. The analysis of the model yields simple formulas for optimal and near-optimal budget allocations that can be readily computed from the parameters of the model.
Robustness of Solutions to Critical Node Detection Problems
Under Conditions of Imperfect Data

Colin P. Gillen†, Alexander Veremyev, Oleg A. Prokopyev, Eduardo L. Pasiliao
†University of Pittsburgh

A class of critical node detection problems based upon the metric of communication efficiency (distance) is considered. While both exact integer programming and approximate centrality-based heuristic methods exist for the solution of these problems, previous work has focused on the case where perfect information about the network is available. We extend this work to include the possibility that some level of misinformation about nodes or edges has been inflicted on the observer’s perception of the network (i.e. there are hidden elements or fake additional elements). Extensive computational studies are conducted to ascertain whether the exact solutions perform better under uncertainty than approximate heuristic methods. Subsequently a truncated version of the exact method is considered for larger networks and bounds derived for solution quality. The truncated solutions are again compared to centrality-based heuristics under the presence of uncertainty.
In this work we initiate the study of sparse spanners. We discuss two separate types of such graphs here. First we study spanners that are robust to node failures. We discuss their existence in a finite metric space with a bounded doubling dimension. More precisely we study the problem of existence of so called, “robust spanners”. These are graphs where the removal of a fixed number of vertices affects only a small number of other vertices. Robust spanners have been studied in Euclidean spaces and in this work we extend the idea of robust spanners to doubling metrics. We describe a construction of robust spanners in doubling spaces having super-linear number of edges, using the idea of the well separated pair decomposition. Next we talk about Minimum Edge Compact Spanners and state a few NP completeness results. Finally we discuss greedy algorithms for solving this problem on weighted graphs.
Discrete Time Dynamic Assignment Models for Evacuation Planning with Boundedly Rational Evacuees

Guanxiang Yun, Qipeng Phil Zheng
University of Central Florida

We proposed a boundedly ration model for the evacuation problems. Under the boundedly ration principle the person may choose any one of the routes, which time costs are within a tolerance, to evacuate. We made our models in dynamic network which related to the time, and we made our model in discreet time periods. As we know, when the evacuation happens, the road directed from the dangerous places to safety places will have many cars. But the reverse direction will be almost empty. So we need to make a decision for which road we need to change the direction, that to let the direction of that road just direct from dangerous places to safety places. This method can lead the evacuation time decreasing, but will make extra cost. So we need to make a balance for the optimization.
An Inverse Containment Control-Based Approach to Solving the Herding Problem

Ryan Licitra
University of Florida

An approach to solving the so-called herding problem using network control techniques is proposed. A group of herding agents is tasked with coralling a group of non-stationary target agents in an effort to prevent evasion. The target agents’ dynamics will be defined such that they are repelled from any nearby herding agent, and will move randomly about the workspace otherwise. Using decentralized vision-based estimation techniques, as well as network communication, the herding agents estimate the current geometric center of the target agents and form a polytope such that all target agents are in the convex hull of the herding agents, preventing any from escaping.
Spatial Control of Linear Multiagent Systems

Dzung Tran and Tansel Yucelen
Missouri University of Science and Technology

Two sweeping generalizations can be made about most decentralized control algorithms developed for networked multiagent systems. The first is that they assume each agent to have single or double integrator dynamics. The second is that they have a lack of network infrastructure to enable spatially evolving formations necessary for applications in cluttered and dynamic environments. To address these issues, this research work considers linear multiagent systems, i.e., a group of agents with each agent having high-order linear state-space models, and establish decentralized control algorithms utilizing multiplex networks - a recently emerging theory in physics and network science - to achieve spatial formation evolution.

We present our results in the context of a formation tracking problem, where a group of networked agents tracks a dynamic target, while forms, maintains and alters the resulting formation’s density and orientation over time in order to adapt to the environment. The proposed algorithms require each agent to communicate and exchange information locally, which is practical for situations involving large numbers of agents and low-bandwidth peer-to-peer communications. Stability of the proposed contributions is theoretically analyzed and their efficacy is illustrated through a numerical example, where we use the linearized spacecraft equations of the relative translational dynamics that are described by the Clohessy-Witshire equations.
Active–Passive Distributed Consensus Filtering with Reduced Communication and Dynamic Agent Roles

J. Daniel Peterson and Tansel Yucelen
Missouri University of Science and Technology

Distributed sensing is a task performed by several to a few hundred agents that work together to achieve a common goal. Unlike classical distributed sensing methods, which assume instantaneous communication, which is not practical for situations involving large numbers of agents, high dimensional measurements, and unpredictable low-bandwidth networks [1]-[3], system-theoretic distributed sensing approaches involve equations of motion to describe dynamic behaviors inherent to the data fusion process, providing better robustness to system uncertainty (e.g. node failures, communication delays, and measurement noise), and allow for a better understanding of the overall network dynamics. Consensus algorithms play a central role in distributed sensing, where agents exchange and fuse information through local communications to build global knowledge.

Among two important classes of consensus algorithms are dynamic and static consensus, where dynamic algorithms are well suited for dynamic environment applications. However, existing algorithms are limited to cases where all agents are subjected to an exogenous input. Recognizing that agents may be heterogeneous with respect to the number of exogenous inputs they are subjected to, as well as heterogeneous in sensing abilities, the authors presented the active–passive networked multiagent systems approach to distributed sensor fusion in [4] and [5], where our aim is to drive the states of all agents to the average of the exogenous inputs acting on the system. An agent is considered as ”active” for exogenous inputs it is subject to, and ”passive” otherwise.

The active–passive networked multiagent systems approach accomplishes distributed fusion through a second-order dynamic consensus algorithm, without requiring excessive information exchange among agents, which may not be suitable for use in low-bandwidth sensor networks. To this end, we propose the following protocol

\[
\dot{x}_i(t) = -\alpha \sum_{i \sim j} (x_i(t) - x_j(t)) - \alpha \beta_i x_i(t) + p_i(t) - e^{-\gamma \sigma t} p(0) - \alpha \sum_{i \sim h} k_{ih}(t) (x_i(t) - c_i(t)),
\]

\[x_i(0) = x_{0i},\]

\[
\dot{p}_i(t) = -\gamma \sum_{i \sim j} (x_i(t) - x_j(t)) - \sigma \gamma p_i(t), \quad p_i(0) = p_{0i},
\]

where \(x_i(t), i = 1, 2, \ldots, N\) is the state of agent \(i\), \(p_i(t)\) is the integral action of agent \(i\), \(k_{ih}(t) \in [0, 1]\) represents the ability of agent \(i\) to observe exogenous input \(h\), and \(\alpha, \beta_i, \gamma > 0, \sigma \geq 0\) are design parameters. As in [4] and [5], (1) and (2) solve the active–passive distributed sensing problem, but only require a single state variable to be exchanged between agents, reducing the communication bandwidth requirements. Additionally, in contrast to
the assumptions in [4] and [5], where the authors assumed at least one agent remained active for all time, (1) and (2) allow all agents to dynamically adjust their active and passive roles. Through a state transformation, and utilizing a quadratic Lyapunov function, the authors will demonstrate that (1) and (2) are ultimately bounded with adjustable bounds defined by the design parameters $\alpha, \gamma$, and $\sigma$.

References

Decentralized Cooperative Control Methods for the Modified Weapon Target Assignment Problem

Kyle Volle
Georgia Institute of Technology

The weapon target assignment problem is a foundational problem in the fields of combinatorial optimization and operations research. In its decentralized form, it is also an important problem for multi-agent robotics. In this work, decentralized algorithms are explored for the solution of a modified weapon target assignment problem in which weapons seek to achieve a prespecified desired probability of kill on each target. These solutions algorithms are defined in a game-theoretic context, in which the cost function that the weapons collectively attempt to minimize is designed to induce desired behavior. Two novel cost functions are proposed which yield better behavior than classical cost functions in cases with low weapon-target ratios. Performance of these cost functions is explored in simulation of both homogeneous and heterogeneous engagement scenarios. Results show that the proposed cost functions achieve better performance in cases where efficient use of weapons is particularly important.
The Influence of Single Crystal Plastic Deformation Mechanisms on Damage Distribution in Porous Materials

Oana Cazacu and B. Revil-Baudard
University of Florida

A strong difference between the plastic response in tension versus compression is observed at the polycrystal level, if either twinning or non-Schmid type slip are contributors to plastic deformation at the single crystal level. Despite recent progress in modeling the effects of this asymmetry in yielding, its influence on damage evolution remains a challenge. Using a recent model [2] for porous polycrystals, in this talk it is shown that if the matrix tensile strength is slightly higher than its compressive strength, void growth is faster than in materials obeying Gurson’s criterion. On the other hand, for certain porous polycrystals in which the matrix tensile strength is lower than its compressive strength, void growth rate is much slower. Damage distribution is significantly different in the latter materials; the location of the zone of maximum porosity shifts from the center of the specimen to the surface (see also [1]). Finally, it is demonstrated that even for a porous solid with von Mises matrix, the dilatational response should depend on Lode parameter [3].

References

Metal-Ceramic Composites in Extreme Environments: Complex Microstructures, Effective Properties, and Thermo-Mechanical Behavior

Olesya Zhupanska
University of Iowa
Deformation of Exotic Metallic Materials Under Extreme Environments

Benoit Revil-Baudard and Oana Cazacu
University of Florida

Recently, fully implicit computational capabilities have been developed to predict the plastic behavior of exotic metals (i.e. Ti, Mo) during dynamic events. It is to be noted that within this formulation framework, the equilibrium equations are solved for each time increment. The couplings of the numerical framework to the Cazacu et al. (2006) plasticity model that accounts for all the key features of the plastic behavior of airframe materials, i.e. the tension-compression asymmetry and the orthotropic behavior, results in high fidelity prediction of the mechanical behavior during dynamic events. The improved predictive capabilities have been assessed for different strain rate conditions and different metallic materials. Furthermore, validation of the models and FE formulation for Taylor impact conditions through comparisons of experimental deformed profiles of Taylor specimens for Ti and Mo has been done. It is worth noting that for the first time, the extent of the zone of plastic deformation, change in geometry and the transition from transient to quasi-steady plastic wave propagation was captured with great fidelity. Furthermore, the model was used to gain understanding of the dynamic deformation process in terms of time evolution of the pressure, the extent of the plastically deformed zone, distribution of the local plastic strain rates, and when the transition to quasi-stable deformation occurs for different dynamic events. It was thus shown that this model has the potential to be used for virtual testing of complex systems.
Turbulence Generation and Energy Transfer Mechanism in Boundary Layer Transition using Direct Numerical Simulation

Shanti Bhushan† and Crystal Pasiliao
†Mississippi State University

Engineering applications often involve bypass transition, which entails strong nonlinear phenomena, and hence their modeling is challenging. Transition models available for engineering applications are mostly based on empirical correlations, which lack universality and can be difficult to implement for complex problems. Physics based models have been developed, but they rely on heuristic assumptions for transition mechanisms [1]. The primary difficulty for transition model development is a lack of clear understanding of turbulence production mechanism in transitional regions. The objective of this research is to perform Direct Numerical Simulation (DNS) of boundary layer bypass transition flows to understand the inter-component turbulence energy transfer in the transition and turbulent regions, and assist in future transition model development and validation. The ongoing research focuses on visualization of the near-wall vortical structures, evolution of the mean and turbulent stresses and energy spectra, and turbulent kinetic energy (TKE) and stress budget in temporally developing plane channel flow at $Re_\tau = 180$ and 590 using DNS [2]. The pre-transition region shows the presence of counter-rotating longitudinal structures, which are identified to be the Klebanoff modes. The length scales of these structures decrease with progression, and they induce lifting on each other to form hair-pin structures as shown in Fig. 1. The transition to turbulence occurs as the frequency of the hair-pin generation increases. The energy and stress budget shows that in the pre-transition region the wall-normal fluctuations or ejection events are primarily induced by the initial turbulence, which leads to the production of shear stress and subsequently longitudinal velocity fluctuations. The pressure-strain terms are negligible in this region, thus redistribution of energy from streamwise to spanwise and wall-normal components are absent. The flow transitions to turbulent state with the growth of pressure-strain term. The scaling of the molecular diffusion and pressure strain time scales in the pre-transition to turbulent regions are being analyzed, which can be used for physics-based transition model calibration.

References

Figure 2: Coherent vortices shown using Q-isosurfaces for $Re_\tau = 590$ in transition and turbulent regimes colored using wall distance. Laminar sub layer region shows longitudinal structures, which ejects from the surface to form hairpin structures in turbulent regions.
Materials Data Requirements for Design of an Expendable Hypersonic Airbreathing Airframe

Lynn J. Neergaard†, Crystal L. Pasiliao, Zachary Witeof, and Andrew Shelton
†Air Force Research Laboratory / Leidos

It is necessary to identify technology advances that can best enhance system performance of an air-launched, air-breathing hypersonic weapon. We will specifically address design strategies that take advantage of materials capabilities beyond the normal range. One example is designing metallic structures at temperatures and stresses beyond the elastic limit. For this application, a better understanding of microstructural transformations at high temperatures and creep rates as a function of stress and temperature is required. Another example is the effect of the compliance of an ablative Thermal Protection System (TPS) material on aero-structural interactions. A final example is oxidation-resistant coatings exposed to the surface temperatures and oxygen partial pressures throughout the trajectory. All three of these phenomena are dynamic and path-dependent, so present unusual challenges to materials and structural modeling.

The hypersonic sizing and design tool, Preliminary Aerothermal Structural Simulation (PASS), currently generates aft-fin, axisymmetric, monocoque hot or cold structures of minimum mass to survive mission stresses for a given material or set of materials. It requires an input trajectory or set of trajectories and a list of internal subcomponents. Outputs include thermal and chemical history at hundreds of surface locations on the body and fins, identification of the trajectory instant that sizes each skin panel, and evolving outer mold line shape due to ablation. This presentation will show typical output data from the structural simulation program, as well as promising approaches to provide the unusual materials data for this application.
Entropy Constrained Flux Reconstruction for Robust High Order Fluid Simulation

Andrew B Shelton
Air Force Research Laboratory / Leidos

The challenge to maintaining solution efficiency of high order methods for non-smooth flow problems (e.g., those with shocks and contact surfaces) centers on a successful strategy for mitigating the Gibb’s phenomena in regions of under-resolution. By appealing to entropy considerations, progress has been made on the derivation and implementation of a high order Flux Reconstruction method to specifically address this problem. An entropy condition may be derived through a change of variables from a conservation law, and each of these may be in turn discretized by a numerical scheme. Imposing the same change of variables at the discrete level provides details about the appropriate form of the derivative and boundary operators, the element node set(s), and the numerical flux functions which are tasked with providing a physically appropriate level of damping. Compared to a traditional high order Discontinuous Galerkin plus Artificial Viscosity approach, the new method enjoys less computational overhead, no timestep penalty for damping, and no problem-specific tuning. This presentation will detail the key mathematical ideas of the method and demonstrate its robust and accurate solution of model problems for the Transport, Burgers, and Euler equations.
Fluid-thermal-structural interactions can create significant uncertainty in the performance of high speed vehicles. A toolset has been created to assess flexible effects at progressive levels of fidelity throughout the preliminary design process. Results for quasi-static deformations and the resultant effect on aerodynamic coefficients are presented for a representative configuration. Plans for progression to dynamic analysis are discussed as well. This toolset augments the Preliminary Aerothermal Structural Simulation (PASS) tool suite for MDAO of high-speed vehicles.
Globally Asymptotically Stable Distributed Control for Distance and Bearing Based Multi-Agent Formations

Kaveh Fathian, Dmitrii I. Rachinskii, Mark W. Spong, Nicholas R. Gans
University of Texas Dallas

We present a distributed control scheme for planar multi-agent formation control based on mixed local distance and bearing measurements. Our control eschews the shortcomings of the existing methods. Distance-based methods often suffer from undesired equilibria, which preclude a globally convergent continuous control. Bearing-based methods have the possible disadvantage that the scale of the formation is uncontrollable. Using distance and bearing, our continuous control law is globally stable, and no knowledge of a common or global coordinate frame is required. A sufficient condition for global asymptotic convergence of the formation to the desired shape is given in terms of the inter-agent communication graph. Global stability of the proposed control is proven using Lyapunov’s method and cascade systems theory. Simulations for up to 32 agents starting from random positions on the plane verifies that agents can successfully converge to the desired formation with no knowledge of the global coordinate frame.
In the past few years, the rise of unmanned vehicles has fascinated significant attention among the control community in multiagent systems. These research works define a new era where agents in squadrons of unmanned vehicles cooperate together in order to achieve common tasks in both military and mixed civilian environment, for example, cooperative exploration, data gathering in critical environments, search and rescue operations just to mention a few. Especially, control algorithms for such tasks require each vehicle and its neighbors to exchange their local, peer-to-peer measurements. In this paper, we consider a scenario, where a group of vehicles in formation tracks a dynamic target while adjusting its density and orientation to fit into cluttered environments.

Current cooperative distributed control methods have a lack of information exchange infrastructure to enable spatially evolving multiagent formations. This is due to the fact that these methods are designed based on information exchange rules represented by a network having a single layer only, which leads to multiagent formation having fixed, non-evolving spatial properties. For situations where capable vehicles, leaders, have to control the resulting formation using these methods, they can only do so if such vehicles have global information exchange ability, but this is not practical for cases involving large numbers of agents and low- bandwidth peer-to-peer communications.

In our research, we attempt to show how information exchange rules represented by a network having multiple layers (multiplex information networks) can be designed for enabling spatially evolving multiagent formations while tracking a target. Toward this goal, we consider formation control problem and introduce a novel distributed control architecture that allows capable agents to spatially alter the resulting formation’s density and orientation while tracking a dynamic target - without requiring global information exchange ability. We also introduce potential field functions to the proposed algorithm to ensure the connectivity and collision avoidance among agents. Stability of the proposed architecture is theoretically analyzed and its efficacy is illustrated by several numerical examples.
Distributed Task-Allocation in Multi-Agent Systems with Limited Dynamic Communication and Agent Attrition

Johnathan Votion
University of Texas at San Antonio

This work assumes that a distributed multi-agent system (DMAS) is susceptible to experiencing communication faults in its network topology. The communication faults are represented by either a temporary limitation in an agent’s transmitting and receiving capability, or agent attrition (permanent removal of the agent from the system). Under this assumption, two estimation methods are proposed that determine two separate but significant features of a DMAS. The first method determines the operational status of system agents by comparing communication times with timing thresholds. The second method estimates the topology of the system network using a multi-weighted consensus strategy. To illustrate its effectiveness, the proposed estimation methods are used to develop a novel solution to the distributed task-allocation problem. The new task-allocation algorithm is shown to have improved and robust performance when compared with existing allocation algorithms in situations where limited and dynamic communication networks are experienced.
A set of nonlinear reduced-order models are developed to determine the variation of structural thermal capacity and thermal conductivity with respect to temperature for a representative hypersonic vehicle on a terminal trajectory. The number of thermal degrees of freedom is first reduced by projecting the thermal state of the structure into a modal space whose bases are determined using proper orthogonal decomposition. Reduced-order models based on least-squares fit polynomials, the method of kriging, and a combination of singular value decomposition and system identification are investigated and compared. Heat transfer simulations of the vehicle structure with and without the thermal property model are then compared to finite element solutions.
There is a premium placed on short range vehicle maneuverability and agility to capture evading targets. Intercept vehicles travel at high supersonic velocities during the final phase of the trajectory, which prohibits large final adjustments to the flight path of the vehicle. This is a weakness that can be exploited by the target vehicle, which limits the effectiveness of the air-to-air vehicle. Significant changes to the trajectory of a supersonic vehicle require very high angles of attack leading to very high pressures on the structure. Therefore the problem includes coupled interactions between the flexible structure, aerodynamics, and flight dynamics.

All of the relevant physical phenomena associated with a supersonic maneuvering vehicle must be modeled to fully understand the flight dynamics, trajectory, and ultimately the performance of the vehicle. Aggressive maneuvers for vehicles are difficult to replicate experimentally, which leads to emphasis placed on numerical analysis. However, simple or theoretical models run the risk of breaking down in extreme conditions and high fidelity tools have very high computational cost and complexity. Reduced order models based on high fidelity analysis are an effective way to capture the relevant physical phenomena and couplings of the full problem while significantly reducing computational cost and complexity. In addition to a lack of appropriate analysis tools, the aeroelastic response of a maneuvering vehicle at supersonic speeds is not well understood. Vehicle flexibility is significant for a maneuvering vehicle due to the very slender structures deforming due to aerodynamic pressure. Additional work with higher-fidelity tools and methods is needed to understand the aeroelastic response of slender flexible vehicles maneuvering at supersonic speeds.

We have developed reduced order models for a representative supersonic vehicle in a coupled aeroelastic framework to simulate the response of a fully flexible vehicle in free flight. The vehicle properties have been chosen to be representative of the short-range air intercept vehicle class such as the AIM-9 Sidewinder. However, the vehicle is unconventional in some aspects in anticipation of future aircraft and air-to-air vehicle technology. Specifically, the vehicle is a simple axisymmetric body without any control surfaces or fins. For control authority, a set of pulse jets are assumed to be located at the nose of the vehicle. The structural properties of the vehicle have been modified to adjust the free vibration modes and align with developing work in the field of maneuverable projectiles. The nonlinearities of the system and the effects of increased flexibility are highlighted by comparing the structural and flight dynamic response for each stiffness value. The vehicle response to a prescribed control force and aerodynamic loads was recorded for varying values of vehicle flexibility. The aerodynamic loading of a deformed vehicle shows a decreased moment coefficient in the direction vehicle bending. Therefore, flexible vehicles require less control force to maintain the required angle of attack or can achieve higher angles of attack for the same force compared to a stiffer vehicle. These qualities are critical to improving the maneuverability of slender intercept vehicles.
Rapid Loads Prediction for Hypersonic Vehicles Using CFD Surrogates

Emily R. Dreyer
The Ohio State University

This work is motivated by the USAF’s desire for hypersonic air-to-ground vehicle systems and the need for rapid loads prediction in extreme environments. The analysis herein includes two computational fluid dynamics (CFD) surrogates, both generated using Kriging. The surrogates are constructed using a set of steady-state CFD solutions defined by a multidimensional Latin hypercube. The variables used in the first surrogate include Mach number, altitude, angle of attack, and sideslip angle. The second surrogate presented includes adiabatic wall temperature in addition to the previous set of inputs. Both surrogates are evaluated by comparisons to steady-state CFD solutions.
Rapid Loads Prediction for Supersonic Vehicles Using CFD Surrogates

Dianne Zettl
The Ohio State University

The United States Air Force (USAF) seeks advanced supersonic air-to-air vehicle systems capable of extreme agility while reducing weight and volume (for internal carriage considerations). For such systems, an inherent crosscutting challenge is managing the associated strong, dynamic fluid-structural interactions; and successfully doing so necessitates consideration of these effects at the early stages of system design. This requires multi-disciplinary computational frameworks that can accurately and expediently predict the unsteady aerodynamic pressure.

Computational fluid dynamics (CFD) can provide a high accuracy solution. However, such an approach is not yet amenable for incorporation at the early design stages of analysis. Classical engineering-level approximations are sufficiently expedient, but cannot provide sufficient accuracy for all required conditions. These general issues have motivated a significant number of studies on model reduction techniques that can harness the capability of high-fidelity flow modeling tools, while remaining computationally feasible for the design process.

One promising approach in supersonic flow fields, where the fluid-structural coupling is typically quasi-steady, is to generate a surrogate model based on a combination of steady-state CFD and theoretical aerodynamics. Here, the steady-state CFD captures complex flow features, while the theoretical models are used to correct the steady-state loads for feedback effects due to dynamic fluid-structural coupling. In order to further reduce the computational effort, the steady-state CFD model is replaced with a data-driven surrogate model using Kriging.

The objective of this study is to develop and assess the CFD surrogate approach for application to supersonic munitions operating on representative trajectories. This is accomplished by constructing surrogate models for a generic supersonic air-to-air vehicle configuration and benchmarking against unsteady CFD solutions.

Representative operating conditions for the supersonic vehicle are above Mach 2, with AOA of up to 60 deg, and turning maneuvers above 20 g’s. The full set of input parameters for this study are Mach number, altitude, angle of attack, sideslip angle, and surface deformation. In the present analysis, models were generated using 100 sample points selected using Latin Hypercube Sampling and benchmarked against 25 steady-state CFD flow solutions not included in the training set. Upcoming results include CFD surrogate load predictions in the presence of representative structural deformations and for the vehicle configuration operating on a representative trajectory.
Projection Methods in p-order Cone Programming

Alexander Vinel
Auburn University

The goal of this research effort is to design a projection-based solution approach to p-order cone programming problems. In our previous works we have shown that this class can play an important role in risk-averse decision making as well as in other areas of science and engineering. Our focus in this talk will be on addressing challenges in the way of implementing efficient projection-based approaches. Namely we will discuss potential general ways to design such methods, such as augmented Lagrangian, regularization method, spectral projection etc. In the second half of the presentation we will concentrate on the problem of calculating the projections onto p-cones themselves, which are an essential part of the considered schemes. We will show that even though accomplishing this task is not as easy as in the case of second-order cones or semidefinite-programming, an efficient numerical procedure can be devised.
Robust Sensitivity Analysis in the Optimal Value of Linear Programming

Guanglin Xu and Sam Burer
University of Iowa

We study sensitivity analysis of the optimal value of linear programming under general perturbations of the objective coefficients and right-hand sides. This leads to non-convex quadratic programs (QPs), which are difficult to solve in general. We then propose copositive relaxations of these QPs that, while exact in some cases, are still computationally intractable. Finally, we derive corresponding tractable relaxations and present preliminary computational results to demonstrate their quality.
Stochastic Accelerated Alternating Direction Method of Multipliers with Importance Sampling

Chenxi Chen
University of Florida

We consider stochastic convex optimization with linear equality constraint. Uniform sampling is always occupied in existed works, which may result in high variance. The convergence rates highly depend on the variance. We incorporate variance reduction method in stochastic accelerated alternating direction method of multipliers for solving stochastic composite problems, to improve dependence of variance resulted by random sampling procedure.
Rapid Characterization of Munitions Using Neural Networks

Mark Carpenter, Norman Speakman, and Roy Hartfield
Auburn University

This paper presents a method for classifying and identifying small caliber rockets, artillery rounds and mortars; generally referred to as RAM threats. Traditional approaches to the classification and identification problem typically use threat signature characteristics, both radar and infrared (IR). The radar signature is radar cross section (RCS); the IR is irradiance. These approaches are affected by weather and environmental conditions and tend to neglect a major and obvious threat-type discriminator, namely the kinematic behavior of the threat. Other popular methods involve estimation of the target’s ballistic coefficient. Different types of ballistic targets usually have different ballistic coefficients, but obtaining accurate estimates in a timely fashion is generally problematic. The innovative method presented here is a neural network-based approach that has been implemented to first classify the target as a RAM threat and further to identify the threat caliber. The neural network is “trained” by employing large numbers of trajectories produced with validated kinematic simulations. The simulations are exercised in Monte Carlo fashion to generate a diverse and realistic trajectory training set for each candidate threat type. The trained neural network processes actual radar measurements in real time to classify and identify targets based on those in the training database. The goal is to perform the classification/identification in less than 20 measurements. Threat-type classification and identification employs conventional radar measurements of the threat’s position in the radar frame transformed to Cartesian coordinates, so additional data sources and signal processing are avoided. The neural network approach is envisioned to provide additional valuable threat information such as point-of-origin (POO) estimation and point-of-impact (POI) prediction.
Optimization of Value-at-Risk: Computational Aspects of MIP Formulations

Konstantin Pavlikov
University of Florida

Value-at-Risk minimization is an important problem both from theoretical prospective and also for many practical applications. It can be represented through a class of chance-constrained optimization problems, which are generally hard to solve. Mixed integer linear optimization with big M constants is a standard way to approach such problems. This study explicitly incorporates the bounds on the optimal solution into the MIP formulation. Moreover, the lower bound is demonstrated to play the key role in obtaining tight big M constants and a procedure to tighten this bound is discussed. Numerical experiments suggest that the proposed solution method can decrease the solution time by up to 80%. In addition, it also helps to control the memory used by the solver allowing to handle larger problem instances on the same machine, which could not be solved to optimality using previously known approaches.
A Simple Scenario Decomposition Algorithm for Stochastic Programming Problems With a Class of Downside Risk Measures

Maciej Rysz
Air Force Research Laboratory / National Research Council

We present an efficient scenario decomposition algorithm for solving large-scale convex stochastic programming problems that involve convex and coherent risk measures. The structure of the feasible set is exploited via iterative solving of relaxed problems, and it is shown that the number of iterations is bounded by the size of the scenario set. The computational performance is illustrated on portfolio optimization problems involving two families of nonlinear risk measures.
Continuous Approaches to Optimization Problems in Graphs

Sergiy Butenko
Texas A&M University

This talk will focus on continuous approaches to discrete optimization problems. In particular, we will discuss methods for developing continuous formulations of graph problems, as well as related theoretical, algorithmic, and computational developments and challenges.
Directed and Parameterized Networks and their Applications in Combinatorial Optimization, Cooperative Control, and Social Networks

Alla Kammerdiner†, Alexander Veremyev, Eduardo Pasiliao
†New Mexico State University

We consider some directed and parameterized networks. We show that eigenspace characteristics of these networks have important implications for theoretical analyses of local search algorithms in combinatorial optimization and for theoretical and numerical analyses of consensus algorithms in cooperative control and social networks.
Loss-Constrained Minimum Cost Flow Under Arc Failure Uncertainty with Applications in Risk-Aware Kidney Exchange

Qipeng P. Zheng
University of Central Florida

The Minimum Cost Flow (MCF) problem is fundamental to many classic network flow problems. However, many applications of MCF may involve (i) rapid changes of a network environment; (ii) extremely short reaction time for resource delivery and network recovery; or both (i) and (ii). For example, a shipment schedule of relief resources is needed immediately after the occurrence of a catastrophic event, when detailed information of road failure and traffic congestion is not available. In this talk, we study a Stochastic Minimum Cost Flow (SMCF) problem under arc failure uncertainty, where an arc flow solution may correspond to multiple path flow representations. We assume that the failure of an arc will cause flow losses on all paths using that arc, and for any path carrying positive flows, the failure of any arc on the path will lose all flows carried by the path. We formulate two SMCF variants to minimize the cost of arc flows, while respectively restricting the Value-at-Risk (VaR) and Conditional Value-at-Risk (CVaR) of random path flow losses due to uncertain arc failure (reflected as network topological changes). We formulate a linear program to compute possible losses, yielding a mixed-integer programming formulation of SMCF-VaR and a linear programming formulation of SMCF-CVaR. We present a kidney exchange problem under uncertain match failure as an application and use the two SMCF models to maximize the utility/social welfare of pairing kidneys subject to constrained risk of utility losses. Our results show the efficacy of our approaches, the conservatism of using CVaR, and optimal flow patterns given by VaR and CVaR models on diverse instances.
Thermo-Mechanical Response of Metal-Ceramic Composites for High Temperature Applications

Phillip Deierling
University of Iowa

In the current work, the thermo-mechanical response of a titanium/titanium di-boride ($Ti/TiB_2$) metal matrix ceramic composite (MMCC) thin panel subjected to high temperatures is studied. Particular emphasis is placed on two-dimensional functionally graded materials (FGMs) subjected to a steep through-thickness temperature gradient as well as non-uniform temperature distribution along the in-plane surface. The response of a FGM panel with through-thickness grading (1D grading) and through-thickness/in-plane grading (2D grading) is compared to that of a typical skin material (titanium) with a thermal protection system (TPS) (Acusil II). Preliminary results illustrating the effect of one- and two-dimensional spatial grading on the structural and thermal response will be discussed. Through-thickness temperature gradients are the result of a transient heat transfer analysis with flight simulation data provided by the Air Force Research Laboratory (AFRL) via in house Aerothermal Targets Analysis Program (ATAP) software. Non-uniform distribution of the in-plane temperatures are artificially generated by adopting a laminar to turbulent transition model. Here laminar to turbulent heat flux is evaluated using a piecewise function with the transitional region determined by a Gaussian distribution function. Due to the nature of FGMs, the effective temperature-dependent material properties (elastic, thermal and thermo-elastic) are required for each volume fraction and temperature expected in the analysis. Determination of these properties is evaluated using micromechanical modeling along with finite element analysis (FEA) of 2D and 3D representative volume elements (RVEs). Models are evaluated over varying ceramic volume fraction content and a wide temperature range with comparisons to the tightest known analytical bounds and approximations for each respective material property.
Modeling of Thermal Ablation in Fiber-reinforced Polymer Matrix Laminated Composites

Yeqing Wang and Olesya I. Zhupanska
University of Iowa

The primary focus of this research is to develop computational methods for modeling plasma-induced thermal ablation in laminated fiber-reinforced polymer matrix laminated composites. In particular, a nonlinear time-dependent heat transfer problem in the composite structures subjected to the direct localized heat injection is of concern. The properties of the polymer matrix composite structures are highly temperature-dependent and quickly deteriorate above the glass transition temperature. A rapid degradation of the polymer matrix occurring at temperatures above the glass transition temperature leads to a significant change in electrical, thermal and physical properties. Extreme heating generates extreme temperatures in a structure and results in material phase transitions. Material phase transition boundaries are not static and move with time due to continuing heating and a moving heat source. Moreover, the boundaries of the materials phases are not known in advance and have to be determined as a part of the solution. The formulated nonlinear heat transfer problem in a laminated composite is solved using finite element analysis (FEA). It is assumed in this work that when the surface temperature reaches a designated ablation temperature, a sublimation reaction takes place and material is immediately removed (i.e., ablation takes place). The simulation method that we developed is based on the traditional element deletion method. A Matlab integrated Abaqus simulation procedure is developed that allows the deletion of elements and the reapplication of the heat flux directly to the remaining elements. An Abaqus user subroutine is also included to monitor the nodal temperature field after each time increment. If the temperature of the bottom nodes of any elements reaches the ablation temperature, the analysis can be paused. The elements whose temperature at the bottom nodes reaches the ablation temperature are identified and deleted using Python script (included in the Matlab code), the new boundary condition for applying the heat flux is calculated in Matlab. The heat flux is therefore reapplied on the new boundary. After that, the FEA analysis can be restarted, the whole procedure repeats until the end of the step (final increment). The obtained results include temperature field and the ablation zone profile of the composite for a given plasma-induced heat flux at various time steps.
A stochastic PDE-constrained optimization approach to vibration control of a composite plate subjected to mechanical load and a piecewise-linear current

Dmitry Chernikov
University of Iowa

In this paper a two-stage stochastic PDE-constrained optimization framework is applied to the problem of vibration control of a thin composite plate in the presence of electromagnetic field. The randomized mechanical load was represented by a bell shape, magnetic field was fixed at a constant level, and electric current was assumed to be of a piecewise-linear form with linear segments defined on the time intervals of equal size. We develop the methodology for calculating the gradient of the objective function in case of a large number of control variables, using adjoint numerical differentiation technique. The value of the objective function is calculated by solving the governing system of PDEs, and a black-box approach with an Active Set Algorithm is used to solve the optimization problem.

The results of the two-stage stochastic PDE-constrained optimization, with the goal of minimizing the vibrations of the plate, show that with a moderate number of linear segments of the current it is possible to practically eliminate the vibrations during the second stage. However even a high number of the segments fails to reduce the first stage vibrations below a certain threshold.
Map Merging of Rotated, Corrupted and Different Scale Maps Using Rectangular Features

Jinyoung Park
Auburn University

Increased demand for a high degree of agent survivability and efficiency has caused an increase in task allocation of cooperative agents. Networked agents accomplish a common mission by sharing and combining their information. In an environmental mapping scenario of multiple agents, they map their areas and share the information of their maps which representation is commonly binary and grid-based. The map merging starts with manipulating the binary numbers and finding maximal rectangles in each map. With the features of the rectangles such as width, height and angles between other rectangles, common areas in the maps are determined. Finally, a merged map is acquired by overlapping the areas.
A Quaternions Formulation for Relative Pose and Structure from Five General Feature Points

Kaveh Fathian, Jingfu Jin, Sung-Gil Wee, Yoon-Gu Kim, and Nicholas R. Gans
University of Texas Dallas

We present a novel algorithm to estimate the rigid transformation between two cameras using images of a set of stationary points taken from the two camera poses in Cartesian space. The algorithm also delivers the 3D structure of the image points up to a constant scale factor. Our approach is immune to the variety of problems that plague existing methods. Methods based on the Euclidean Homography matrix require only four points, but only function when all points are coplanar in 3D space. Methods based on the Essential matrix can be estimated by using five or more points, but the Essential matrix becomes degenerate as the translation between two camera views goes to zero and cannot function when the set of points are coplanar. Our new and practical algorithm eschews the shortcomings of the Homography and Essential matrix based methods by formulating the pose estimation problem using quaternions. The approach requires five features points with no limitation for or against planarity. Furthermore, the algorithm is robust to noise. Investigations using both simulated images and experimental results have validated the new method and verified that the algorithm can be used in practical context such as Position Based Visual Servoing. Noise and time comparison between the proposed algorithm and the existing algorithms are given.
Bi-Directional Cooperative Obstacle Avoidance for Heterogeneous Unmanned Vehicles

Jonathan Lwowski
University of Texas at San Antonio

This work presents a novel bi-directional cooperative obstacle avoidance system for heterogeneous unmanned vehicles, consisting of a unmanned ground vehicle (UGV) and an micro-aerial vehicle (MAV), equipped with only visual electro-optic sensors operating in an indoor environment, where Global Positioning System (GPS) signals may not be available. In the communication protocol, the UGV tells the MAV if a doorway is detected. If a doorway is not detected, the MAV, using it’s bottom facing camera, calculates a directional path plan for the UGV using Dijkstra’s algorithm. The UGV uses this directional path plan in parallel with information gathered from its own front facing camera to navigate through a cluttered environment using a Lyapunov stable sliding mode controller. If a doorway is detected, the UGV will guide the MAV through the doorway using a homography based visual servo controller. To the best of our knowledge, no other bi-directional cooperative obstacle avoidance techniques can be found in the literature that only use visual electro-optic sensors. The bi-directional cooperation has been tested in simulation and its results show its effectiveness.
Understanding the Aeroacoustic Radiation Sources and Mechanisms in High-Speed Jets

Michael Crawley and Mohammad Samimy
The Ohio State University

Since the advent of turbojet engines in aeronautical applications, acoustic radiation has been a significant problem for the aviation industry. During takeoff and landing, when noise emission is the most problematic to surrounding personnel and communities, the dominant noise source of the jet engine in the noise generated by the high velocity engine exhaust. While the noise problem had previously only affected the commercial sector, the military has begun to face some problems in recent years. This has compounded with the fact every generation of tactical aircraft has had larger noise footprint than the previous one. Many techniques to reduce the acoustic radiation from high-speed jets using either passive or active modifications to the nozzle have been investigated; however only a passive control, namely chevrons, has been implemented. However, these passive control techniques have non-trivial penalties to the aircraft’s performance. In order to meet noise regulations and performance requirements for future aircraft engines, active manipulation of the flow is necessary. Effective and efficient control of the jet requires a full understanding of the mechanism by which aeroacoustic radiation is produced, something which does not yet exist. While great progress has been made, as of yet no consensus has been formed over the precise mechanism by which subsonically convecting coherent structures generate sound, despite decades of work.

To improve our understanding of the aeroacoustic sources and mechanisms, experiments were conducted at the Gas Dynamics and Turbulence Laboratory free jet facility within the Aerospace Research Center at the Ohio State University. A converging, axisymmetric nozzle with exit diameter of 25.4 mm was used; the jet was operated at a Mach number of 0.9, and with a total temperature ratio of unity. This resulted in a Reynolds number based on the jet exit diameter of $6.2 \times 10^5$. Near- and far-field pressure was acquired from a total of 18 Bruel & Kjaer microphones using National Instruments A/D boards and LabView software. Simultaneously, two-component streamwise PIV was acquired using LaVision software/hardware, two Imager SX 5 megapixel cameras, and a 10 Hz Spectra Physics PIV-400 dual-head laser. An external signal supplied by the LaVision PTU was used to synchronize the microphone system to the PIV; the acoustic system was pre-triggered so that the PIV image pair was acquired roughly in the center of a block of data. The jet was excited using localized arc-filament plasma actuators in order to seed well-defined coherent structures which could be identified and analyzed far more easily than the structures in the natural jet.

The acoustic near-field was first analyzed by decomposing the total near-field into its constitutive hydrodynamic and acoustic components. This was accomplished by linearly filtering the irrotational pressure based on phase velocity. A two-dimensional spatio-temporal continuous wavelet transform was used for this task; this enabled the identification of the weaker acoustic field originally masked by the hydrodynamic. Subsequent two-point correlations
between the acoustic near-field and the far-field led to the conclusion that the dominant acoustic source region comprised the upstream region of the jet, up to the end of the potential core. Time-resolved velocity measurements are not possible, due to limitations in experimental hardware. Instead, a time-resolved estimate of the velocity field is made using stochastic estimation. A feedforward, backpropagation neural network was chosen to identify the mapping between the (time-resolved) near-field pressure measurements and the velocity field. Learning was performed using a combination of gradient descent and particle swarm optimization. The reconstructed velocity field showed the large-scale structures undergoing a process of deceleration, merging with subsequent structures, and ultimately decaying. The region in which this occurs was found to coincide with the dominant noise source region identified previously by the two-point correlations. Extensive analysis of the obtained data is underway for identification of noise sources.
A Parametrized Framework for Modeling and Control of a Vehicle Family

Austin Brockner
University of Florida

The U.S. Air Force maintains a vast array of aerial platforms with each being optimized for a limited role. Such a fleet requires extensive modeling and control for each type of platform along with requiring certification for each type of platform. As such, the cost of developing such an array is considerable.

A set of common aircraft components were designed and the resulting combinations used to represent generic UAV. Experimental data from wind tunnel testing along with computational data from Athena Vortex Lattice (AVL) is examined to note variations of aerodynamics and flight dynamics for each UAV configuration. A polytopic representation of the aerodynamics and flight dynamics will be generated from the data after which a polytopic controller will be generated using a linear parameter-varying formulation.
Numerical Study of Synthetic-Jet Actuation Effect on Airfoil Leading and Trailing Edge Noise

Marco Sansone
Embry-Riddle Aeronautical University

The current study conducts numerical experiments to assess possibility of employing synthetic-jet actuators (SJAs) as active noise control devices for reduction of airfoil acoustic radiation. High-accuracy numerical efforts employ a 6th-order Navier-Stokes solver implementing low-pass filtering of poorly resolved high-frequency solution content to retain numerical accuracy and stability over the range of transitional flow regimes. In the adopted numerical procedure, the actuator is modeled without its resonator cavity through imposing a simple fluctuating-velocity boundary condition at the bottom of the actuator’s orifice. The orifice cavity with the properly defined boundary condition is then embedded into the airfoil surface for conducting high-accuracy viscous analysis of SJA-based active noise control.
Effect of Flow-Acoustic Resonant Interactions on Aerodynamic Response of Transitional Airfoils

Joseph Hayden
Embry-Riddle Aeronautical University

Investigating the effect of flow-acoustic resonant interactions on aerodynamic response of transitional airfoils. Performing high-accuracy CFD analysis on the NACA-0012 and SD7003 airfoils using a 6th-order Navier-Stokes solver at various angles of attack to investigate the tone generating Acoustic Feedback-Loop (AFL). The acoustic spectra is determined at multiple locations as well as the lift characteristics for each case. Turbulence is then applied to each case in order to eliminate the AFL. The results of clean and turbulent cases are compared in order to determine the effect of the AFL on the airfoil performance.
Optimal Placement for a Limited Range Binary Sensor

J. Pablo Ramirez-Paredes, Nicholas R. Gans
University of Texas Dallas

We present an optimal strategy for the placement of a binary sensor, based on maximizing the mutual information between the distribution of possible target locations, the sensor footprint and the sensor’s probability of Type I and II errors. Contributions include closed-form expressions for the optimal sensor placement and a proposed control algorithm for a mobile sensor. Throughout this work, we focus on finding the conditions that minimize the entropy of the posterior distribution of the target location for a special class of binary random variables. Minimizing this quantity is equivalent to maximizing the mutual information. We conclude that the mutual information between the target location and the sensor detection indication is a function of the probability volume covered by the sensor support, and we find and present its optima. Simulations and experiments are presented to demonstrate its effectiveness, including statistical analysis.
System Level Design and Optimization of LQR Flight Controllers

Sandor Valenciaga
University of Florida

Manual tuning of control design for aircrafts over a wide flight envelope is a time-consuming and expensive task. Optimal control, such as the linear quadratic regulator (LQR), is amenable to systematic automated control design. Yet, the results are optimal in the sense of a time domain cost function and not in the sense of the system level performance and robustness. Further, hardware dynamics and state estimation degrade robustness properties. In addition there is no intuitive way to pick design variables that meet sensitivity/co-sensitivity requirements at the plant output. Given these motivations, we assess the feasibility of a system-level optimization process to rapidly meet autopilot performance and robustness criteria. We pose the system-level design of linear quadratic flight controllers as a non-linear optimization problem constrained to meet performance and robustness criteria. In this project we show the new design approach applied to the vertical acceleration tracking of two different missile systems, and demonstrate the viability of the approach to rapidly produce controllers that meet numerous system level criteria. We find that increasing the number of tuning variables may lead to more efficient optimization despite the cost of greater dimensionality. This approach can be easily applied to different aerodynamic systems unlike a manual tuning or trial and error.
Differential Drag-Based Guidance for Spacecraft Relative Maneuvering Using Spatial Information in Atmospheric Density Prediction

Dave Guglielmo
University of Florida

Atmospheric differential drag can be used to control the relative motion of multiple coplanar spacecraft in Low Earth Orbit (LEO), without the use of propellant, provided that they can vary their ballistic coefficients. However, the variation in atmospheric density, and therefore the drag acceleration, makes the generation of accurate drag-based guidance a challenging problem. Currently available density models have biased results, causing errors in the drag force estimation. In this work a method for predicting the atmospheric density along the orbit of a spacecraft is combined with a calibrator used with existing empirical atmospheric models. The combination is used to improve differential drag-based relative maneuvering by adding spatial information to atmospheric density prediction methods. This leads to the creation of more realistic guidance trajectories for spacecraft relative maneuvering based on differential drag.