2nd Annual Meeting of the AFRL Mathematical Modeling and Optimization Institute

BOOK OF ABSTRACTS

University of Florida
Research Engineering and Education Facility
Shalimar, FL
July 28 – July 31, 2014

This meeting is sponsored by the Department of Industrial and Systems Engineering and the Defense-Oriented Operations Research Lab at the University of Florida

Meeting Information

Registration

Registration is free and all meeting attendees **must register**. Registration material can be picked up on Monday-Thursday 8:00-8:30 in the UF-REEF lobby.

Coffee Breaks

Coffee breaks will be held 9:30-9:45, 1:30-1:45, and 3:15-3:30 on Monday-Thursday in the UF-REEF lobby.

Lunch Break

Lunch breaks will be 11:15-12:30 on Monday-Thursday.

Internet Access

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

Meeting Rooms

UF-REEF Auditorium
UF-REEF Studio 110

Whenever there are parallel sessions the session marked with 1 (e.g., Session E-1) is organized in the UF-REEF Auditorium, while the one marked with number 2 (e.g., Session E-2) is organized in the UF-REEF Studio 110.

Monday, July 28th

8:25-9:30 Session A
UF-REEF Auditorium

Opening remarks by Vladimir Boginski

Plenary Talk
Munitions Directorate Overview
Mikel Miller, ST, Chief Scientist, AFRL/RW

9:30-9:45 Coffee Break

9:45-11:15 Session B-1
UF-REEF Auditorium

Critical Nodes for Communication Efficiency and Related Problems in Graphs
Oleg Prokopyev, University of Pittsburgh

New Integer Programming Based Approaches for Finding Maximum Quasi-Cliques and Dense Subgraphs
Alexander Veremyev, AFRL Munitions Directorate

9:45-11:15 Session B-2
UF-REEF Studio 110

Casting Visual Search Problems as Optimization Problems to Solve in Real Time
Nicholas Gans, University of Texas at Dallas

Information Fusion in Human-Robot Collaboration using Neural Network Representation
Ashwin Dani, University of Connecticut

Simultaneous Target Estimation and Path Planning in Urban Environments
Michael McCourt, University of Florida

11:15-12:30 Lunch Break

12:30-1:30 Session C
UF-REEF Auditorium

Computational Challenges in Assured Distributed Seeker-Sensor Fusion
Piyush Kumar, CompGeom Inc.

1:30-1:45 Coffee Break

1:45-3:15 Session D-1
UF-REEF Auditorium

A stochastic PDE-constrained optimization approach to active control of multifunctional composite structures
Pavlo Krokhmal, University of Iowa

Accelerated methods for large-scale compressive sensing and machine learning problem
Yuyuan Ouyang, University of Florida

1:45-3:15 Session D-2
UF-REEF Studio 110

A Switched Systems Approach to Vision-Based Localization of a Target with Intermittent Measurements
Anup Parikh, University of Florida

Target Search and Acquisition by UAVs and Unattended Ground Sensors in Urban Environments
Pablo Ramirez, University of Texas at Dallas

Decentralized Event-Triggered Based Containment Control for a Network System
Teng-Hu Cheng, University of Florida

3:15-3:30 Coffee Break

3:30-5:00 Session E-1
UF-REEF Auditorium

An Integer Programming Framework for Detecting Sybil Nodes in Online Social Networks
Chrysafis Vogiatzis, University of Florida

Detecting Critical Vertex Structures on Graphs: A Mathematical Programming Approach
Jose L. Walteros, University of Florida

Sequential network interdiction with incomplete information
Juan Borrero, University of Pittsburgh

3:30-5:00 Session E-2
UF-REEF Studio 110

Design of a guidance controller using network topology
Clay Robertson, Auburn University

Frontier Based Exploration with the use of Navigation Function
Carlos Caballero, University of Florida

Rough-Map Merging by Clustering Obstacles
Jinyoung Park, Auburn University

Path Planning for Multiple Observer, Multiple Target Vision-Based Tracking Applications with Loss-of-Sight Considerations
Ryan Licitra, University of Florida

Tuesday, July 29th

8:30-9:30 Session A
UF-REEF Auditorium

Plenary Talk

Embedded Feature Selection for High Dimensional Data Sets

Panos M. Pardalos, Distinguished Professor, Industrial and Systems Engineering, University of Florida

9:30-9:45 Coffee Break

9:45-11:15 Session B-1
UF-REEF Auditorium

GPOPS-II: A MATLAB Software for Solving Multiple-Phase Optimal Control Problems Using hp-Adaptive Gaussian Quadrature Collocation Methods and Sparse Nonlinear Programming

Michael Patterson, University of Florida

Source Transformation via Operator Overloading for Automatic Differentiation in MATLAB

Anil Rao, University of Florida

A dual weighted Residual error estimation scheme for mesh refinement

Murat Engin Unal, University of Florida

9:45-11:15 Session B-2
UF-REEF Studio 110

High performance algorithm design for sensor fusion and target tracking on a smart grid of munitions

Alla Kammerdiner, New Mexico State University

Simultaneous Geometry and Weight Optimization for Electronically Scanned Wideband Planar Arrays

Serdar Karademir, University of Florida

Minimum Risk Network Coverage Problems

Konstantin Pavlikov, University of Florida

11:15-12:30 Lunch Break

12:30-1:30 Session C
UF-REEF Auditorium

Error Estimation in Nonlinear Optimization and Dual Active Set Constraints
William Hager, University of Florida

A semi-analytical split-Bernstein approach to chance constrained programs
Mrinal Kumar, University of Florida

1:30-1:45 Coffee Break

1:45-3:15 Session D-1
UF-REEF Auditorium

A Graph Coarsening Method for KKT Systems Arising in Orthogonal Collocation of Optimal Control Problems
Begum Senses, University of Florida

Minimum-Time Trajectory Optimization of Many Revolution Low-Thrust Earth-Orbit Transfers
Kathryn Graham, University of Florida

Control Approximation for Switching Structure Identification in Gauss Collocation Methods
Joseph Eide, University of Florida

Adaptive Mesh Refinement Method for Optimal Control Using Nonsmoothness Detection and Mesh Size Reduction
Fengjin Liu, University of Florida

1:45-3:15 Session D-2
UF-REEF Studio 110

Adaptive BOSVS Algorithm for Ill-Conditioned Linear Inversion with Applications to Partially Parallel Imaging
Maryam Yashtini, University of Florida

An Accelerated Bregman Operator Splitting-Type Algorithm with Applications to Partially Parallel Imaging
Xianqi Li, University of Florida

Fast bundle-level method for multi-task learning
Wei Zhang, University of Florida

Multi-Channel Image Reconstruction
Hao Zhang, University of Florida

3:15-3:30 Coffee Break

3:30-5:00 Session E-1
UF-REEF Auditorium

Rendezvous with Scalar Control for Nonholonomic Robots
Chau Ton, NRC Postdoc

Fractional-order System based Human-Robot Network for Rendezvous Problems with Common Scalar Control
Zhen Kan, University of Florida

An Attacker-Defender Game and A Cooperative Estimation Scheme
Neha Satak, University of Florida

3:30-5:00 Session E-2
UF-REEF Studio 110

The Stochastic Incremental Network Design Problem with Shortest Paths and Uncertain Build Times
Nathaniel Richmond, University of Iowa

Jammer Placement to Partition Wireless Network
Jixin Feng, University of Florida

New analytical lower bounds for the maximum clique number of graphs
Vladimir Stozhkov, University of Florida

Wednesday, July 30th

8:30-9:30 Session A
UF-REEF Auditorium

Plenary Talk

Modeling and Analysis of Fluid-Thermal-Structural Interactions in Hypersonic Flow
Jack McNamara, Associate Professor, Mechanical and Aerospace Engineering, The Ohio State University

9:30-9:45 Coffee Break

9:45-11:15 Session B-1
UF-REEF Auditorium

Towards Aerothermoelastic Tailoring of Waveriders
Narayanan Komerath, Georgia Institute of Technology

The Discontinuous Galerkin Method as a Mainstream Approach for Computational Fluid Dynamics
Andrew Shelton, Leidos

Reactive Burn Model Parameterization Incorporating Ignition and Sustained Pulse Data Sets
Robert Dorgan, AFRL/RWWC

9:45-11:15 Session B-2
UF-REEF Studio 110

Approaches for Aggregating Information From Conflicting Sources
Tathagata Mukherjee, Florida State University

Belief Propagation Algorithm for Near-optimal Graph Matching in Formation Reconfiguration Problems
Xin Li, University of Florida

Distances Between Multidimensional Distributions for Image Classification
Aleksandr Mafusalov, University of Florida

Support Vector Machines with Risk Constraints
Victoria Zdanovskaya, University of Florida

11:15-12:30 Lunch Break

12:30-1:30 Session C
UF-REEF Auditorium

Experimental Characterization and modeling of plastic deformation in Titanium
Oana Cazacu, University of Florida

Sensing and Imaging of Impact Damage in Composites
Olesya Zhupanska, University of Iowa

1:30-1:45 Coffee Break

1:45-3:15 Session D-1
UF-REEF Auditorium

New three-dimensional strain-rate potential for porous metals with faceted yield surface
Benoit Revil-Baudard, University of Florida

Calculation of thermal properties of silicon carbide from the first principles using density functional perturbation theory of phonons
Anna Kuznetsova, Air Force Research Laboratory

Modeling of the effective thermo-mechanical properties of Aluminum/Zirconia composite over a wide temperature range
Phillip Deierling, University of Iowa

A stochastic PDE-constrained optimization approach to vibration control of a composite plate subjected to mechanical and electromagnetic loads
Dmitry Chernikov, University of Iowa

1:45-3:15- Session D-2
UF-REEF Studio 110

Decentralized Riemannian Particle Filtering & Multiagent Navigation Without GPS
Martin Eilders, AFRL/RWWN

Integrated Control and Estimation
Adam Rutkowski, AFRL/RWWI

Bioinspired Magnetic Reception and Multimodal Sensing
Brian Taylor, AFRL/RWWI

3:15-3:30 Coffee Break

3:30-5:00 Session E-1
UF-REEF Auditorium

High Speed Fluid Structural Interactions and Reduced-order Modeling
Ryan Klock, AFRL/RW

Aerothermodynamic Modeling of Munitions on Terminal Hypersonic Trajectories: Grid Generation
Emily Dreyer, Embry-Riddle Aeronautical University

Aerothermodynamic Modeling of Munitions on Terminal Hypersonic Trajectories
Jake Larkin, The Ohio State University

Aeroelastic Simulation of Flexible High Speed Vehicles
Dianne Zettl, USRA

Aeroelastic Simulation of Flexible High Speed Vehicles
Ryan Kitson, University of Michigan

3:30-5:00 Session E-2
UF-REEF Studio 110

On solution approaches to a class of mixed-integer non-linear stochastic programming problems
Alexander Vinel, The University of Iowa

A Multistage and Multiscale Stochastic Programming Approach to Electricity Infrastructure Investment
Zhouchun Huang, University of Central Florida

Nonlinear Mixed Integer Programming Approaches for Generalized Geometric Programming
Yiduo Zhan, University of Central Florida

Thursday, July 31st

8:30-9:30 Session A
UF-REEF Auditorium

Plenary Talk

Nonlinear Dynamics of Fluid and Structural Systems
Earl Dowell, William Holland Hall Professor of Mechanical Engineering in the Edmund T. Pratt, Jr. School of Engineering, Duke University

9:30-9:45 Coffee Break

9:45-11:15 Session B-1
UF-REEF Auditorium

Scale-reduction Techniques for Optimization Problems in Networks
Sergiy Butenko, Texas A&M

Node Interdiction in Coupled Interdependent Networks with Cascading Failures
Vladimir Boginski, University of Florida

9:45-11:15 Session B-2
UF-REEF Studio 110

Multi-Purpose Guidance
James R. Cloutier, AFRL/RWWN

Optimal Control
Quang Lam, AFRL/RWWN

11:15-12:30 Lunch Break

12:30-1:30 Session C-1
UF-REEF Auditorium

On connectivity constraints in integer programs
Austin Buchanan, Texas A&M University

Facets of Connected Subgraph Polytope via Lifting Procedure
Yiming Wang, Texas A&M University

12:30-1:30 Session C-2
UF-REEF Studio 110

Robust Adaptive Control in the Presence of Unmodeled Dynamics
Heather Hussain, MIT

Higher Order Sliding Mode Control of 6DOF Hypersonic Missile during Terminal Approach using an Adaptive Observer
Stephen Phillips, The University of Alabama in Huntsville

1:30-1:45 Coffee Break

1:45-3:15 Session D-1
UF-REEF Auditorium

AFRL Autonomous Navigation and Control Laboratory Overview
Kevin Brink, AFRL/RWWI

A Robust Relative Estimation Framework for GPS-Denied Navigation
Daniel Koch, Brigham Young University

Comparison of Bayesian Search Algorithms
Drew Ellison, CU Boulder

Distributed Solutions to the Dynamic Weapon Target Assignment Problem
Kyle Volle, Georgia Institute of Technology

1:45-3:15 Session D-2
UF-REEF Studio 110

Control of Nonlinear Aerospace Systems using Micro-Jet Actuators
Siddhartha Mehta, University of Florida

Multi-Grid Analysis of High Order Synthetic Jet Actuators and LCO Simulations
Marco Sansone, ERAU

Store-Induced Limit Cycle Oscillations due to Nonlinear Wing-Store Attachment
Madhusudan Padmanabhan, Duke University

3:15-3:30 Coffee Break

3:30-5:00 Session E-1
UF-REEF Auditorium

Cooperative estimation for feature-based SLAM
Timothy Woodbury, Texas A&M University

Hardware and Capability Build for an Autonomous Relative Navigation Framework
Gary Ellingson, Brigham Young University

AFRL Autonomous Lab Demo
Kevin Brink, AFRL/RWWI

3:30-5:00 Session E-2
UF-REEF Studio 110

The Maximum s-Stable Cluster problem
Chitra Balasubramaniam, Texas A&M University

Heuristic approaches for detecting robust cliques in graphs subject to uncertain edge failures
Oleksandra Yezerska, Texas A&M University

On the Lagrangian duality of the maximum γ-quasi-clique problem
Zhuqi Miao, Oklahoma State University

Resilient Network Design via Spanning k-Cores
Juan Ma, Oklahoma State University

Munitions Directorate Overview

Mikel Miller
Air Force Research Laboratory

An overview of the Air Force Munitions Directorate.

Critical Nodes for Communication Efficiency and Related Problems in Graphs

Oleg Prokopyev
University of Pittsburgh

In graph-theoretical models the decision-maker is often interested in evaluating the overall system's vulnerability and robustness properties with respect to node failures. One popular strategy, which is often applied for addressing this question, is based on the concept of critical nodes, defined as a subset of nodes whose removal maximally degrades the connectivity of the considered graph or, equivalently, maximally fragments the graph according to some pre-defined metric. The corresponding optimization problem is known as the Critical Node Detection problem (CNP). In this talk we first review some of the recent results in the area. Furthermore, we propose a new class of CNPs that consider communication efficiency of the graph, which is assumed to be a general distance-based metric (e.g., Harary index, characteristic path length, residual closeness) that depends on actual pairwise distances between nodes in the remaining graph rather than simply the fact whether nodes are connected or not, which is a typical assumption in standard CNP models. We discuss in details the developed solutions approaches and briefly overview the results of our computational experiments on real-life and synthetic networks. In particular, one important conclusion of our work is that vulnerability of real-life networks to targeted attacks can be significantly more pronounced than what can be estimated by using heuristic methods commonly used in the literature. Finally, we discuss some related implications of our work to distance-based clique relaxations, namely, s-clubs. This is a joint work with Alexander Veremyev and Eduardo Pasiliao.

New Integer Programming Based Approaches for Finding Maximum Quasi-Cliques and Dense Subgraphs

Alexander Veremyev
Air Force Research Laboratory

Dense component discovery is one of the most important aspects of network analysis. In many real-life networked systems, dense regions may indicate high degrees of interactions, pairwise similarities, and may correspond to communities sharing some common properties. Naturally, from a graph theoretical perspective, dense components have small diameters and average pairwise distances. Moreover, they are usually robust in the sense that they remain connected even if many links become “broken,?? e.g., due to an attack or a failure. Dense components have been studied in many types of networks, including social, communication, internet, financial markets and biological systems. Identifying the maximum dense network clusters is typically an NP-hard problem. In this talk, we present a new integer programming (IP) based approach for finding largest dense components in graphs. Specifically, we first develop several new IP formulations and exact iterative algorithms for solving the maximum ?-quasi-clique problem, which seeks for the largest subgraph with edge density $\gamma \in (0, 1)$. We derive upper and lower bounds for LP relaxations of new formulations and demonstrate that our upper bounds are substantially tighter for sparse graphs (real-life networks are typically sparse) than the LP bounds obtained using other formulations available in the literature. Second, we show that the proposed methodology can be naturally generalized for the $f(k)$-dense subgraph problem, which seeks for the largest subgraph induced by k vertices with at least $f(k)$ edges. In particular, we discuss two well-known examples of such graph structures: $f(k) = k(k-1)/2 - s$ (s-defective clique) and $f(k) = k(k-s)/2$ (average s-plex). Finally, we illustrate performance of the proposed formulations and exact algorithms for various real-life and synthetic networks instances by solving instances with up to 10000 vertices. The talk is based on a joint work with Oleg Prokopyev, Sergiy Butenko, and Eduardo Pasiliao.

Casting Visual Search Problems as Optimization Problems to Solve in Real Time

Nicholas Gans
University of Texas at Dallas

Information Fusion in Human-Robot Collaboration using Neural Network Representation

Ashwin Dani
University of Connecticut

Simultaneous Target Estimation and Path Planning in Urban Environments

Michael McCourt
University of Florida

Target location estimation and path planning are each crucial components of target interception. However, there are limitations to the achievable performance when considering these two problems separately. This is especially true when considering nonlinear motion models with non-Gaussian state uncertainty. This presentation explores a framework for simultaneous estimation and path planning in real time. The target state estimation makes use of the particle filter framework for recursive Bayesian estimation. Path planning is achieved using rapidly-exploring random trees. The path to traverse is chosen based on a recursive optimization problem that balances the goals of reducing uncertainty in the environment and intercepting the target in minimum time. Preliminary simulations have been completed that provide a baseline performance for this framework.

Computational Challenges in Assured Distributed Seeker-Sensor Fusion

Piyush Kumar
CompGeom Inc.
Florida State University

In this talk, we present the challenges faced by drone designers when using wide filed of view cameras to do precise location in GPS Free or noisy GPS environments. We will explore multiple proposed solutions to this problem.

Under adverse networking conditions, where noise in communication is an issue, we also look at estimating the noise level in the communicated bits. This is a precursor to designing assured communication algorithms that can smoothly communicate over lower bandwidth caused by noise. Our location computation proposal degrades gracefully as the bandwidth gets limited or the communication breaks.

A stochastic PDE-constrained optimization approach to active control of multifunctional composite structures

Pavlo Krokhmal
University of Iowa

A new two-stage stochastic partial differential equation (PDE)-constrained optimization methodology is developed for the active vibration control of structures in the presence of uncertainties in mechanical loads. The methodology relies on the two-stage stochastic optimization formulation with an embedded first-order black-box PDE-constrained optimization procedure. The PDE-constrained optimization procedure utilizes a first-order active-set algorithm with a conjugate gradient method. The objective function is determined through solution of the governing PDEs and its gradient is computed using automatic differentiation with hyper-dual numbers. The developed optimization methodology is applied to the problem of post-impact vibration control (via applied electromagnetic field) of an electrically conductive carbon fiber reinforced composite plate subjected to an uncertain, or stochastic, impact load. The corresponding governing PDEs consist of a nonlinear coupled system of equations of motion and Maxwell's equations. The conducted computational study shows that the obtained two-stage optimization solution allows for a significant suppression of vibrations caused by the randomized impact load in all impact load scenarios. Also, the effectiveness of the developed methodology is illustrated in the case of a deterministic impact load, where the two-stage strategy enables one to practically eliminate post-impact vibrations.

Accelerated methods for large-scale compressive sensing and machine learning problem

Yuyuan Ouyang
University of Florida

We present accelerated first-order methods for solving a class of convex optimization problems that has wide applications in compressive sensing and machine learning. Since only first-order information of the objective function is used, the proposed methods possess cheaper iteration costs and are suitable for many large-scale optimization problems. By incorporating Nesterov's multi-step acceleration scheme, we prove that the proposed methods have improved iteration complexity in terms of the Lipschitz constant of the smooth component in the objective function. Preliminary experimental results are presented to demonstrate the effectiveness of the proposed methods.

A Switched Systems Approach to Vision-Based Localization of a Target with Intermittent Measurements

Anup Parikh
University of Florida

Switched theory is used to analyze the stability of vision-based observers for 3D localization of features in a scene. Filters that are exponentially stable under persistent observability may have unbounded error growth under intermittent sensing loss, even while providing seemingly accurate state estimates. Therefore, trust conditions are developed based on an average dwell time criteria to guarantee state error convergence with a known decay rate. In cases where observability is controllable, these conditions relax path constraints for visual servoing applications. The conditions are developed in a general form, applicable to any exponentially stable observer, and utilize feature motion knowledge to maximize the allowable time spent in stabilizable, but unobservable, periods.

Target Search and Acquisition by UAVs and Unattended Ground Sensors in Urban Environments

Pablo Ramirez
University of Texas at Dallas

We are concerned with the search and acquisition of a moving target in an urban environment, using mobile sensor platforms and stationary sensors. We assume prior knowledge of the environment and a target with no evasion tactics. A particle filter is used to estimate the target state, allowing us to remove assumptions like linear dynamics of the target or a Gaussian distribution of its states. We explore the use of Unmanned Aerial Vehicles (UAVs) as the mobile sensor platforms. Depending on the type of aircraft selected, it can be possible to obtain data at different resolutions in both the spatial and temporal domains. The use of sensor carrying mobile robots such as UAVs is not the only information gathering strategy to cover. In addition, we will incorporate stationary Unattended Ground Sensors (UGS) which may not provide information accurate enough to guarantee detection beyond a certain threshold, but which will aid in the location of the target. The range to which these sensors can communicate is limited, giving rise to delayed measurements. Due to this fact, we are developing techniques to incorporate time-delayed information into our search and estimation scheme. The search and tracking task can be cast as an optimization problem, in which the cost function contains terms reflecting the energy expenditure of the sensor platforms and the amount of uncertainty about the target at a given time. By minimizing this function the target can be located and tracked while using every information gathering resource available at once.

Decentralized Event-Triggered Based Containment Control for a Network System

Teng-Hu Cheng
University of Florida

A decentralized event-triggered control scheme for containment control problem is developed. The control strategy seeks to reduce communication over the network thereby reducing energy consumption and reduce a potential of communication congestion while still achieving the control objective. To this end, an estimate-based controller that requires only intermittent communications with its neighboring agents is developed: instances requiring communication are determined by a decentralized trigger function. The decentralized trigger function is designed so that each agent requires only local information to detect the next event-time for communication. Since the trigger function produces switched dynamics, analysis is provided to show that Zeno execution is avoided. A Lyapunov-based convergence analysis is also provided to ensure the developed strategy yields asymptotic convergence, which is also supported by simulation results.

Design of a guidance controller using network topology

Clay Robertson
Auburn University

This presentation aims to address a decentralized control problem through the use of an agreement, or consensus, protocol. Given a connected network of heterogeneous unmanned aerial vehicles, a guidance controller is designed to react to the changing internal consensus dynamics of the network. This project utilizes the internal consensus dynamics in an effort to design a guidance controller that flows between a leader-follower and virtual structure formation, viewing the two formation structures as part of a continuum by manipulating the guidance controller?s dependence on the internal network dynamics.

An analysis of directed and undirected graphs and their effect on the consensus dynamics is presented. Looking at chain and branched networks, the time response and controllability of a network using a single node for the exogenous input provide metrics to develop a hierarchy of leadership within the network. With a predetermine network structure set by the selection of a leader for the network dynamics, the effect of leadership placement within the physical dynamics of the flight formation are analyzed as well for the two formation types. Lastly, the effects of a human input to the leadership node is researched to determine the form of feedback the user needs to effectively pilot the formation as well as the reaction of the formation to a exogenous input.

Frontier Based Exploration with the use of Navigation Function

Carlos Caballero
University of Florida

In this investigation, a frontier exploration based approach is presented that uses a navigation function for collision avoidance. In an effort to maximize exploration area, two possible probability based methods are described which utilize knowledge of a compiled occupancy grid.

Rough-Map Merging by Clustering Obstacles

Jinyoung Park
Auburn University

In mapping a ground area by aerial vehicles, completeness the map depends on the performance of the vehicle?s obstacle-detection sensors. The sensor transmits a signal to the ground and receives a reflected signal, thereby recognizing the obstacles. If the sensor has low frequency or the vehicle moves too fast, the sensor will miss some portions of obstacles. This study researches map merging of two agents that have such sensing limitations.

Since the obstacles in maps from the agents have missing portions, even the same obstacle in both maps can have different shapes. This makes finding overlapping coordinates to merge the maps an issue. However, if several neighboring obstacles are considered as a cluster in both maps, the shape of the clusters will have similarities. This algorithm finds the most similar clusters and merges the maps by overlapping coordinates. Because this merging is based on probability, the obstacles in the merged map may be offset from the actual arrangement of the obstacles. However, this study proposes an approach to the rough-map merging problem.

Path Planning for Multiple Observer, Multiple Target Vision-Based Tracking Applications with Loss-of-Sight Considerations

Ryan Licitra
University of Florida

In many applications, it is desirable for one or more agents to possess the ability to visually track multiple targets, and maintain minimal target-tracking position estimation error when there are loss-of-sight occurrences. When more than one agent is involved, it is imperative that the agents work together so that these loss-of sight situations are minimized, and overall target tracking in a convex, finite search area can be achieved. This work proposes a decentralized controller that will adjust the waypoint locations of each observing agent?s path in real time, given known information about the environment acquired by every observing agent, as well as their current path waypoint locations. Each observing agent must be able to independently run the path planning algorithm, gather data about the environment using a bottom-mounted camera, and share its interpretations with the remaining observing agents. In addition to updating its current path, each observing agent will also implement a controller to influence how it will travel along its path. This will include how fast to traverse along its path to the next waypoint, as well as whether or not to loiter at times or reposition itself to improve the efficacy of its field of view. These control laws will be influenced by a virtual area of interest sensory function cast over the ground plane which will vary with time based on current environment information, but will appear identical to all observers at any given time. This area of interest can be modeled as truncated Gaussian distributions centered at the most recently known location (or best prediction of current location) of currently and previously tracked targets. The magnitudes and truncation parameters of these distributions at a given time will be calculated using a profit/reward numeric system based on calculated "dwell on" and "dwell off" times. These dwell times will define the minimum time a target must be in an observer?s field of view (?dwell on?) and maximum time it may remain out of an observer?s field of view (?dwell off?) in order to guarantee target position tracking error convergence. Each waypoint will be drawn to the centroid of its Voronoi region, with the area of interest sensory function acting as the density function.

An Integer Programming Framework for Detecting Sybil Nodes in Online Social Networks

Chrysafis Vogiatzis
University of Florida

As online social networks become bigger and more widespread, they also become more prone to Sybil node attacks. In its most basic form, a perpetrator creates multiple identities and tries to form bonds with "honest" users in order to disperse information, affect elections, and intercept messages. We formulate the problem as a Rayleigh ratio problem, and derive the complexity of detecting cohesive and highly associated subgraphs with sparse cuts to the rest of the network. We conclude by proposing different approaches to tackling the problem, and showing some preliminary computational results.

Detecting Critical Vertex Structures on Graphs: A Mathematical Programming Approach

Jose Walteros
University of Florida

In this study we consider the problem of detecting a collection of critical vertex structures of a graph, subject to different budgetary constraints, whose deletion optimally deteriorates the graph's connectivity and cohesiveness. The principal objective of the proposed approach is to generalize other models existing in the literature whose aim is restricted to removing individual and unrelated vertices. We focus our attention on the cases where the vertex structures are cliques or stars, albeit the proposed technique es general enough to be easily extended for detecting other critical structures. We first introduce a general mathematical formulation as a mixed integer linear program, which, depending on the kind of vertex structures, may have an exponentially large number of variables and constraints. To solve this potentially large model, we develop a branch-price-and-cut framework and use it for solving the particular cases of the cliques and stars. We provide computational complexity results for both of such cases and develop additional preprocessing algorithms to speed up the column generation stage of the algorithm. Finally, we test the quality of our approach by solving a collection of several real-life and randomly generated instances with various configurations analyzing the benefits of the proposed model as well as some possible further enhancements.

Sequential network interdiction with incomplete information

Juan Borrero
University of Pittsburgh

We study sequential interdiction of evaders on a network when the interdictor has partial initial information about the network structure and costs. In each period, the interdictor removes up to k arcs from the network, after which an evader travels along a shortest path. By observing the evaders' actions, the interdictor learns about the network and adjusts its actions accordingly. We analyze a class of policies that remove a set of k-most vital arcs of the observed network, and assess its optimality. A salient feature of our work is that the feedback each period is deterministic and adversarial.

This is a joint work with Dr. Denis Saure (Universidad de Chile) and Dr. Oleg Prokopyev (University of Pittsburgh).

Embedded Feature Selection for High Dimensional Data Sets

Panos Pardalos
University of Florida

High Dimensional datasets are currently prevalent in many practical applications. Classification and feature selection are common tasks performed on such datasets. In this talk, a new embedded feature selection method for high dimensional datasets is introduced by incorporating sparsity in Proximal Support Vector Machines (PSVMs). Our method called Sparse Proximal Support Vector Machines (sPSVMs) learns a sparse representation of PSVMs by first casting it as an equivalent least squares problem and then introducing the $l1$-norm for sparsity. An efficient algorithm based on alternate optimization techniques is proposed. Numerical experiments on several publicly available datasets show that our proposed method can obtain competitive or better performance compared with other embedded feature selection methods. Moreover, sPSVMs remove more than 98% features in many high dimensional datasets without compromising on generalization performance and also show consistency in the feature selection process. Additionally, sPSVMs can be viewed as inducing class-specific local sparsity instead of global sparsity like other embedded methods and thus offer the advantage of interpreting the selected features in the context of the classes.

GPOPS-II: A MATLAB Software for Solving Multiple-Phase Optimal Control Problems Using hp-Adaptive Gaussian Quadrature Collocation Methods and Sparse Nonlinear Programming

Michael Patterson
University of Florida

A general-purpose MATLAB software program called GPOPS-II is described for solving multiple-phase optimal control problems using variable-order Gaussian quadrature collocation methods. The software employs a Legendre-Gauss-Radau quadrature orthogonal collocation method where the continuous-time optimal control problem is transcribed to a large sparse nonlinear programming problem (NLP). An adaptive mesh refinement method is implemented that determines the number of mesh intervals and the degree of the approximating polynomial within each mesh interval to achieve a specified accuracy. The software can be interfaced with either quasi-Newton (first derivative) or Newton (second derivative) NLP solvers, and all derivatives required by the NLP solver are approximated using sparse finite-differencing of the optimal control problem functions. The key components of the software are described in detail and the utility of the software is demonstrated on five optimal control problems of varying complexity. The software described in this paper provides researchers a useful platform upon which to solve a wide variety of complex constrained optimal control problems.

Source Transformation via Operator Overloading for Automatic Differentiation in MATLAB

Anil Rao
University of Florida

A source transformation via operator overloading method is presented for computing derivatives of mathematical functions defined by MATLAB computer programs. The transformed derivative code that results from the method computes a sparse representation of the derivative of the function defined in the original code. As in all source transformation automatic differentiation techniques, an important feature of the method is that any flow control in the original function code is preserved in the derivative code. Furthermore, the resulting derivative code relies solely upon the native MATLAB library. The method is useful in applications where it is required to repeatedly evaluate the derivative of the original function. The method has been recently implemented in the ADiGator software.

A dual weighted Residual error estimation scheme for mesh refinement

Murat Engin Unal
University of Florida

A Dual Weighted Residual (DWR) error estimation scheme is proposed for mesh refinement when solving an optimal control problem using collocation at Legendre-Gauss-Radau points. DWR error estimation has been used for finite element methods and indirect methods of solving optimal control problems in the past, but has yet to be applied to orthogonal collocation methods. This error representation has two important aspects. First, it incorporates deviations from all of the optimality conditions, instead of relying only on primal feasibility error. This requires calculation of control derivatives, which can be obtained by taking the time derivative of the first order necessity conditions for optimality, then solving a linear system of equations; and co-state estimation which is readily available for orthogonal collocation methods. Second, this method emphasises the errors that have high effect on the objective function value. Although this might result in poor feasibility in optimization of systems governed by partial differential equations, no such effects are reported for systems governed by ordinary differential equation. A new mesh is generated based that has increased collocation points in regions of high error. It is expected that the error calculated using the DWR method will locate regions of high error faster than previous methods, therefor leading to fewer mesh iterations to solve the problem. This shall remove some of the responsibility of obtaining a solution which satisfies first order necessary conditions of the continuous optimal control problem, from the NLP solver. Preliminary results demonstrate improved performance for problems with continuous solutions.

High performance algorithm design for sensor fusion and target tracking on a smart grid of munitionsg

Alla Kammerdiner
New Mexico State University

Centralized sensor fusion and target tracking can be performed using a system of smart munitions as a distributed computational resource. To enable ?efficient use of limited memory and computational resources on a grid of munitions, we formulate a new class of optimization problems. This new class of problems allows one to make better decisions on how to store the data and share the computational load among multiple munitions. We demonstrate how that this can improve performance of parallel algorithms for solving computationally challenging data association problems that arise in multi-sensor multi-target data fusion.

Simultaneous Geometry and Weight Optimization for Electronically Scanned Wideband Planar Arrays

Serdar Karademir
University of Florida

Wideband phased arrays have a wide range of applications in defense, communication, and surveillance. In subarrayed implementations, two crucial factors defining array's performance are subarray architecture and element weighting. In this work, we present optimization approaches that tackle these challenges simultaneously.

Minimum Risk Network Coverage Problems

Konstantin Pavlikov
University of Florida

The network maximum coverage problem under uncertainty is considered. In this problem, network vertices are assumed to cover their adjacent nodes with some probability, independently of each other. The emphasis is put on minimizing the risk of losing coverage in the presence of random failures of "covering" components. We formalize the stochastic coverage problem, formulate and further investigate the corresponding combinatorial optimization problems.

Error Estimation in Nonlinear Optimization and Dual Active Set Constraints

William Hager
University of Florida

A semi-analytical split-Bernstein approach to chance constrained programs

Mrinal Kumar
University of Florida

A Graph Coarsening Method for KKT Systems Arising in Orthogonal Collocation of Optimal Control Problems

Begum Senses
University of Florida

A graph coarsening method is described for solving large sparse Karush-Kuhn-Tucker (KKT) linear systems associated with the nonlinear programming problem that arises from the discretization of a continuous optimal control problem using a Legendre-Gauss-Radau collocation method. The method matches the vertices of each state and defect constraint at a particular collocation point, represents each vertex pair using a single vertex in the coarsened KKT matrix and performs a fill-reducing ordering on the coarsened matrix. As a result of these steps the state and defect constraint corresponding to a particular collocation point are placed in adjacent rows in the reordered KKT matrix. It is demonstrated that the proposed method decreases both the number of delayed pivots and floating point operations during the numerical factorization phase, making it possible to solve KKT linear systems more efficiently and more robustly.

Minimum-Time Trajectory Optimization of Many Revolution Low-Thrust Earth-Orbit Transfers

Kathryn Graham
University of Florida

The problem of determining high-accuracy minimum-time Earth-orbit transfers using low-thrust propulsion is considered. The optimal orbital transfer problem is posed as a constrained nonlinear optimal control problem and is solved using a variable-order Legendre-Gauss-Radau (LGR) quadrature orthogonal collocation method. Initial guesses for the optimal control problem are obtained by solving a sequence of modified optimal control problems where the final true longitude is constrained and the mean square difference between the specified terminal boundary conditions and the computed terminal conditions is minimized. It is found that solutions to the minimum-time low-thrust optimal control problem are only locally optimal in that the solution has essentially the same number of orbital revolutions as that of the initial guess. A search method is then devised that enables computation of solutions with an even lower cost where the final true longitude is constrained to be different from that obtained in the original locally optimal solution. A numerical optimization study is then performed to determine optimal trajectories and controls for a range of initial thrust accelerations and constant specific impulses. The key features of the solutions are then determined, and relationships are obtained between the optimal transfer time and the optimal final true longitude as a function of the initial thrust acceleration and specific impulse. Finally, a detailed post-optimality analysis is performed to verify the accuracy of the solutions obtained.

Control Approximation for Switching Structure Identification in Gauss Collocation Methods

Joseph Eide
University of Florida

This paper provides a new method of mesh refinement for Gauss collocation methods in which the discrete control information provided by the NLP solver is utilized to create a control profile for regions of the solution and used in the next iteration of the NLP. This mesh refinement technique requires a minimum of three iterations. In the first iteration, the optimal control problem is solved on a coarse grid. A continuous time control profile is approximated based on the previously calculated discrete control. Then control dynamics are calculated and used on the second iteration of the problem as additional state dynamic constraints based on the continuous control approximation. If piecewise behavior is detected in the solution, then a multiphase control approximation will be used. If a region has a control behavior that cannot be mapped to a profile, then the control in that region is solved as usual on the new mesh. The final phase is a verification phase, where the control dynamics are removed and any phase start points will be replaced with the start of a mesh interval. This motivation for the development of such a technique is presented for two control profiles of classic optimal control problems: The step control of the lunar lander and the ramp-coast-ramp control of the Bryson-Denham problem. It will be shown that this method is able to find the switching structure of these two controller quicker than previous mesh refinement techniques, and will also provide continuous control as a function of time. Future work will focus on increasing the complexity of the control approximation that can be generated.

Adaptive Mesh Refinement Method for Optimal Control Using Nonsmoothness Detection and Mesh Size Reduction

Fengjin Liu
University of Florida

An adaptive mesh refinement method for solving optimal control problems is developed. The method employs orthogonal collocation at Legendre-Gauss-Radau points, and adjusts both the mesh size and the degree of the approximating polynomials in the refinement process. A previously derived convergence rate is used to guide the refinement process. The method brackets discontinuities and improves solution accuracy by checking for large increases in higher-order derivatives of the state. In regions between discontinuities, where the solution is smooth, the error in the approximation is reduced by increasing the degree of the approximating polynomial. On mesh intervals where the error tolerance has been met, mesh density may be reduced either by merging adjacent mesh intervals or lowering the degree of the approximating polynomial. Finally, the method is demonstrated on three examples from the open literature and its performance is compared against a previously developed adaptive method.

Adaptive BOSVS Algorithm for Ill-Conditioned Linear Inversion with Applications to Partially Parallel Imaging

Maryam Yashtini
University of Florida

An Accelerated Bregman Operator Splitting-Type Algorithm with Applications to Partially Parallel Imaging

XIanqi Li
University of Florida

In this paper, we propose an accelerated Bregman operator splitting-type algorithm for solving problems of the form $\min\{\frac{1}{2}||Au - f||_2^2 + \phi(Bu)\}$, where ϕ may possibly be nonsmooth. Instead of choosing a fixed stepsize, we employ a line search to improve the efficiency. Moreover, we incorporate a second 'stepsize' into our scheme and analyze its influence by choosing different numbers. In the numerical experiments, the proposed schemes are compared with other state-of-the-art algorithms on partially parallel magnetic image reconstruction. Numerical results show that the proposed methods perform effectively and efficiently in terms of image quality and CPU time, respectively.

Fast bundle-level method for multi-task learning

Wei Zhang
University of Florida

Comparing to single-task learning, multi-task learning has been introduced to improve generalization performance by learning multiple related tasks simultaneously and meanwhile exploiting their intrinsic relatedness. In this talk, we will present a new trace norm regularization model for multi-task learning, and extend our recently developed fast bundle-level method to solve the corresponding optimization problem. Some applications in classification and image recognition will also be discussed.

Multi-Channel Image Reconstruction

Hao Zhang
University of Florida

Multi-shot echo-planar imaging (EPI) based Diffusion weighted imaging (DWI) has the potential to provide higher spatial resolution results compared with the generally used Single-shot EPI method. However, there are motion-induced phase errors among different shots. We make use of the low-rank property of the magnitude of intensity matrices (In) of images from different shots and under-sampled data from multi-channel scans to jointly reconstruct images for each shot. Our proposed model is a combination of the data fitting, gradient weighted Total Variation regularization and low-rank decomposition of In, which is solved by an ADMM scheme. Other potential applications of this model will also be discussed.

Rendezvous with Scalar Control for Nonholonomic Robots

Chau Ton
NRC

Nonlinear scalar control methods for nonholonomic robots will be discussed. Specifically, scalar controls for a two-robots system are developed. The robots under consideration are Dubins cars that share the same scalar orientation control input. There are two cases under consideration: rendezvous and orientation without targeted location, and rendezvous with targeted location. The control method is based sliding mode control. The control structure is simple, requiring no estimation or adaptation. Numerical simulations are provided to demonstrate the performance of the control methods.

Fractional-order System based Human-Robot Network for Rendezvous Problems with Common Scalar Control

Zhen Kan
University of Florida

A human-robot network that consists of human operators and semi-autonomous robots is considered to navigate the robots to achieve rendezvous within a desired area. The human operators form a social network, where each operator is assumed to maintain an opinion and communicate with other operators in determining the rendezvous area where the robots should meet. Motivated by the non-local property of fractional-order systems, the social interaction among operators are modeled by fractional-order dynamics whose opinions depend on influences from social peers and past experiences. A decentralized influence method is developed to influence the social group to achieve consensus on the rendezvous area. The robots considered are semi-autonomous in the sense that the robots are assumed to have onboard intelligence that allows them to autonomously perform preassigned cooperative tasks by interacting and collaborating with other robots. In addition to the onboard intelligence, the robots are also capable of receiving commands from human operators, allowing operators to influence the behaviors of the robots when necessary. Distinguished from most existing works, all semi-autonomous robots receive an identical control input from an operator (i.e., common control). The key contribution of the developed control structure is that a single human operator can control multiple robots in the same manner the operator will control a single robot, thus significantly reducing cognitive workload and operator fatigue. The developed robust controller ensures rendezvous of the robots within the desired area by using the common input from an operator. The human-robot interface is developed and experimental results with different subjects are provided to demonstrate the designed control strategy.

An Attacker-Defender Game and A Cooperative Estimation Scheme

Neha Satak
University of Florida

An attacker-defender incomplete information game is solved. The attacker chooses between two equally important targets to attack. A Gaussian impact distribution is assigned to both agents. The attacker plays to minimize its distance from either of the targets. The success of the attack is measured by the position of the target in the impact radius of the attacker. The attacker is considered destroyed if the defender reaches within a certain impact radius of the attacker. The game is incomplete information as the defender does not know which target the attacker will attack. The attacker also does not know the defenders plan of defense. A second problem related to cooperative estimation is solved between two robots equipped with an odometer, a bearing sensor to features and a range & bearing sensor to the other robot. A brief discussion with preliminary results will be presented on this second topic.

The Stochastic Incremental Network Design Problem with Shortest Paths and Uncertain Build Times

Nathaniel Richmond
University of Iowa

The deterministic incremental network design problem (DINDP) refers to the task of choosing how to grow an existing network over a finite time horizon. A network optimization problem (i.e. shortest path problem) is solved on the existing network at each time epoch, and the objective is to minimize the total cost over the given horizon. We introduce the stochastic incremental network design problem (SINDP) with shortest paths and uncertain build times. We design and discuss the model and examine interesting properties of its solution.

Jammer Placement to Partition Wireless Network

Jixin Feng
University of Florida

Wireless communication systems are susceptible to jamming attacks, and the use of unmanned vehicles bring new opportunities for coordinated jamming attacks. At the same time, systems of autonomous vehicles that coordinate their movements over a wireless network may be particularly vulnerable to jamming attacks that disrupt the control information. Much research has been conducted on how to efficiently jam single communication links and how to protect such links from jamming. However, less research has focused on problems of jamming attacks on the overall network. In this paper, we consider the problem of determining how to efficiently position jammers so as to partition a wireless network. The communication network is represented as a graph with the vertices representing the radios, and the edges representing the communication links. Although there has been extensive research into the problem of efficiently partitioning a graph via edge separators, the action of a jammer in a wireless network is more closely analogous to blocking reception at one or more radios, which may be modeled as partitioning a graph via node separators. We formulate several optimization problems for jammer placement. Since the optimal solution to these problems are computationally complex, we develop suboptimal solutions using spectral partitioning followed by greedy jammer placement and also a harmony search. The results show that these algorithms offer a tradeoff between complexity and performance. In the scenarios where we were able to compare performance with the optimal solution, the harmony search algorithm offered performance close to that of the optimal solution while requiring a much lower complexity.

New analytical lower bounds for the maximum clique number of graphs

Vladimir Stozhkov
University of Florida

We propose three new analytical lower bounds for the maximum clique number. Two most effective of them are derived from the Motzkin-Straus formulation for the maximum clique problem. We also prove several theoretical results for them. Finally, we compare its performance with well-known maximum clique lower bounds and show superiority of our best new bound. We run our experiments on various random graph models that simulate graphs with different densities and assortativity coefficients.

Modeling and Analysis of Fluid-Thermal-Structural Interactions in Hypersonic Flow

Jack McNamara
The Ohio State University

Over the last decade, motivated by a desire for air-breathing hypersonic systems, a growing body of research has emerged seeking to understand complex multi-physics interactions associated with compliant systems operating in the extreme hypersonic environment. This talk will review the modeling needs, challenges, progress to date, and remaining gaps for carrying out coupled fluid-thermal-structural analysis for different classes of hypersonic systems; i.e., reusable systems or weapons on terminal trajectories.

Towards Aerothermoelastic Tailoring of Waveriders

Narayanan Komerath
Georgia Institute of Technology

A capability is being developed to address the aerodynamics of airbreathing hypersonic vehicles. The thermo elastic response of a typical surface panel on the windward side of a generic waverider is considered starting from an analytical framework with real-gas effects modeled. A series of test cases progresses from textbook problems to cases dealing with waverider geometries. The postulate is that low-order aerodynamic formulations, when combined with accurate flow properties, can yield accurate predictions of aerothermoelastic deflections in equilibrium, and perhaps good predictions of unsteady response. The hyperbolic nature of the describing equations, and the particular regime of hypersonic flight, offer encouragement. A progression of aerodynamics models is used to develop predictions.

The Discontinuous Galerkin Method as a Mainstream Approach for Computational Fluid Dynamics

Andrew Shelton
Leidos

This research focuses on performing compressible unsteady computational fluid dynamics (CFD) with higher fidelity at lower cost using the discontinuous Galerkin (DG) method for high order spatial discretization. The discontinuous Galerkin (DG) method is the natural extension of finite volume to high order, and as such, enjoys high accuracy per degree of freedom while retaining geometric versatility. The method assumes a function expansion for the distribution of the flow variables within each individual element and solves for the modes of the expansion by minimizing the residual in the Galerkin approach. The flow variables are generally discontinuous across the element boundaries, requiring the application of a Riemann-like flux to maintain inter-element communication. The element solution reconstruction is self-contained such that the stencil is invariantly compact with increasing order of accuracy. This presentation will provide an overview of the DG method and demonstrate its application to problems such as shock interactions and vortex instabilities. A particular points of emphasis is a strategy to alleviate the Gibbs phenomenon (suffered by all high order methods) employing resolution-based damping.

Reactive Burn Model Parameterization Incorporating Ignition and Sustained Pulse Data Sets

Robert Drogan
Air Force Research Lab

Pressure based reactive models have been used successfully by the community for many years to investigate topics on problems involving high-velocity impacts, penetrations, and explosive ignition and detonations. Calibration of models for different materials is an important part of the modeling process and typically is performed using sustained pulse data from Pop-plot experiments. These data provided the run-to-detonation behavior for explosives due to a supported shock condition. However, simulations using Pop-plot derived coefficients are not generally able to match experimental data from thin-pulse-driven explosive ignition tests. This work focuses on the development of reactive models based on the combination of thin pulse and sustained pulse data sets. The additional complexity incorporated through a wide spectrum of experimental loading regimes allows for complex computational predictions. The Sandia National Laboratory hydrocode CTH is used to develop parameters for various reactive burn models, including Lee-Tarver's Ignition & Growth (I&G) model, Sandia?s History Variable Reactive Burn (HVRB) model, and the Arrhenius Burn model.

Approaches for Aggregating Information From Conflicting Sources

Tathagata Mukherjee
Florida State University

In this talk we will present approaches for aggregating information from conflicting sources. This problem has been given different names like the Veracity Problem, the Truth Finding Problem and the Information Fusion Problem and deals with aggregating information from n sources $S_1, S_2, \ldots, S_n$ which present potentially conflicting information about an object of interest O. This is also very similar to the sensor data fusion problem and the approaches discussed here have the potential of being applied to sensor data fusion as well. In this talk we will present three different approaches, the first one based on a PageRank type algorithm, the second one based on a Bayesian probabilistic network and the last one based on a geometric approach for detecting outliers.

Belief Propagation Algorithm for Near-optimal Graph Matching in Formation Reconfiguration Problems

Xin Li
University of Florida

Systems of networked autonomous vehicles often need to be reconfigured from one physical formation into another physical formation, depending on the tasks to which the vehicles are assigned. If the vehicles are identical, then an important problems is how to assign or map the vehicles in the initial formation to the set of desired positions (also called roles) in the final formation. The problem is complicated by the fact that the optimization criteria may not be additive in nature and that the optimization algorithm should be implementable in a distributed fashion. In this work, we propose the use of belief propagation (BP) to find suboptimal, but distributed solutions to these problems. BP is an iterative, local, message-passing algorithm for statistical inference on graphs. To apply BP to the formation-matching problem, we place the initial and final positions as vertices in a bipartite graph. Then the distances among the positions are mapped to probabilities, where the choice of the probability density function and its parameters affect the approximated optimization criterion. Because the bipartite graph is very loopy, we force decisions periodically in the BP algorithm. After the assignment of the destination to each identical vehicle, in order to navigate each vehicle to their decided position, we use prefix label algorithm to control the formation while maintaining the connectivity of the network.

Distances Between Multidimensional Distributions for Image Classification

Aleksandr Mafusalov
University of Florida

Image classification is an important problem for various applications. We consider metric-based classification algorithms. In order to use these algorithms we have to choose metric between images. Image can be represented as a matrix of brightness values of pixels. One heavily used class of metrics is pixel-to-pixel comparison based metrics. The alternative is cross-pixel comparison based metrics. We treat image as a two-dimensional probability measure with density proportional to pixel brightness. We propose several metric families in multidimensional probability measure space. We use kNN (k nearest neighbors) as a baseline classification method. We compare classification accuracy of metric-based algorithms for chosen metrics.

Support Vector Machines with Risk Constraints

Victoria Zdanovskaya
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.

Experimental Characterization and modeling of plastic deformation in Titanium

Oana Cazacu
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. In this paper, the combined effects of texture and asymmetric single-crystal plastic deformation mechanisms on the response of voided polycrystals are assessed for the first time. Using analytical homogenization, it is shown that for untextured metals deforming solely by slip, there should be a very specific dependence on the signs of the third-invariant and mean stress that induces a more accelerated void growth than predicted by current models. If the single crystal plastic deformation mechanism is twinning both numerical results using a full-field dilatational viscoplastic Fast Fourier (FFT)- based approach and a recent analytical yield criterion reveal unusual features of the dilatational response, namely a lack of symmetry of the yield surface with respect to both the hydrostatic and deviatoric axes.

Sensing and Imaging of Impact Damage in Composites

Olesya Zhupanska
University of Iowa

New three-dimensional strain-rate potential for porous metals with faceted yield surface

Benoit Revil-Baudard
University of Florida

Calculation of thermal properties of silicon carbide from the first principles using density functional perturbation theory of phonons

Anna Kuznetsova
Air Force Research Lab

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. Immense thermal gradients and associated mechanical stresses that are developed at the leading edge of hypersonic vehicles require materials with not only high thermal conductivity but also with high thermal conductivity anisotropy. This anisotropy would allow efficient reduction of thermal gradients along the surface of the vehicle, while minimizing heating of the interior of the vehicle. Silicon carbide (SiC) is among the best candidates for such applications due to its ability to operate at high temperatures and superior properties, such as, low density, low thermal expansion, high strength, high thermal conductivity, high elastic modulus and superior chemical inertness. SiC has high thermal conductivity, which is substantially anisotropic and depends on its crystal structure. Thermal properties of SiC have not been sufficiently studied and the detailed investigation would facilitate development of a new material based on SiC with superior thermal transport properties. In the talk we will illustrate application of density functional perturbation theory of phonons to investigation of thermal properties of materials. We will also discuss a well-known example of phonon dispersion calculation for silicon.

Modeling of the effective thermo-mechanical properties of Aluminum/Zirconia composite over a wide temperature range

Philip Deierling
University of Iowa

In this work, micromechanical modeling is employed to determine the effective elastic and thermal properties as well as the temperature-dependent stress-stain relationships of an Aluminum/Zirconia functionally graded material (FGM). The analysis is performed at varying volume fractions and a wide temperature range. The modeling includes 3D finite element analysis (FEA) based numerical homogenization using a representative volume element (RVE) and comparison to variational bounds on the elastic and thermal properties.

The RVE in this work consists of a unit cube with randomly distributed monosized spherical inclusions. The inclusions represent the phase material with a lower volume fraction while the matrix represents the phase material with a higher volume fraction (i.e. Zirconia inclusions if the Aluminum volume fraction is greater or Aluminum inclusions if the Zirconia volume fraction is greater). Periodic boundary conditions are implemented into the FEA along with temperature-dependent mechanical and thermal properties for linear elastic Zirconia and elastic-plastic Aluminum.

Effective elastic moduli, thermal conductivity, specific heat and thermal expansion have be estimated using FEA and compared against the tightest variational bounds (i.e. Hashin-Shtrikman bounds on the elastic properties and thermal conductivity, Shapery and Rosen-Hashin bounds on the coefficient of thermal expansion, and Rosen-Hashin bounds on the specific heat). FEA results indicate that the obtained material constants are within bounds. Furthermore, it has been revealed through evaluation of the bounds that the elastic moduli, specific heat and coefficient of thermal expansion are well approximated by the upper bounds. However, the thermal conductivity bounds are wide and specific FEA microstructure is required to determine the overall thermal conductivity of the Aluminum/Zirconia composite.

The results of the aforementioned analysis are incorporated into the thermo-mechanical analysis of an Aluminum/Zirconia FGM plate subjected to a steep temperature gradient. Preliminary results illustrating the effect of spatial grading on the structural and thermal response will be discussed.

A stochastic PDE-constrained optimization approach to vibration control of a composite plate subjected to mechanical and electromagnetic loads.

Dmitry Chernikov
University of Iowa

It is known from previous studies that mechanical vibrations of a thin plate can be effectively damped by applying electromagnetic field to it. However, application of excessive electric current may lead to overheating and damage of the plate, thus it is crucial to find the proper profile of the electromagnetic field to apply. In addition, the mechanical load is assumed to be stochastic with known discrete distribution. In this work we address the problem to find the optimal profile of the electromagnetic field under stochastic mechanical load, which is formulated as a stochastic PDE-constrained optimization problem. The governing system of PDEs is solved numerically and the optimization is done with the aid of a two-stage stochastic programming. The gradient of the objective function is found by using automatic differentiation. Numerical results are presented.

Decentralized Riemannian Particle Filtering & Multiagent Navigation Without GPS

Martin Eilders
Air Force Research Laboratory

Integrated Control and Estimation

Adam Rutkowski
Air Force Research Lab

This work studies the problem of guiding a vehicle from a known initial location to a known goal location as accurately as possible, without direct observation of the goal location (such as a bearing measurement, or line-of-sight to the goal), and without direct position measurements, such as those provided by GPS. The vehicle travels in a planar environment and has an onboard inertial measurement unit and an onboard visual system to measure bearing angles to features in the environment. Taking a zigzagging path toward the goal provides better position estimation than a straight path. For a given energy budget, there is a certain path width, or amplitude, that results in the best estimation performance, and this optimal path width depends on the sensor noise parameters. A batch estimator is derived to analyze the effect of the entire time history of the vehicle trajectory on final position estimation performance. The formulation results in a linear system of equations. The path width that minimizes the condition number of the system matrix also minimizes the final position estimation error when the feature bearing measurement noise is relatively large compared to the inertial measurement noise.

Bioinspired Magnetic Reception and Multimodal Sensing

Brian Taylor
Air Force Research Lab

Several animals use the Earth's magnetic field in concert with other sensor modes to accomplish navigational tasks ranging from local homing to continental migration. However, despite years of research, animal magnetoreception remains poorly understood. Simultaneously, the Earth's magnetic field offers a potential signal for engineered systems to perform GPS-degraded or GPS-less navigation. This work uses a biologically inspired behavioral strategy with limited a priori environmental knowledge to locate a magnetic target, and respond to other sensory cues when they are present. The underlying data processing is performed within a biologically relevant framework that can be adapted to use methods that range from engineering-based to biomimetic. Work to date shows that by tracking two magnetic coordinates independently of each other, a simulated agent can move from a starting location to a goal. In addition, the agent's behavior can be context dependent so that it can respond to other sensory cues when they are available.

High Speed Fluid Structural Interactions and Reduced-order Modeling

Ryan Klock
Air Force Research Lab

Model reduction techniques are applied to a hypersonic strike vehicle on terminal trajectories to capture the aerodynamic, thermodynamic, and structural dynamic system evolution and couplings. The General Purpose Optimal Control Software (GPOPS-II) was used to determine a set of terminal trajectories which maximized impact velocity or range and minimized target error. Shock, Prandtl-Meyer expansion, and piston theory were combined to create an approximate flow solution over the vehicle outer mold line which was then compared to Fully Unstructured Navier-Stokes 3-Dimensional (FUN3D) computational fluid dynamics solutions. Proper orthogonal decomposition of the thermal state of the vehicle was conducted leading to 15 thermal degrees of freedom rather than approximately 28,000 contained by the original Abaqus finite element model, while sacrificing negligible system energy. Free vibration mode shapes are derived by the Lanczos algorithm and used to generalize the structural dynamics equations of motion reducing the number of structural degrees of freedom to 3 from the original 130,000. Finally, the combination of these reduced models is discussed in the context of future work toward a full vehicle simulation for control law development and evaluation.

Aerothermodynamic Modeling of Munitions on Terminal Hypersonic Trajectories: Grid Generation

Emily Dreyer
Embry-Riddle Aeronautical Universityå

A capability is being developed to address the aerodynamics of airbreathing hypersonic vehicles. The thermo elastic response of a typical surface panel on the windward side of a generic waverider is considered starting from an analytical framework with real-gas effects modeled. A series of test cases progresses from textbook problems to cases dealing with waverider geometries. The postulate is that low-order aerodynamic formulations, when combined with accurate flow properties, can yield accurate predictions of aerothermoelastic deflections in equilibrium, and perhaps good predictions of unsteady response. The hyperbolic nature of the describing equations, and the particular regime of hypersonic flight, offer encouragement. A progression of aerodynamics models is used to develop predictions.

Aerothermodynamic Modeling of Munitions on Terminal Hypersonic Trajectories

Jake Larkin
The Ohio State University

The research conducted over the summer was primarily focused on the CFD simulation of high-speed munitions on terminal, hypersonic trajectories. The development of high-speed weapons strongly relies on a multi-fidelity and multi-physics simulation framework that can model realistic munitions in a computationally efficient manner. To determine if the proposed approach could sufficiently handle large accelerations (12-20 g?s) at extreme operating conditions, a much simpler 2D model of the full-diamond control surface was put through maneuvers in similar flight conditions and compared to results previously found for the same geometry. This model required an in-depth grid convergence study, maneuver design and careful CFD analysis using FUN3D. This experience was applied to the full-scale vehicle to begin developing the high-speed simulation framework. The first step was to model aerothermodynamic loads (i.e. surface pressure, heat flux) using steady state CFD solutions of a sample hypersonic vehicle. This was done by generating a grid of the vehicle that was properly converged in order to capture different flow features accurately and then applying appropriate boundary conditions to simulate a variety of operating environments in the CFD solver. In addition, the full-scale vehicle was used to simulate different flight maneuvers of interest.

Aeroelastic Simulation of Flexible High Speed Vehicles

Dianne Zettl
USRA

My summer research with USRA-AFRL aims to identify and exploit the relevant physics associated with the fluid-structural interaction (FSI) effects critical for highly maneuverable (high AoA, 20-40 G loads) supersonic (Mach 3) air-to-air missiles. My partner on this project, Ryan Kitson of University of Michigan, focuses on the structural analysis while I focus on trajectories and fluid analysis. My research thus far has involved the study of 2D rigid body kinematics and non-uniform circular motion to define the trajectory of a flat plate traveling at uniform free stream experiencing a constant centripetal acceleration. In this analysis, both the radius of curvature and angle of attack are accelerating with time. The resulting induced velocities on the plate normal to the free stream will define a pitch-plunge motion to be simulated using computational fluid dynamics (CFD) and passed along for structural analysis. This summer marks the starting point of my graduate research for my Masters thesis, which I will continue at Ohio State University.

Aeroelastic Simulation of Flexible High Speed Vehicles

Ryan Kitson
University of Michigan

The fluid-structure interaction of a vehicle in supersonic flight is considered using reduced order modelling techniques. In particular the flexible vehicle is modeled similar to the AIM-9 sidewinder currently in use with the exception of no control surfaces towards the leading edge. In this work reducing the span and overall box size of the vehicle is explored with the use of direct attitude control systems similar to those seen previously on the Standard Missile-3. In addition the impact of flexibility on system maneuverability and agility will be explored in future work. Initial structural modelling and order reduction using the normal mode method is discussed. Aerodynamic forces are included using traditional shock-expansion theory with piston theory for unsteady corrections. Some preliminary time simulations of the vehicle in free flight and maneuver are included.

On solution approaches to a class of mixed-integer non-linear stochastic programming problems

Alexander Vinel
University of Iowa

A class of mixed-integer non-linear programming problems which arise in certain recent approaches to risk-averse decision making under uncertainty is considered. We aim at applying some of the techniques that have been shown to be successful for other types of mixed-integer programming problems. Among other approaches, we show how a family of linear disjunctive cuts can be derived for our problem class and develop an efficient branch-and-bound method based on outer polyhedral approximations. First results of a numerical case study that is being conducted will be presented.

A Multistage and Multiscale Stochastic Programming Approach to Electricity Infrastructure Investment

Zhouchun Huang
University of Central Florida

To study the infrastructure needs of an electricity grid, we propose a stochastic programming model that integrates long-term investment planning and short-term unit commitment models, both of which are multistage decision problems in nature but have different time scales. The infrastructure expansions are planned several years ahead and the time scales for unit commitment decisions are in hours.

Nonlinear Mixed Integer Programming Approaches for Generalized Geometric Programming

Yiduo Zhan
University of Central Florida

Generalized geometric programming (GGP) is a type of mathematical optimization problem with nonlinear objective and constraints. Some of the GGP problems have negative terms, and thus cannot be transformed to convex problems. Therefore, this leads to a global optimization problem that is difficult to solve. This talk will introduce a solution algorithm for non-convex GGP. This method involves employing method of generalized benders decomposition to separate the convex and non-convex part of the problem. The convex part will be solved efficiently by a convex solver. For the non-convex part, which is the main problem after decomposition, we developed an algorithm that utilized the logarithmic variable transformation and converted the non-convex terms to mixed integer linear programming (MILP) problems using piecewise-linear approximations. It is solved by an integer solver and therefore acquire the overall optimal of GGP.

Nonlinear Dynamics of Fluid and Structural Systems

Earl Dowell
Duke University

Fluid and structural systems and their possible interaction have a rich array of behavior being susceptible to instabilities and thus the generation of limit cycle oscillations and on occasion chaotic response. in this talk we will touch on several example including solar sails, high performance aircraft and aerodynamic decelerators from space into planetary atmospheres. Much of the talk will be devoted to the large and small scale oscillations that may appear in fluid flows and thus excite structural motion. The large scale motions include buffet in aircraft and non-synchronous vibration in jet engines, the classic case being the Von Karman vortex street. The small scale motions have as their most well known example the transition from laminar to turbulent flow. In all of the above cases a combination of theory, computation and experiment is used to understand the nonlinear dynamics of such systems.

Scale-reduction Techniques for Optimization Problems in Networks

Sergiy Butenko
Texas A&M University

Many large-scale networks arising in practice are characterized by special structural properties. This talk will discuss how these properties can be exploited in developing exact algorithms for solving NP-hard optimization problems on real-life networks.

Node Interdiction in Coupled Interdependent Networks with Cascading Failures

Vladimir Boginski
University of Florida

We consider node interdiction problems in two-layer interdependent networks with cascading node failures that can be caused by two common types of interdependence ("one-to-many" and "many-to-one"). Previous studies on interdependent networks mainly addressed the issues of cascading failures from a numerical simulations perspective, whereas this work proposes a rigorous optimization-based approach for identifying an optimal subset of nodes, whose deletion would effectively disable both network layers through cascading failure mechanisms. We discuss computational complexity issues, mathematical programming formulations, related theoretical results, and possible extensions of the considered problems. We also present computational experiments that illustrate interesting properties of interdependent networks with different types of interdependence.

Multi-Purpose Guidance

James Cloutier
Air Force Research Lab

A multi-purpose guidance structure is developed which contains reference signals to which the vehicle's inertial position and velocity are slued. The guidance structure is the optimal solution of an infinite-horizon, time-invariant, linear-quadratic regulator with servomechanism action. The structure represents an infinite family of guidance laws since there are an infinite number of ways of selecting the position and velocity reference signals. Using the geometry of the guidance problem at hand, proper reference signals can be derived to make the guidance law perform as desired. Numerous air-to-surface guidance laws and an all-aspect proportional navigation-like guidance law have been produced. Against both fixed and moving targets, the algorithms are capable of guiding the vehicle in the execution of (1) satisfaction of pre-specified terminal flight path angles, (2) a stealthy low approach to the target followed by a pop-up maneuver, (3) obstacle avoidance maneuvers, (4) a strictly homing mode, and (5) ingress to a search area followed by circular search, circular surveillance, and attack of multiple targets The guidance laws are evaluated via a three-degrees-of-freedom simulation and results are presented. It should be noted, however, that almost all of the guidance laws developed have been evaluated in various six-degrees-of-freedom simulations and have produced excellent results.

Optimal Control

Quang Lam
Air Force Research Lab

Robust Adaptive Control in the Presence of Unmodeled Dynamics

Heather Hussain
MIT

Robust adaptive control of scalar plants in the presence of unmodeled dynamics is established and demonstrated using the roll subsidence mode of the lateral-directional dynamics of an aircraft in the presence of actuator dynamics. It is shown that implementation of a projection algorithm with standard adaptive control of a scalar plant ensures global boundedness of the overall adaptive system for a class of unmodeled dynamics.

Higher Order Sliding Mode Control of 6DOF Hypersonic Missile during Terminal Approach using an Adaptive Observer

Stephen Phillips
The University of Alabama in Huntsville

The problem of terminal phase control of a six degree of freedom hypersonic missile is considered and addressed using a continuous higher order sliding mode controller. The scramjet engine of the hypersonic missile is considered to be in a shutdown mode and therefore the available thrust for control is considered to be zero. Since the aerodynamic forces are dependent on effects from each control surface, the governing equations are studied. The forces are presented in matrix form which allows for the design of independent control laws for each control surface. The overall system is considered a disturbance for the purpose of controller design and is reconstructed by an adaptive disturbance observer. The proposed controller may be verified for the longitudinal case.

On Connectivity Constraints in Integer Programs

Austin Buchanan
Texas A&M University

Many large-scale networks arising in practice are characterized by special structural properties. This talk will discuss how these properties can be exploited in developing exact algorithms for solving NP-hard optimization problems on real-life networks.

Connected Subgraph Polytope via Lifting Procedure

Yiming Wang
Texas A&M University

We study the problem of describing the connected subgraph polytope for graphs. We show lifting is an important technique to generate facet-defining inequalities for the polytope but it is NP-hard to generate a facet-defining inequality via lifting in general graphs. On the other side, we show lifting procedure generates a facet-defining inequality in linear time when the graph is a forest and such procedure gives a full description of connected subgraph polytope. We also consider the graphs with small independent number and gives full description of connected subgraph polytope when independent number is 2.

The Maximum s-Stable Cluster problem

Chitra Balasubramaniam
Texas A&M University

We introduce and study the maximum s-stable cluster problem which, given a graph and a positive integer s, asks to find a largest induced subgraph such that the size of the maximum stable set in the subgraph is restricted to s. This problem has applications in social network analysis and areas using graph-based data mining. We show the NP-completeness of the decision version of the problem, present an integer programming formulation and provide a detailed polyhedral study to identify different classes of facets. Two different solution methods are presented with preliminary computational results.

Heuristic approaches for detecting robust cliques in graphs subject to uncertain edge failures

Oleksandra Yezerska
Texas A&M University

We develop and compare several heuristic approaches for detecting robust cliques in graphs subject to uncertain edge failures. A clique is robust if it satisfies certain risk requirements modeled using the CVaR concept. The proposed heuristics employ techniques borrowed from the well-known tabu search and GRASP metaheuristics.

On the Lagrangian duality of the maximum γ-quasi-clique problem

Zhuqi Miao
Oklahoma State University

Quasi-clique detection has been witnessed as a useful tool for detecting dense clusters in graph-based data mining, especially in error-prone data sets in which clique model is overly restrictive. The maximum γ-quasi-clique problem (MQCP) which detects a maximum γ-quasi-clique from a given graph, can be formulated as a $\{0, 1\}$-program with a linear objective function and a single quadratic constraint. This research studies the Lagrangian duality of MQCP based on the quadratically constrained formulation, and developed a cutting plane method that is capable to provide both good feasible solutions and tight Lagrangian upper bounds for MQCP.

Resilient Network Design via Spanning k-Cores

Juan Ma
Oklahoma State University

Given a non-negative integer k, a graph of minimum degree at least k is called a k-core. The concept of k-cores can be used to design resilient networks that preserve low diameter and high vertex-connectivity upon random graph component failures. This talk focuses on minimum spanning k-core problem under probabilistic edge failures using appropriate risk measures. We discuss polyhedral reformulations and algorithms to solve the problem.

A Robust Relative Estimation Framework for GPS-Denied Navigation

Daniel Koch
Brigham Young University

This work presents a relative estimation framework for increasing the robustness of GPS-denied navigation solutions for small multirotor vehicles to varied and dynamically changing environments. Primary goals include enabling seamless transitions between indoor and outdoor flight, as well as robustness for flight in changing environmental factors such as lighting conditions. The proposed framework should allow for the modular integration of multiple keyframe-based sensors and algorithms such as visual odometry and laser scan matching. The framework should also be able to detect and robustly handle sensor failures and degraded sensor performance to maintain good estimates in challenging conditions.

Comparison of Bayesian Search Algorithms

Drew Ellison
CU Boulder

Integrated surveillance and reconnaissance (ISAR) missions are an important application class for cooperative networks of unmanned aerial vehicles (UAVs), which must provide timely information about adversarial activities, environmental conditions, and friendly asset status to support coordinated dynamic decision-making. To improve the robustness and performance of such systems in urban environments, the AFRL Munitions Directorate seeks to develop formal online estimation and planning strategies for conducting probabilistic target search using MAVs (such as quadcopters) in urban indoor/outdoor environments. The current work being done explores the comparison of discretized space Bayesian search algorithms in realistic urban environments. The discretization of space, however, often scales poorly and is computationally expensive. This motivates the development of information-drive continuous planning techniques for quadcopters.

Distributed Solutions to the Dynamic Weapon Target Assignment Problem

Kyle Volle
Georgia Institute of Technology

The weapon-target assignment problem has been the subject of much research in the field of combinatorial optimization. A generalization of the classical assignment problem, it allows for multiple agents to be assigned to any given task. In particular, this work investigates the distributed, dynamic, weapon-target assignment problem where each agent makes decisions without the aid of a central planner and replan throughout the engagement as the situation changes. The assignment algorithm presented here uses a distributed game-theoretic approach where individual agents probabilistically switch to targets that improve the overall distribution. The algorithm leverages the fact that for large numbers of agents, each agent can only affect a small portion of the state space meaning that each agent?s decisions are largely independent so long as asynchronicity is maintained. As a result, a relatively straightforward local optimization approach converges exponentially to the global optimum. The relative priority of targets can be expressed as the desired probability of successful engagement of that target. A dynamic simulation of autonomous air-to-ground munitions is presented for testing and evaluation the proposed assignment algorithm. This simulation implements varying time-to-targets for each agent as well as a stochastic attrition model that represents unknown defensive capabilities on the part of the enemy. Results are compared to a naïve assignment approach in terms of overall system effectiveness.

Cooperative estimation for feature-based SLAM

Timothy Woodbury
Texas A&M University

In simultaneous localization and mapping, a vehicular agent creates a map of perceived landmarks in its environment while estimating its own position relative to said landmarks. In the current research, two agents operate in a purely planar workspace. The agents share landmark measurements to improve estimation accuracy. Sharing is effected by equipping each vehicle with sensors that measure the relative range and bearing to other agents. The preliminary results presented consider only the localization problem, in which landmarks are sensed but have a priori known locations. Each agent constructs an Extended Kalman Filter of its own position and translational velocity, and uses a nonlinear measurement model to incorporate landmark measurements made by itself and by the other agent. Estimation effectiveness is considered in Monte Carlo simulations. Two scenarios are considered; one in which landmark range and bearing is sensed, and one in which landmark bearings only are measured. Interagent measurements are available in both cases, and the performance of agents with and without measurement sharing is contrasted. Simulations are conducted at varying sensor variance levels and with varying numbers of features to gain insight into when this cooperative estimation scheme offers greatest benefits. All simulations consider two agents only; however, the architecture presented does not require the estimation of any additional states, and the only computational burden added by cooperation is a larger measurement vector. This architecture should be extensible to larger teams of agents, limited only by interagent communication bandwidth and relative agent sensing quality.

Hardware and Capability Build for an Autonomous Relative Navigation Framework

Gary Ellingson
Brigham Young University

In recent years researchers at Brigham Young University have been working on a relative navigation framework for autonomous aircraft. The framework and associated hardware platform have been a testbed for collaborative study of multiple associated researchers topics. The hardware platform consist of a multi-rotor aircraft carrying a autopilot for low-level attitude control and an Intel i7 computer running ROS for higher level functions. However, because of an unreliable and proprietary autopilot, testing of the higher level functions has been limited. The researcher has exchanged the proprietary autopilot for the open source solution allowing for more flexibility and control of the software used for low-level functions. Low level estimation and control have been integrated onto the autopilot and flown while receiving commands from an on-board computer. Testing of higher level navigation functions is now possible. Further, as the research matures, more of the relative navigation framework will be moved from the on-board computer to the autopilot allowing for more real-time execution.

Control of Nonlinear Aerospace Systems using Micro-Jet Actuators

Siddhartha Mehta
University of Florida

Store-Induced Limit Cycle Oscillations due to Nonlinear Wing-Store Attachment

Madhusudan Padmanabhan
Duke University

Fighter aircraft encounter aeroelastic Limit Cycle Oscillations (LCO) when carrying certain combinations of under-wing stores, leading to structural fatigue as well as pilot discomfort and loss of eff?ectiveness. The roles of various aerodynamic and structural non-linearities involved in the LCO are not well understood, and their numerical exploration via time marching is computationally expensive. In the absence of reliable prediction of critical parameters such as onset speed and response level, current practice is to restrict store carriage to a safe subset of the flight envelope. This work examines a possible cause for LCO, namely a structurally nonlinear (in stiff?ness and damping) wing-store attachment, without or with nonlinear aerodynamics. The wing-store attachment is modeled with a ?finite, adjustable stiff?ness that can accommodate the nonlinearity. Results are obtained by the computationally effi?cient Harmonic Balance (HB) method and compared against time marching solutions. For the case of nonlinear damping, an adaptation of the HB method for nonlinear sti?ness is used. Two systems are considered, namely a generic wing-with-store and the F-16 aircraft, respectively. Whereas the wing is modeled directly, the aircraft linear structural model is obtained from the Air Force Research Laboratory and modi?fied subsequently to include the wing-store nonlinearity.

Multi-Grid Analysis of High Order Synthetic Jet Actuators and LCO Simulations

Marco Sansone
ERAU

The current work investigates the use of Synthetic Jet Actuators (SJAs) in both low speed acoustic noise reduction, and Limit Cycle Oscillation (LCO) control. Both are analyzed with the Air Force FDL3DI code, which solves the full Navier-Stokes Equations.

Post processing of both cases is handled by the code JAFpp. Previously, this code was split into separate versions that have now been integrated together, along with the ability to function with multi-grid meshes. It is capable of extracting data from the FDL3DI solution files for the airfoil surface, Kirchhoff surfaces, and points above and below the trailing edge, and prints a time average flow file for the entire domain. In addition, it has been made more robust with automatic point selection for the trailing edge points and Kirchhoff surfaces that were previously inputted manually.

The ongoing noise reduction study continues the work of Cody Sewell on high fidelity simulations of the Joukowski symmetrical airfoil, with and without embedded SJAs. Current results from retesting his parameters roughly match the published results, but irregularities in the grid independence study point to instabilities that must be researched further. LCO simulations will be performed on the NACA0012 airfoil with 2 embedded SJAs, with updated modules written by Lap Nguyen. The control parameters governing the SJAs were written by Dr. William Mackunis.