6th Annual Meeting of the AFRL Mathematical Modeling and Optimization Institute

MEETING PROGRAM WITH ABSTRACTS

University of Florida
Research & Engineering Education Facility (REEF)
Shalimar, FL
July 31–August 2, 2018

Meeting Information

Registration

Registration is free and all meeting attendees must register. **All presenters have been automatically registered.** Non-presenting attendees can register by emailing the organizers at mmo.meeting.2018@gmail.com with your name and affiliation or stopping by the registration desk on-site. Registration material can be picked up on Tuesday–Thursday 9:00am–4:15pm in the UF-REEF lobby.

Coffee Breaks

Coffee breaks will be held at 10:30–10:45am and 2:30–2:45pm daily in the UF-REEF lobby.

Luncheon

Lunch will be provided to the registered meeting attendees from 11:45am-1:00pm daily in the UF-REEF lobby.

Internet Access

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

Meeting Room

REEF Auditorium (all sessions)

Tuesday, July 31

9:30 Opening Remarks

9:30-10:30 Session A

Robustness and Vulnerability of Interdependent Infrastructure Networks: Mathematical Modeling and Optimization Aspects

Vladimir Boginski, University of Central Florida

Abstract: Interdependent networks arise in many application domains associated with infrastructure systems, such as electric power, telecommunication, and transportation networks. In a real-world setup, these systems interact with each other, so that disruptions/failures of components in one of the systems may affect the performance of other systems that depend on those components. Thus, failures can propagate through interdependent networked systems in a cascading fashion, where a failure of a component in one system may cause a failure of multiple components in another system, and so on. Important research issues that need to be addressed in studying such interdependent networks include developing mathematical models of cascading failures, as well as assessing robustness/vulnerability of these networks via appropriate quantitative metrics. Furthermore, these mathematical representations may allow one to formulate and solve optimization problems that can potentially reveal interesting properties of the underlying systems and optimal strategies for enhancing their resilience. In this presentation, we will discuss some of our recent results and identify challenges and potential future research directions in this area.

The Subgraph Identification and Network Design Problems

Neng Fan, University of Arizona

Abstract: Many combinatorial optimization problems can be considered as finding a subgraph of a given graph with different requirements of graph properties (e.g., spanning tree problems, dominating set, connected subgraph). They can be generalized for network design in different application areas, such as power grids, communication networks, supply chain, social network analysis, etc. The network design has many requirements, such as survivability (to maintain maximum network connectivity and quality of service under failure conditions), and robustness (to withstand failures and perturbations), which can be ensured by corresponding graph properties. In this talk, we will revisit some classic combinatorial optimization problem from subgraph perspective, and then discuss two survivable network design problem via subgraph identification.

10:30-10:45 Coffee Break

10:45-11:45 Session B

Temporal Network Flow Models for Evacuation Planning with Contraflows

Qipeng Phil Zheng, University of Central Florida

Abstract: It is important to consider temporal network flows in evacuation planing as road congestion and traffic stalling are common. Lane reversals is an important way to increase outbound flow capacities from disaster areas. This paper presents a temporal network flow model with lane reversals which incorporates multiple sources and multiple destinations to predict optimal traffic flow at various times throughout the entire planning horizon. To avoid potential head-on collisions, a collision prevention constraint is introduced to limit directional flow on lanes based on departure time. This model belongs to the class of mixed integer nonlinear programming dynamic traffic assignment (DTA) problem. Initially formulated as a nonlinear system optimum DTA (DTA-SO) problem, through various proven theorems, a linearized upper bound DTA (DTA-UB) was able to be derived that is able to approximate the original problem with very high precision. Extensive numerical experiments are conducted to investigate the effectiveness of our DTA-SO model compared to one without lane reversals.

Data-driven approach to solving the MAP with the long short-term memory (LSTM) networks and Pointer networks

Alla Kammerdiner, New Mexico State University

Abstract: Recurrent neural networks have been recently applied for solving hard combinatorial optimization problems, such as the traveling salesman problem (TSP). While promising, this novel approach has shown reduced accuracy on the larger problem instances of the TSP. The multidimensional assignment problem (MAP) is a computationally difficult combinatorial optimization problem. Its size quickly becomes large even for moderate dimensionality and cardinality parameters. In this study we experiment with different types of LSTM and pointer networks and the representation of the problem solutions to understand how well the long short-term memory (LSTM) networks and Pointer networks can solve the MAP.

11:45-1:00 Luncheon

1:00-2:30 Session C

A Distributed Sensing Approach for Single Platform Image-based Localization

Tathagata Mukherjee, Intelligent Robotics

Abstract: We present a distributed image based robot (re)-localization system with 4 non-stereo monocular cameras using a deep Convolutional Network (Convnet). Our system trains the well known Posenet (Kendall et al 2015) CNN architecture, with minor changes, for regressing the position of a ground robot using a compound image, consisting of images from 4 non-stereo monocular cameras mounted on the robotic platform. The training of the network is done end-to-end without the need for any special feature engineering to work with the compound image input. Our results show that there is significant advantage to using a compound image obtained from cameras with non-overlapping field of view (non-stereo) as compared to using images

from single cameras, for image based localization. The compound-image based training yields median accuracy of 12 cm in an indoor environment which is at least twice as good as the results obtained with the same network trained on single image inputs.

A Distributed Sensing Approach for Single Platform Image-based Localization using Spatio-temporal Features

Orhan Akal, Florida State University

Abstract: In this work we present novel convolutional filters for single platform distributed image based indoor localization. Convolutional neural networks(CNN) have achieved huge success in several different fields like computer vision, natural language processing, data analytics and robotics to name a few. One of the problems where CNNs have shown remarkable success is that of 6-DOF image localization where the position and pose of a camera are estimated using a deep CNN from a single image. However, if instead of the 6-DOF pose only the position needs to be predicted these networks fail to perform well with single images. One of the reasons for this is the lack of field-of-view and context from single monocular images. In order to circumvent this problem we introduce the idea of "spatio-temporal filters", we call them horizontal and vertical filters and apply them to a stacked time series of compound images for the problem of indoor positioning. On a deep CNN architecture designed and implemented by us, we show that these novel filters can achieve a median accuracy of 16 cm in indoor environments.

Estimating Step function using ReLU activation

Indrajit Ghosh, Texas A&M University

Abstract: Deep neural networks incurred a resurgence of interest due to the pioneering theoretical developments in approximation theory. In this work, we focus on providing an upper bound to the number of neurons and layers required for estimating multivariate step functions using the `ReLU` activation. Step functions are an important class of functions having huge implications in Image Classification, Speech Recognition etc. We first give a framework of how to estimate a 2 class classification Step function in 1-dimension. We show that for a p-class classification in 1 dimension we need $2(p-1)$ neurons to estimate the function. We also show that, for 2 class classification in d-dimension we need $2d+2^d$ neurons. We generalize this idea for multi-class classification in d-dimensions. We also provide an upper bound to the number of neurons needed for Tree based classifiers and SVMs and explore the relationship between the number of neurons and number of layers used for implementing the network. Our results show the `ReLU` activation function requires a much smaller number of neurones for desired approximation as opposed to the existing results.

2:30-2:45 Coffee Break

2:45-4:15 Session D

Two-Stage Stochastic Interdependent Networks: Mitigation and Restoration

Cheng-Lung Chen, University of Central Florida

Abstract: We propose a two-stage stochastic program for determining the optimal mitigation and restoration strategy on two-layer interdependent networks with cascading node failure caused by random disruption. Previous studies mainly focused on either static or deterministic type of network failure, while our model features a dynamic failure propagation over time given initial stochastic node disruption. The first-stage problem allows arc capacity expansion and node fortification to mitigate the impact of future disruption on network performance. Particularly, the objective is to restore network performance during the recovery planning horizon in the second-stage problem with total minimum cost. We implement a Benders dual decomposition method that utilizes acceleration technique including use of various strengthened cutting plane and warm-start strategies to solve the problem.

Information Diffusion Prediction Based on Graph Neural Networks

Zhecheng Qiang, University of Central Florida

Abstract: Predicting information diffusion through social networks plays an important role in human activities analysis and influence maximization. Traditional methods for information diffusion prediction can be categorized into probabilistic models based and user profile or content features based machine learning model. In this paper, we propose a new framework combining user's explicit attributes, content similarity and the local subgraph around each target link into a single graph neural network (GNN). GNN is a new type of neural network which is designed to treat graphs as input and output their labels. Our GNN incorporates the graph structure features and the user profile and content features to predict the information diffusion. We evaluate our models on two real data sets: Weibo and VK to compare the performance with the state-of-the-art methods.

Stochastic Dynamic Programming in Information Networks with Discrete Choice Model

Mengnan Chen, University of Central Florida

Abstract: In this project, we study the network structure based on the user preference within finite-time information cascade. Information networks are usually composed of autonomous nodes that make their own decisions when forming links with other nodes and transmitting information. One of the well-known mathematical models for individual choices in socio-economic sciences is the Discrete Choice Model (DCM), or qualitative choice models. We use the Discrete Choice Model to build the node preference distribution and the dynamic changing of network structure is model by the Stochastic Dynamic Programming, which can be solved by the Markov Decision Process (MDP). In our model, SDP is a recursive solution method for optimization problems which have a dynamic structure and contains some stochastic elements (the choice set only takes discrete values). DCM provide a good description and prediction of behavior to dynamic optimization under uncertainty. By solving our model, we can analyze the changing of network structure by controlling information flow, which can be use in Information maximization problem.

Information Networks with Bounded Rationality

Guanxiang Yun, University of Central Florida

Abstract: We propose to apply the idea of bounded rationality to information networks. Bounded Rationality in the context of human behavior was originally proposed by Simon in 1957, who then further developed it in several studies and won the Nobel Prize in Economics in 1978 for his pioneering research. The essence of bounded rationality in the context of human behavior is that the utility is to achieve a percentage of "ideal" goals, within the limits defined by given conditions and constraints. The idea of Bounded Rationality User Equilibrium (BRUE) principle can be described by a mathematical model with equilibrium constraints using bounded rationality. We assume that an individual node (user, agent) in the information system has multiple choices (alternatives) to build connections, and for each choice i the corresponding utility value is $U(i)$. Without loss of generality, we can assume that the choice i^* has the optimal utility value. BRUE states that any choice i with the following property will be deemed as a possible choice of an individual node: $\{i|U(i) \geq U(i^*) - \rho\}$, where ρ is the bounded rationality coefficient. The condition $\rho \geq 0$ should hold because of the optimality of the choice i^*. Due to to this condition, incorporating BRUE to a mathematical model would imply uncertainty in the feasible choice regions for the nodes/users. It should be noted that if $\rho = 0$ the model is reduced to perfect rationality user equilibrium in the classical game theory. Thus, models that use BRUE can be viewed as extensions of traditional game-theoretic concepts.

Wednesday, August 1

9:30-10:30 Session A

Sampled Fictitious Play on Networks

Alexander Nikolaev, University at Buffalo

Abstract: We formulate and solve the problem of optimal information propagation between multiple communicating agents. In a given space of multiple "interests", each agent is defined by a vector of their personal interests, called "filter", and a vector of available information, called "source". The agents seek to build a directed network that maximizes the amount of desirable information that each agent receives less the expense due to filtering undesirable information. The key idea is to frame this optimization problem as a game of common interest, where the Nash equilibria can be attained as limit points of Fictitious Play (FP). Specifically, we explore Sampled FP, a modification that replaces the computationally demanding expected utility calculations in FP with their sampled approximations. To our knowledge, this is the first successful application of this theory to network structure optimization. Finally, we compare the performance of the developed algorithms in two settings: centralized (full information) and decentralized (local information).

Q-Learning on Networks with Attribute-Rich Nodes

Alexander Semenov, University of Jyväskylä, Finland

Abstract: We apply dynamic programming for solving the problem of optimal information propagation in a network formed by communicating agents. Each node in the network is endowed with features: a vector of their interests, and a vector of the information available to them. The information is assumed to spread through a directed network, built as a result of the agents' "pull" decisions; the objective to iteratively achieve such a network that maximizes the usefulness of the information that each agent receives. We apply reinforcement learning algorithms towards learning a policy that maximizes the total value of information in centralized and distributed settings. Further, we explore how deep neural networks can be used to approximate these algorithms by producing approximate state representations for Markov decision processes with network state spaces.

10:30-10:45 Coffee Break

10:45-11:45 Session B

On Exact Solution Approaches for the Longest Induced Path Problem

Oleg Prokopyev, University of Pittsburgh

Abstract: Graph diameter, which is defined as the longest shortest path in a graph, is often used to quantify graph communication properties. In particular, the graph diameter provides an intuitive measure of the worst-case pairwise distance. However, in many practical settings, where vertices can either fail or be over-

loaded or can be destroyed by an adversary and thus cannot be used in any communication or transportation path, it is natural to consider a more general measure of the worst-case distance. One such measure is the longest induced path. The longest induced path problem is defined as the problem of finding a subgraph of the largest cardinality such that this subgraph is a simple path. In contrast to the polynomially computable graph diameter, this problem is NP-hard. In this talk, we focus on exact solution approaches for the problem based on linear integer programming (IP) techniques. We first propose three conceptually different linear IP models and study their basic properties. To improve the performance of the standard IP solvers, we propose an exact iterative algorithm that solves a sequence of smaller IPs to obtain an optimal solution for the original problem. In addition, we develop a heuristic capable of finding induced paths in reasonably large networks. Finally, we conduct an extensive computational study to evaluate the performance of the proposed solution methods.

Information Cascades on Hypergraphs

Colin Gillen, University of Pittsburgh

Abstract: Network cascades represent a number of real-world phenomena, including social influence, electrical grid failures, cyber communication, virus spreading, and so on. The common factor in these phenomena is that they begin from a set of seed nodes and spread throughout the network; on bilateral networks (graphs) this area has been well-studied. We extend the information cascade abstraction into the broader realm of hypergraphs, where each hyper-edge may connect more than two nodes. The hypergraph representation is better-suited for cases where multi-lateral, simultaneous communication is possible between (for example) people, wirelessly-communicating devices, or other entities. A new conceptually simple but mathematically flexible model for cascade propagation is presented for this setting. Insights into the model's behavior are gained by theoretical derivation as well as by observing experimental hypergraphs. These experimental hypergraphs are derived by methods such as preferential attachment, random sampling, or from real-life data. The second phase of the research involves extending bilateral network results, such as optimal seed node/community selection, into the hypergraph environment.

11:45-1:00 Luncheon

1:00-2:30 Session C

Optimization of Camera to Vehicle Orientations for GPS Denied Geolocalization Algorithms

Lauren Johnson, University of North Carolina at Charlotte

Abstract: The use of vision aided navigation algorithms are one of many methods to enable aircraft and weapons to navigate in areas where Global Positioning System (GPS) signals may be degraded or denied. The Air Force Research Lab (AFRL) has been developing such algorithms for geolocalization of unmanned aerial vehicles. Specifically AFRL has used image processing techniques to relate a down-looking camera view to a database image. A hindrance to the AFRL thus far, has been that this algorithm can only handle the nadir camera position on a vehicle at this time. Thus, this talk will discuss improvements to generalize the algorithm to utilize varying camera-to-vehicle orientations. This optimization will be useful not only for

different cameras or orientations, but also for improving the results of the vehicle's localization in cases where one camera's position estimation is uninformative or false.

Multi-Hypothesis Relative Localization

Anusna Chakraborty, University of Cincinnati

Abstract: Unmanned Vehicles (UVs) have found various applications in both civilian and military scenarios such as border surveillance, aerial refueling, target tracking, highway patrol *etc.* Multi-vehicle missions are preferred as they have several advantages like increased robustness, increased sensing range and better efficiency. Most autonomous missions use Global Positioning System (GPS) for absolute localization. However, in many scenarios GPS may not be available or may be faulty or spoofed. In such cases, vehicles rely on the knowledge of Points of Interests (POCs) or landmarks whose positions are known as prior information to localize themselves. Landmark unavailability severely handicaps a vehicles' ability to navigate autonomously. For applications such as formation flying or forming patterns to prevent targets from escaping, the absolute pose of the vehicle is not needed as long as the vehicles are aware of their relative pose with their neighbors. Global pose may be important but not entirely critical for mission execution. Various estimation techniques have been used to solve the problem of relative localization. Most of the literature on this subject assumes a decent a priori knowledge of the vehicle's relative pose and orientation with a tight uncertainty bound. This may not always be the case such as for vehicles which have been flying without GPS for a long time and have no good knowledge of their pose. To help negate this problem, instead of using a single Extended Kalman Filter (EKF) with a large uncertainty that is likely to blow up the jacobians, a number of filters with different initial conditions based on the range measurement between the vehicles is initialized for a pair-wise vehicle case, where each of these filters have smaller uncertainty. A light-weight elimination metric has been identified which helps prune out the extremely bad filters online and provides the filters which are good enough to help seed a bigger filters with more number of vehicles. Based on the Multi-Hypothesis EKF (MHEKF) approach, monte-carlo simulations are performed to validate the consistency of the filter identified by the MHEKF. Observability conditions have been developed for the relative localization with range-only measurement case which provides us with conditions on the linear and angular velocity for the vehicles that helps generate trajectories which improves the observability of the system. This relative framework has been applied in problems as formation control around a moving target and landing a quadcopter on a moving platform. The system has been validated on hardware using turtlebots and decawave range sensors using Robot Operating System (ROS) to communicate between the ground station and the robots and results are presented for simulation and hardware scenarios.

Distributed Formation Control of Autonomous Vehicles via Vision-Based Motion Estimation

Kaveh Fathian, University of Texas at Dallas

Abstract: We present a novel strategy for a team of unmanned aerial vehicles (UAVs) to autonomously achieve a desired formation. Only the visual feedback provided by the UAV's onboard cameras are used to achieve the formation, effectively eliminating the need for global position measurements. The proposed formation control approach is distributed and further encompasses a fully distributed collision avoidance scheme. To attain the relative position information of other vehicles that is required for the formation control, UAVs extract and communicate the feature points of images that are captured by their onboard cameras. If images captured by two UAVs have a part in common, the feature points corresponding to the common parts are matched, and the relative position and orientation of the UAVs are estimated from a pose estimation algorithm. In particular, our novel algorithm, called QuEst, is used to estimate the relative pose

from matched feature points. Compared to existing methods, QuEst has better estimation accuracy and is robust to camera/feature point degeneracies. We validate the proposed strategy using simulations with quadrotors. The simulations are performed in the high-fidelity Unreal Engine 4 environment via Microsoft AirSim. Source code for the algorithms used in this work is made available to public and can be accessed online.

Autonomous Vehicles Lab: Multirotor System and Algorithm Development

William Warke, University of Florida

Abstract: Autonomous flight is a complex, multidisciplinary subject, making research in this area difficult to communicate, demonstrate, or hand off to new contributors. If existing systems and algorithms can be effectively communicated, researchers will spend less time recreating existing capabilities, and more time focused on new, relevant research in the areas of guidance, control and navigation (GNC). Recently, researchers at BYU successfully demonstrated a Relative Multiplicative Extended Kalman Filter (RMEKF) that fused data from IMU, altimeter, and RGBD camera for relative indoor navigation of a multirotor UAV. This summer, the Autonomous Vehicles Lab (AVL) built on the concepts of RMEKF to design a set of simplified, modular UAV navigation filters and controllers more suitable for effective communication to a wider audience. These filters were implemented on hardware and evaluated via working demonstrations on flying systems in the AVL. This includes onboard estimators for vehicle attitude, altitude, and velocity as well as controllers for those same states. The focus of these algorithms is simplicity and reproducibility, not only for the sake of future scholars and researchers passing through the AVL, but for ease of communication to the greater public, such as collaborating academic labs, small businesses, and other members of AFRL and the Department of Defense.

2:30-2:45 Coffee Break

2:45-4:15 Session D

Single Agent Indirect Herding of Multiple Targets with Unknown Dynamics

Ryan Licitra, University of Florida

Abstract: In this paper, an indirect herding problem is considered for a single herder that is outnumbered by multiple target agents. Indirect herding is a problem that involves a network of one or more controllable herding agents and indirectly controlled target agents (i.e., the target agents can only be controlled through the herder by exploiting herder-target interactions), where the goal is to achieve a network-wide objective. This paper investigates the unique problem where a single herder is required to regulate all the target agents to some desired formation. The problem is further complicated by the fact that the target agents have uncertain nonlinear dynamics, including uncertainties in the herder-target interaction. Neural network function approximation methods are used along with switched systems methods to ensure uniformly ultimately bounded convergence of the agents trajectories provided developed dwell-time conditions are satisfied. Experimental results that involve a quadcopter herding agent and six unactuated targets that slide across the ground demonstrate the validity of the designed controller for two different herding strategies.

Indirect Herding Strategy for Munitions to Aircraft Interception

Christian Harris, University of Florida

Abstract: This paper considers the case where a team of munitions are tasked with intercepting a fleeing aircraft. To accomplish this task, the team will influence the behavior of the aircraft and force it into a scenario where interception is guaranteed. Even though the aircraft's behavior is uncertain and uncontrollable, the proposed approach considers the aircraft to be a vehicle that can be indirectly controlled by exploiting the interaction between the munitions and the aircraft. As the munitions team approximates this interaction, the team will predict the aircraft's future behavior and adjust the geometry of their network to contain the aircraft as they trail behind it. The proposed approach will guarantee that as the distance between the munitions network and the aircraft decreases, the size of the network will converge to a value within a specified success region, and aircraft will be contained within the network's boundaries.

Target Tracking in Uncertain Environments Using Mobile Cameras

Zachary Bell, University of Florida

Abstract: The primary objective of this work is to further the development of a target tracking algorithm that relies on aerial cameras in environments where global positioning is unreliable and targets do not communicate velocity or position. This research seeks to extend previous work that assumed a stationary object was trackable in addition to the target. In this work, the camera is able to track and reconstruct moving targets over larger environments where no stationary objects are assumed to be in the field-of-view of the camera.

Leader Selection On Signed Leader-follower Multi-Agent system from Control Energy's Perspective

Baike She, University of Iowa

Abstract: Leader group selection that takes into account the network controllability and control energy is investigated in this work. Specifically, a dynamic signed leader-follower multi-agent network is considered. Motivated by the fact that many practical networks, e.g., social network, fault tolerant networks, and resilient networks, can have both friendly and adversarial interactions, the dynamic multi-agent system is represented by a signed network where both positive and negative edges are considered. For the leader-follower signed network, we consider two key network control problems via leader group selection: 1) network controllability, i.e., the identification of a small subset of agents as leaders such that the selected leaders is able to drive the network to a desired behavior, and 2) control energy, i.e., the total energy required to steer the network to a target state by the selected leaders. To address these challenges, graphical characterizations of the controllability of signed networks are developed based on the investigation of the interaction between network topology and agent dynamics. Graph centrality based metrics are then developed to quantify the difficulty of the network control as a function of the required control energy.

Thursday, August 2

9:30-10:30 Session A

Flight Parameter Prediction & Sensor Location Selection using Fully Connected Deep Networks

Chaity Banerjee Mukherjee, University of Central Florida

Abstract: In this work we present a deep neural network architecture (NN-regressor) for predicting flight parameters using data from a distributed set of sensors on or near the airframe. More precisely we predict the pitch and yaw of the flying object based on pressure readings at regular intervals on or near the surface of the object. We preprocess the pitch and yaw and convert them from polar coordinates to Cartesian coordinates before using them for the NN-regressor training. We used several different fully connected network architectures for this problem. For each one of them we used the ReLU activation function and used the mean squared loss (MSE). Our data was collected on a simulated trajectory using a V-Bomb object and has a total of 20,000 iterations (readings of pressure vs yaw and pitch). For each iteration there are 2000 sensor positions (and readings) on the free stream (near the object) providing pressure readings. For the surface data we simulated a trajectory with 40,000 iterations with 3475 sensor readings for each of them. Finally we also present an algorithm for identifying the most important sensor positions for regressing the pitch and yaw both for the free stream as well as for the airframe data. Our algorithm uses the weight metric learned by the fully connected layers for identifying the most relevant sensor positions.

Detection of Rouge Transmitter in RFML System for Vehicular Networks

Debashri Roy, University of Central Florida

Abstract:Understanding and analyzing the RF environment have become indispensable for wireless deployments of different automated domains. Various learning mechanisms are used to characterize RF signals which in turn are used to identify RF transmitters and model their transmission behavior. Machine learning methods, that include recurrent structures, have shown to create such functions in Radio Frequency Machine Learning (RFML) systems for autonomous control, such as in self-driving vehicles. The signals received from other vehicles and/or road side units play a crucial role in the decision making process of any autonomous vehicle. However, the signal can be deprecated or modified with ill intentions by malicious entities. The objective of this project is to learn, characterize, and determine such rouge transmitters by proposing and implementing Generative Adversarial Networks (GAN) based learning techniques for RFML systems. We propose a generative and discriminative model based on RFML system for rouge transmitter detection in vehicular networks. Our aim is to detect the signals from malicious transmitters leveraging the concept of radio fingerprinting. Radio fingerprinting is a process that identifies a radio transmitter by the "fingerprint" that uniquely characterizes its signal transmission and is hard to imitate. One type of radio signature is the *rise time* signature, which is generated by the slight variations of component values during manufacture. However, the *rise time* signature is not commercially available for most of the radios. In this work, we propose a radio fingerprinting technique by leveraging the raw I/Q data only. Our approach has two folds. First we implement a deep neural network for multi-class classifications in a supervised learning environment for collected raw signal data. In the second part, we try to detect the trusted and fake transmitters by a trained version of the discriminative model on the same data set in an unsupervised learning environment. Later, the trusted transmitters are recognized based on the aforementioned multi-class classification algorithm. For the generative network, we use unsupervised learning module autoencoders, which is well suited for reducing the parameter space, forcing time-invariance features, and forming a compact front-end for the radio data. We have collected 40,000 raw I/Q data from each of the eight USRP B210 transmitters using a RTL-SDR radio. We used different sample sizes for QPSK modulation scheme in 902-928 MHz ISM frequency band. A typical dataset of 1024 sample size consists of 320,000 rows and 2048 columns (I and Q values for each 1024 sample). Results reveal that our proposed algorithm is able to identify the 8 transmitters with 96.24% accuracy.

10:30-10:45 Coffee Break

10:45-11:45 Session B

Object Detection on Aerial Images using Image Segmentation and Metric Learning

Yimeng Li, George Mason University

Abstract: Object detection is an important and challenging problem in computer vision. Although during the past 6 years, we have witnessed major advances in object detection on natural scenes using state-of-the-art CNN object detectors, such success doesn't continue on aerial images. In this paper, we propose a unified approach using image segmentation and metric learning to tackle this problem. We first segment an aerial image using convolutional oriented boundaries. Then we use a changed region pooling layer to extract CNN features from irregular shaped segments. With the help of ground truth bounding box, we learn a distance metric between segments to compare the similarity. We can simply train a kNN classifier with the learned metric to decide the class of each segment. Finally, we combine similar segments and detect objects at the same time. We evaluate our approach on a recent large aerial image dataset and achieve satisfying results.

Road Network Graph Extraction from Aerial Lidar and Images

Biswas Parajuli, Florida State University

Abstract: We consider the problem of automatically extracting accurate road network graph simultaneously from aerial Lidar and high resolution aerial images. Applications like online mapping services, autonomous navigation, location based mobile services to name a few require correct road network information. Labeling of roads is labor intensive and error prone making it hard to obtain this information manually. In this work we investigate deep convolutional architectures that can merge information from both aerial Lidar and images for road segmentation. We present a network design which performs better than the current state-of-the-art RGB-only methods. We obtain a graph from the predicted road segmentation after thinning and skeletonization and then use an integer programming technique for predicting the missing links in this graph. Finally we present a comparison of our results with that obtained from the state-of-the-art road network graph extraction methods.

11:45-1:00 Luncheon

1:00-2:30 Session C

Thermoelastic Flight Dynamics Equations

Yuri A. Antipov, Louisiana State University

Abstract: A variety of aerospace structures can be modeled as unrestrained flexible (elastic) and thermoelastic bodies. Examples of these include helicopters, aircrafts, and missiles. Building a flight dynamics model for an elastic aircraft is particularly important for frequency domain analysis and control design of such structures as NASA Helios type aircrafts which are highly flexible and fly at low speeds and high altitude. Thermoelastic flight dynamics equations are necessary for an accurate modeling of a missile flight at a hypersonic regime and of the atmospheric reentry of a space aircraft. In this talk, based on variational formulation we generalize the classical rigid body flight dynamics equations for the case of an elastic and thermoelastic aircraft. In our derivations, we do not use the controversial concept of mean axes that decouples the vibration and rigid body equations. Instead, we obtain a system of flight dynamics equations which couples the thermoelastic displacements with the coefficients of the rigid body dynamical system. The variational formulation includes the kinetic energy, the gravitational potential energy, the generalized free energy, and the dissipation function. In addition to the thermoelastic flight dynamics equations, by employing a local analysis we derive a system of partial differential equations of coupled thermoelasticity for the elastic displacement and the entropy flow and eventually for temperature. Motivated by flexible Helios type structures to compute large deflections of a beam, we develop an efficient model that is simpler than the elastica model and gives practically the same results. Finally, to understand the impact of easticity on flight dynamics, we analyze the Bode root locus associated with the rigid and elastic body linearized flight dynamics equations.

Simulation of High Speed Micro-Rotating Structures for Mechanical Integrity

David Veazie, Kennesaw State University

Abstract: Power generation by the magnetic interaction between a microscale magnetic ultra-high speed, high-density rotor and stator is investigated for portable compact power. Small-scale, permanent-magnet synchronous generators and motors are considered for machines that can serve as electric power sources for soldiers, autonomous sensors or robots as well as coolant or fuel pumps, or air handlers. These machines, operating at or above the multi-watt power level, are fabricated from bonded stacks of silicon wafers using a combination of standard MEMS silicon processing, and electroplating of integrated magnetic materials and thick conductors. Their fabrication is batch implemented, enabling low-cost high volume production. Scaling their size to the centimeter range of Power MEMS, the machines operate with current densities 100 times larger than conventional machines at very high speeds. This study demonstrates numerical approaches, including numerical finite element simulations (FEM), to optimize the mechanical response, geometry and fabrication of magnetic machines, as well as develop the most suitable design approaches. This research builds on the previous complex 2D axisymmetric elastic/plastic thermo-structural modeling of the magnetic rotation devices in that mechanical failure prediction of micro-rotating structures at very high speeds requires full 3D modeling. The SiC housing and NdFeB permanent magnet rotor demonstrates that an ultra-high speed magnetic rotor structure is viable allowing speeds of 500,000+ rpm. Magnet micro-fabrication and the high-density rotor integration are also discussed.

Development of a Model for the Design of Interfaces in Steel/Steel Hybrid Composites

Charles Monroe, University of Alabama at Birmingham

Abstract: A novel approach to creating steel components is presented using traditional manufacturing casting methods of melting and pouring steel combined with the use of internal chills. These methods have the advantage of being immediately available to the supply chain of producers. The promise of a composite design with multiple steel materials and a tailored interface condition opens up a new design space of functional requirements by abandoning monolithic structures. A computer model of the heat transfer and interface evolution show the possibility of using the coherent interface of internal steel chills in the design of net shape components. The preliminary experimental results show that the full range of interface conditions exist from incoherent to fully coherent both to the transmission of load as well as chemical diffusion. A discussion of the possible conditions for a coherent interface as predicted by the thermal model and needed improvements is expected.

2:30-2:45 Coffee Break

2:45-4:15 Session D

TBA

Daniel Reasor, Air Force Research Laboratory

Abstract: TBA

Thin Cylinder Thermal Induced Flutter

John Moran IV, Arizona State University

Abstract: Structures can be exposed to rapidly changing thermal loading, such as in orbit while transitioning from the shadow of Earth to full solar illumination. The rapid heating of surfaces due to incoming radiation causes physical expansion and under certain conditions can induce significant excitation. This has been a subject of interest since the sixties where it was first observed and studied. The specific parameters that facilitate the creation of thermal flutter in thin walled cylinders has been a topic of extensive research for over fifty years. Using CalculiX, a powerful open source finite element software package, previously conducted experiments are recreated, and the results are verified. The thin walled storable tubular extendable members (STEM's) used for spacecraft booms are analyzed using linear and quadratic shell elements. The sensitivity of the structure's response to the radiation incident angle, frequency of heating, and the cylinder dimensions are the focus of the study. Understanding the phenomena of thermal flutter in these members may have useful applications to other rapidly heated surfaces on aerospace vehicles with similar geometry.

Integration of Hamiltonian Symmetry Fields

Michael Sparapany, Purdue University

Abstract: In the Bolza problem, one seeks to minimize a performance index subject to a set of dynamic constraints. Solutions naturally arise as symplectic systems on a manifold with generalizations to Poisson structures. The existence of symmetries and constants-of-motion enable one to dimension reduce such a sys-

tem resulting in the structure of a G-bundle. These reduced systems have computational advantages due to the overall lower number dimensions. However, mission design requirements live in the full dimensional space resulting in required reconstructions of reduced dimensional solutions. Such reconstructions are performed by integrating the Hamiltonian fields originally removed from the full dimensional space. Reconstruction techniques are explored primarily based on the exponential mapping. Examples are shown including problems in $SE(n)$, $SO(n)$, and mixed cases $SE(n) \times SO(n)$.