5th Annual Meeting of the AFRL Mathematical Modeling and Optimization Institute

MEETING PROGRAM WITH ABSTRACTS

University of Florida
Research & Engineering Education Facility (REEF)
Shalimar, FL
August 1–3, 2017

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.2017@gmail.com` with your name and affiliation or stopping by the registration desk on-site. Registration material can be picked up on Tuesday–Thursday 8:30am–4:15pm in the UF-REEF lobby.

Coffee Breaks

Coffee breaks will be held at 9:45–10:00am and 2:30–2:45pm daily in the UF-REEF lobby.

Luncheon

Lunch will be provided to the registered meeting attendees from 11:30am-1:00pm daily in the UF-REEF lobby.

Internet Access

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

Meeting Rooms

Sessions A and B - Auditorium
Sessions C1 and D1 - Auditorium
Sessions C2 and D2 - Room 117

Tuesday, August 1

9:00 Opening Remarks (Auditorium)

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

Sequential Max-Min Bilevel Linear Programming with Incomplete Information and Learning

Oleg A. Prokopyev, Professor, University of Pittsburgh

Abstract: We present a framework for a class of sequential decision-making problems in the context of max-min bilevel programming, where a leader and a follower repeatedly interact. At each period, the leader allocates resources to disrupt the performance of the follower (e.g., as in defender-attacker or interdiction problems), who in turn minimizes some cost function over a set of activities that depends on the leader?s decision. While the follower has complete knowledge of his problem, the leader has only partial information, and needs to learn about the cost parameters, available resources, and the follower's activities from the feedback generated by the follower's actions. We measure policy performance in terms of its time-stability, defined as the number of periods it takes for the leader to match the actions of an oracle with complete information. In particular, we propose a class of greedy and robust policies and show that these policies are weakly optimal, eventually match the oracle's actions, and provide a real-time certificate of optimality. We also study a lower bound on any policy performance based on the notion of a semi-oracle. Our numerical experiments demonstrate that the proposed policies consistently outperform reasonable benchmark, and perform fairly close to the semi-oracle.

This is a joint work with Juan Borrero (University of Pittsburgh) and Denis Saure (University of Chile).

9:45-10:00 Coffee Break

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

The Bilevel Quadratic Knapsack Problem

Gabriel Zenarosa, University of North Carolina, Charlotte

Abstract: We present the bilevel quadratic knapsack problem (BQKP) and develop an exact solution approach based on dynamic programming and the branch-and-backtrack algorithm. We also present a single-level reformulation of BQKP as a mixed-integer quadratically constrained program (MIQCP) enabled by value functions. Our computational experiments show that our approach for solving BQKP outperforms a commercial state-of-the-art global optimization software solving the MIQCP reformulation.

Thermo-structural Modeling and Simulation of High Speed Micro-Rotating Structures
David Veazie, Kennesaw State University

Abstract: 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 structural and thermal response, geometry and fabrication of magnetic machines, as well as develop the most suitable design approaches. The complex 3D elastic/plastic thermo-structural modeling of the magnetic rotation devices is shown to predict the failure of micro-rotating structures at very high speeds. The NdFeB permanent magnet rotor incorporating stiff housing structures (e.g., silicon nitride or alumina), demonstrates that a high speed magnetic rotor structure is viable allowing speeds of 400,000 + rpm. Fracture models are compared to experiments using a vacuum rotation system with acoustic and optical measurement capability.

Deformation of Metallic Materials During Dynamic Events
Benoit Revil-Baudard, University of Florida

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

11:30-1:00 Luncheon

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

Micromechanical Modeling of Ti/TiB Composites: Effects of TiB Whisker Orientation and Distribution on the Overall Properties
Phillip Deierling, NRC

Abstract: Metal-ceramic composites offer several mechanical and thermomechanical advantages over conventional materials for structures operating at elevated temperatures. Here, the characteristics of ceramics offer high-temperature tolerance coupled with increased stiffness and reduced thermal stress as a result of thermal expansion. One such material combination that draws attention for these types of applications is Titanium/Titanium DiBoride (Ti/TiB_2) composites. However, it has been shown that pure two-phase Ti/TiB_2 composites can be difficult to manufacture due to formations of Ti_3B_4 and TiB at the Ti/TiB_2 interface. These intermediate phases can impede on the design of structures employing such materials, as the material properties of these intermediate phases can alter the desired material response. Furthermore, intermediate phases can be difficult to determine in experimental and computer simulations adding further design challenges. An attractive alternative to Ti/TiB_2 is Ti/TiB due to the absence of the intermediate phase formation between Ti and TiB. In addition, a lower amount of boron is required to form TiB compared to TiB_2, thus offering reduced manufacturing cost and time. Yet, from a design standpoint, TiB brings about additional considerations. Due to the manufacturing process, TiB forms whiskers compared to the somewhat spherical shape particles of TiB_2, which can vary in length, orientation and create complex interconnected networks. In view of this, it is important to consider orientation and size dependence of whiskers for prediction of the overall properties of Ti/TiB composites.
In this presentation, two approaches for modeling of the overall properties of Ti/TiB whisker reinforced composites with orientational distribution of TiB whiskers are presented. The first approach is representative volume element based, where finite element analysis based numerical homogenization of RVEs with prescribed orientational distributions of inclusions is performed to evaluate overall properties. The second is micromechanics-based and includes the Mori-Tanaka model with prescribed orientational dependence of TiB whickers in Ti matrix and analysis of the rigorous variational bounds. The first approach presents more flexibility for the analysis of the real microstructures, while being, at the same time, computationally expensive. The second approach is computationally cheap, but has limitations with respect to accounting for the real features of microstructures. Resulting elastic properties obtained by each method will be presented and compared with experimental data to gauge confidence in predicting the apparent composite properties.

Verification and Validation of a Re-entry Ablation Model for PICA Using ABAQUS
Yeqing Wang, University of Florida

Abstract: During hypersonic reentry, the outer surface of the heat shield (i.e., the ablating Thermal Protection System (TPS)) experiences extreme high temperature due to complex convective and radiative heating. With increasing temperature, pyrolyzing TPS material decomposes and then releases the pyrolysis gas. Meanwhile, the outer surface undergoes chemical reactions, including vaporization, nitridation, and oxidation, which leads to the progressive material removal (i.e., the ablation). For the past several decades, the development of accurate simulation models to predict the thermal and ablative response of such pyrolyzing materials has been an interest in the ablation research community. As a consequence, numerous corresponding computational codes have been successfully developed to date, such as the Charring Material Ablation (CMA) code and the Fully Implicit Ablation and Thermal (FIAT) analysis tool. The common feature of these codes is that they utilize moving grid systems with finite difference (or finite volume) method. However, the availability of these codes to the research community is often restricted. Moreover, these codes are limited to

one-dimensional (1D) geometries/configurations and, thus, may not fully capture the effects of the complex geometric features on the resulting thermal and ablative response. When compared to the finite difference (or finite volume) method, the finite element method provides improved computational capabilities due to the flexibility and enhanced applicability of the method, especially to complex geometries. In this presentation, I will present our newly developed computational procedure with finite element analysis in ABAQUS that enables us to model a 1D pyrolyzing ablation test case. The computational procedure is performed using the ABAQUS coupled thermal-displacement step with multiple user subroutines and the Arbitrary Lagrangian-Eulerian (ALE) adaptive remesh algorithm, which allows a tight coupling between the in-depth heat conduction considering the material decomposition and the progressive material removal. Moreover, the proposed procedure solves sequentially the temperature and the density change (i.e., the temperature is solved first and then used to calculate the density change afterwards). In addition, the proposed FEA computational procedure is verified by comparing the predictions of the temperature and ablation histories of the pyrolyzing material with the predictions obtained from the well-validated ablation code FIAT. Furthermore, the model validation against existing experimental test results will also be presented.

New Approach for Describing Meso-scale Effects on Structural Behavior
Nitin Chandola, University of Florida

Abstract: It has been long recognized that the preferred orientation of the grains, arising from processing of metallic materials, result in anisotropic plastic behavior. An accurate assessment of the resulting plastic anisotropy is thus essential in predicting the mechanical performance of alloys. This paper presents a new approach for modeling polycrystalline behavior. A key aspect in the formulation is the use of the single-crystal yield criterion recently developed by Cazacu et al. (*Int. J. of Solids Struct.,* 2017) for the description of the plastic properties of the constituents grains. The capabilities of the polycrystalline model in predicting the directionality of macroscopic tensile properties are illustrated by comparing the theoretical prediction with mechanical data on steel sheets of various textures. There is a good agreement between experimental and theoretical predictions.

Thermal Degradation of Polymer Matrix Composites at Elevated Temperatures
Teja Konduri, University of Arizona

Abstract: Thermal degradation of polymers is a fundamental problem that needs to be studied to improve the design capabilities of thermal protection systems for hypersonic vehicles and space return vehicles, or composite structures under adverse loading conditions such as lightning strikes and laser ablation. The aim of this discussion is to present a computational framework to investigate the effect of thermal degradation on the effective thermo-mechanical properties of polymer matrix composites at elevated temperatures. The work is focused on generating micromechanics based models and leveraging Finite Element Analysis (FEA) to evaluate the overall thermal (thermal conductivity and specific heat), elastic, and thermo-mechanical (thermal expansion) properties of the structure, at temperatures where the thermal degradation of the polymer matrix essentially produces two new phases, namely pyrolytic phase and pores. These different phases have different thermal and mechanical properties which evolve with temperature, influencing the overall properties of the structure. The boundaries of these phases are not constant but are temperature dependent and need to be determined as a part of the solution. In our present work we focus on thermal degradation of unidirectional composites. Prelimianary results of these simulations are presented and compared with an existing semi-analytical modeling techniques to gauge our level of confidence in our model development.

1:00-2:30 Session C2 (Room 117)

Single Scene and Path Reconstruction of Moving and Stationary Objects Using a Moving Monocular Camera
Zachary Bell, University of Florida

Abstract: In many applications using inhabited and uninhabited vehicles, it is necessary to build models of the surrounding environment and avoid moving and stationary obstacles in that environment in real time. For example, if a ground vehicle is traveling through an environment it will need to avoid obstacles it cannot traverse over such as fallen rocks and tree limbs. As another example, if a small aerial vehicle is flying low in an environment to search for a target it will need to avoid buildings and trees while simultaneously estimating the targets state. Cameras provide an inexpensive and reliable way of reconstructing these environments in real time given some constraints. Previous results achieve exponential depth estimation of a feature with respect to the current view of the camera. However, this requires the use of acceleration measurements of the camera directly or the estimation of optical flow of the feature which both may have large amounts of noise. A newly developed result, [1], uses integral concurrent learning to have exponential estimation of the distance to a feature and exponential estimation of the path of the camera through the environment. The developed estimation technique removes the need of acceleration or optical flow measurements and instead only requires velocity measurements of the camera, which typically have less noise. This research focuses on extending the integral concurrent learning estimation technique developed in [1] to reconstruct moving targets and estimate the targets motion, i.e., the structure and motion from motion problem (SaMfM). A Lyapunov based stability analysis shows the developed estimator is globally uniform ultimate bounded. Simulation result demonstrate the performance of the developed estimator.
[1] Z. I. Bell, H. Chen, A. Parikh, W. E. Dixon, “Single Scene and Path Reconstruction with a Monocular Camera Using Integral Concurrent Learning”, to appear on the IEEE-CDC 2017.

Data-Based Approximate Optimal Regulation with Unknown Parameters and Control Fault
Patryk Deptula, University of Florida

Abstract: In regulation problems, the need to operate efficiently under system uncertainties plays an important part of robotic control. In many situations, systems are nonlinear and contain unknown parameters which makes controlling them difficult, especially when the system has a cost associated with its control actions. To estimate unknown parameters and control faults, a parameter estimator is developed using sampled data. Using a history stack of sampled data relaxes the typical persistence of excitation condition usually associated with parameter identification in adaptive control. Adaptive dynamic programming (ADP) is used to learn the approximate optimal control while the system is subject to control constraints. In ADP, parametric methods such as neural-networks are used to approximate the unknown optimal value function. A state-following (StaF) ADP approach is used where the basis functions have state varying centers which reduces the computational complexity compared to traditional ADP approaches. To approximate the unknown weights for the value function, Bellman Error (BE) extrapolation is used by selecting sample trajectories in a neighborhood of the state and evaluating the true BE at the sample trajectories.

Camera Pose Estimation Using Quaternions
Kaveh Fathian, University of Texas, Dallas

Abstract: We present a novel algorithm to estimate the motion of a camera from a sequence of images. The motion or pose of the camera consists of rotations and translations between consecutive image frames and can be estimated from matched feature points in the images. Most existing methods estimate the pose by first recovering the homography or essential matrix and then decomposing this matrix into a rotation and translation. These methods can suffer from the limitations of these matrices, since the homography matrix is defined only when feature points are coplanar in 3D space, and the essential matrix is ill-defined when the translation between the camera frames is small. Our formulation of the problem eschews the shortcomings of the existing methods by recovering the rotation and translation directly. Using both synthetic and real images, we have compared our method to the existing algorithms and established its merits. Source code of this algorithm is available to public and can be accessed online.

Runway Inspection using Multiple Quadrotor UAVs
William Warke, University of Texas, Dallas

Abstract: This research investigates a guidance and control method for autonomous inspection of runway damage using quadrotor UAVs. This method focuses on efficiency and scalability to multiple UAVs, and allows for a specified level of detail of inspection. It will operate on quadrotors possessing standard outdoor navigation stacks and downward-facing high definition video cameras, but may be augmented with ranging sensors such as LIDAR scanners. A Robot Operating System (ROS) simulation environment was tailored for design and validation of this method, complete with high resolution imagery of actual runway damage. Additionally, a quadrotor research platform was designed and constructed for implementation and feasibility analysis.

2:30-2:45 Coffee Break

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

High Speed Fluid-Thermal-Structural Interactions and Reduced Order Modeling
Emily Dreyer, Ohio State University

Abstract: The USAF desires reliable and high precision hypersonic vehicle systems. An inherent challenge is tracking and managing the associated strong, dynamic, fluid-structural and fluid-thermal interactions over extended operation in extreme environments, which requires multi-disciplinary computational frameworks that can expediently predict the aerothermodynamic loads in a coupled manner. This study focuses on this issue by assessing the accuracy and studying the impact of a computational fluid dynamics (CFD) surrogate approach that combines theoretical and data-driven models over a broad operational space. The data-driven element is supplied using Kriging interpolation over a set of steady-state Reynolds-Averaged Navier-Stokes (RANS) solutions. Here, the RANS solutions are generated using rigid deformations and isothermal wall conditions. As such, theoretical components are developed in order to accommodate both fluid-structural and fluid-thermal coupling with flight dynamics. The surrogate approach is benchmarked on a complete vehicle system against both CFD and basic engineering methods.

Unsteady Fluid-Structure-Jet Interactions of Agile High-Speed Vehicles
Ryan Kitson, University of Michigan

Abstract: This work considers the multidisciplinary effects that must be considered for high-speed vehicles designed for aggressive maneuvers over a wide range of flight conditions. Slender vehicle structures introduce additional flexibility that will couple with the external flow. In addition, the control system will interact with the external flow, rigid-body and structural response. This coupled aeroservoelastic problem is analyzed with high-fidelity computational fluid dynamics simulations to understand the various interactions and aid in engineering model development. Time-accurate dynamic results will be presented that provide insight into the various degree of coupling between interactions. A reduced order model is developed based on the high-fidelity results that enables rapid, robust, and accurate simulation of the fully coupled system.

Thin Cylinder Structural and Aerodynamic Modeling

James Clinton, Georgia Institute of Technology & John Moran IV, California State University, Chico

Abstract: High speed vehicles experience high energy, combined loading due to aerothermodynamics and structural response which drive complex fluid-thermal-structural interactions. These fluid-thermal-structural interactions introduce uncertainty in the loads and performance due to their path-dependent nature. Analysis of these vehicles requires solution of the coupled fluid, thermal and structural equations at disparate time scales. In this work, a thin cylinder model and grid are created using open source Finite Element Analysis (FEA) software. The modal frequency and shape characteristics are captured and compared to previously conducted physical experiments and theoretical studies. Using quadratic S6 triangular shell elements, the results are shown to be consistent with previous work. Stress stiffening effects due to internal pressurization are also investigated. This has been shown to strengthen the cylinder and increase the resonant frequencies observed in computational testing. The new model will be used to analyze the flutter envelope of the pressurized cylindrical panel exposed to high-speed hypersonic flow. Once high-fidelity simulations have been completed, the data set will be used to construct reduced-order models capable of modeling the coupled system at off- design conditions.

Towards the Design of Optimal Trajectories on Reduced Dimensional Manifolds

Michael Sparapany, Purdue University

Abstract: Trajectory optimization algorithms fall under one of two categories: direct and indirect methods. Direct methods solve the problem as explicitly stated, whereas indirect methods rephrase the problem as a Two-Point Boundary-Valued Problem (TPBVP). The latter carries the structure of a Hamiltonian system on a symplectic manifold, (M, ω), and the former does not.

For Hamiltonian systems, Noether's Theorem guarantees the existence of symmetries and constants-of-motion in a one-to-one correspondence and Poisson's Theorem guarantees constants-of-motion form a finite-dimensional Lie algebra, $\mathfrak{g} = \text{span}(f_1, f_2, \cdots, f_n)$, under the Poisson bracket, $\{f_i, f_j\} = c_{ij}^k f_k$. In the involutive case, $c_{ij}^k = 0$, the results of Marsden, Weinstein, and Meyer necessarily state that the Lie group of $\mathfrak{g}$, G, acting symplectically on (M, ω) reduces its dimension. The moment map of the G-action on M, is $\mu : M \to \mathfrak{g}^*$ and reduction is performed at level r such that the reduced symplectic manifold is $M_r = \mu^{-1}(r)/G = M//G$. In the non-involutive case, $c_{ij}^k \neq 0$, the result of Mishchenko and Fomenko necessarily states that a Lie subalgebra, $\mathfrak{h} = \{h \in \text{Ad}_h^* r = 0\} \subseteq \mathfrak{g}$ may be used in place of $\mathfrak{g}$. For the Lie group of $\mathfrak{h}$, H, the reduced manifold is $\mu^{-1}(r)/H$.

The purpose of this presentation is to present the progress made in Computer Algebra Systems (CAS), problem formulations, and numerical algorithms that are ultimately in support of constructing optimal trajectories on reduced dimensional manifolds in a coordinate-free system. Results on $\mu^{-1}(r)$ are presented, and initial work towards algorithms on $\mu^{-1}(r)/G = M//G$ (or $M//H$ in the non-involutive case) are discussed.

2:45-4:15 Session D2 (Room 117)

Health Monitoring of Autonomous Systems under Uncertain Initial Conditions
Alejandro White, North Carolina A&T University

Abstract: The developed novel diagnosis tool, so called diagnoser, is a discrete event system (DES) that is able to detect and isolate a system?s fault occurrences without the knowledge of the system?s past behavior. This allows the diagnoser to asynchronously begin its diagnosis of a system's behavior at any time instance of system operation (including post fault occurrence); consequently removing the generally required synchronous initialization between a diagnoser and the system under diagnosis. The necessary and sufficient conditions are derived for the diagnosability of a given DES plant under this asynchronous situation. Also, an upper-bound is found for the maximum delay (the number of system state transitions after the activation of the diagnoser) for diagnosis of faults in an asynchronously diagnosable DES plant model. An example showing the application of the asynchronous diagnoser to the flight operation of an unmanned autonomous vehicle (UAV) is provided to illustrate the details of the proposed diagnosis framework.

Control of Human-in-the-Loop Systems with Input Delay
Mackenzie Matthews, North Carolina A&T University

Abstract: Shared control is a class of human-in-the-loop robotic systems where a human operator and an autonomous controller simultaneously affect the states of a robotic system to achieve desired objective. Shared control systems are inherently subjected to input delays due to latencies in human perception and actuation. The delay can vary based on the complexity of the process and human factors, and hence the delay magnitude can be considered to be unknown and time-varying. The objective of this research is to develop a robust autonomous controller using shared control architecture to compensate for the human input delays. Specifically, robust PID controllers with neural network estimator are being investigated to identify and compensate for the unknown time-varying input delay. Simulation results are provided to demonstrate the behavior of a system with first-order integrator dynamics subjected to constant and time-varying human input delay. Future work will include experimental validation of the developed controller using iRobot Create. The shared controller will be implemented in Robotic Operation System (ROS) while the delay will be estimated using MATLAB/Simulink. Furthermore, a robotic system may not be co-located with the human/controller (e.g., in telerobotics). In such scenarios, the control input will often be communicated to the system over a network channel (wired or wireless). The network channel introduces additional input delays which can be unknown and time-varying. Leveraging on the ongoing efforts, a robust shared controller will be developed to guarantee stability of the networked shared control system.

An Inexpensive Ground Vehicle Platform for Formation Control, Formation Monitoring, and Camera Pose
Landen Blackburn, University of Utah & Valentina Catanho, University of Florida

Abstract: This work extends previous research in the fields of formation control, formation monitoring, and camera pose estimation. An inexpensive, robust, open-source, ground-vehicle platform was developed to test formation and camera pose algorithms outside of simulation. This ground-vehicle platform can be paired with other similar platforms and controlled with either a centralized or a decentralized control system. Although GPS could be used if outdoors, ground robots more often function in GPS-denied environments, so an indoor ultrasonic positioning system was used. The resulting network of ground-robots can also be paired with Unmanned Aerial Vehicle (UAV) and additional sensors for various research scenarios. Overall, the system proves to be robust and inexpensive, while providing reliable data for physical implementation of various algorithms.

Inter-Vehicular Video Quality Assessment via EXata Emulations

Debashri Roy, University of Central Florida

Abstract: Availability of real time video streams capturing surrounding road conditions can not only aid automobile drivers and autonomous vehicles, they can also enhance road safety and improve traffic efficiency. However, provisioning of such services is challenging due to the harsh operational environments and stringent resource requirements of the applications. Nevertheless, radio access technologies like IEEE 802.11p, LTE, and LTE Direct have provisions for supporting real time streams for inter-vehicular communications. Moreover, guaranteeing quality of service (QoS) for inter-vehicular communication is a challenge due to the i) inherent wireless channel characteristics and ii) high mobility of the source and destination vehicles. The problem is even more aggravated for *real time* video transmissions because of the strict delay and bandwidth requirements.

The main objective of this project is to show the feasibility, or the lack thereof, of attaining inter-vehicular video streaming with high vehicular speeds with realistic wireless channel models. To that end, we model and emulate the performance of three networks: IEEE 802.11p, LTE, and LTE Direct using EXata which is a network emulation platform based on QualNet. We emulate Rayleigh and Ricean channels that closely mimic congested urban areas and highway respectively. We explore the radio and network parameters under which it is possible to stream uninterrupted video over these networks. We use the H.264 codec for encoding primarily 360p and 480p videos at 24 frames per second. The data traffic thus generated was streamed using real-time transport protocol. As for assessing the quality of the video, we use two metrics: Peak signal-to-noise ratio (PSNR) and Structural SIMilarity (SSIM) index. Analysis of such video quality parameters allows us to determine the best network protocols, safe communication ranges, inter-vehicular distances, their relative speeds, coding rates, supported bandwidth, and video resolutions. EXata emulations demonstrate to what extent these networks are able to sustain real-time video streaming for vehicle-to-vehicle communication. The emulation was done for varying encoding rates, relative speeds between vehicles, and inter-vehicular distances. We also find the link layer throughput that these networks can support. The results reveal that LTE Direct performs better than IEEE 802.11p, which in turn performs better than LTE. This study also provides insights into how to configure the radio and network parameters for delivering streaming services to vehicular networks.

Wednesday, August 2

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

Cyber Attacks in Online Social Networks through Socialbots
My T. Thai, Professor, University of Florida

Abstract: With a huge amount of personal information ripe for the taking in modern Online Social Networks (OSNs), privacy breaches have become a central concern, especially with an introduction of automated attacks by socialbots, which can automatically extract victims? private content by exploiting social behavior to befriend them. In this talk, we explore the social strategies of socialbots and see how they can harvest the most of private information using at most k friend requests, modeled as Max-Crawling. The two main challenges of this problem are how to cope with incomplete knowledge of network topology and how to model users? responses to friend requests. Accordingly, we present an adaptive approximation algorithm using adaptive stochastic optimization. The key feature of our solution lies in the adaptive method, where partial network topology is revealed after each successful friend request. Thus the decision of whom to send a friend request to next is made with the outcomes of past decisions taken into account. Traditional tools break down when attempting to place a bound on the performance of this technique with realistic user models as it is no longer submodular. Therefore, we additionally introduce a novel curvature-based technique to construct an approximation ratio of for a model of user behavior learned from empirical measurements on Facebook.

9:45-10:00 Coffee Break

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

Network Analysis of Social Media Portal VK.com
Vladimir Boginski, University of Central Florida

Abstract: We present the study of the social network of VK.com (also known as VKontakte), which is the largest European (mainly Eastern-European) social portal, with over 300 million nodes. We analyze several aspects of the VK network structure, including its global connectivity patterns and community composition and draw conclusions about the "social media landscape" of Eastern Europe and the so-called post-Soviet space. This is a joint work with A. Semenov and J. Veijalainen (University of Jyväskylä, Finland), A. Mantzaris (University of Central Florida), A. Nikolaev (University at Buffalo), A. Veremyev (University of Florida), and E.L. Pasiliao (AFRL).

Analysis of Dynamics of Blockchain Peer-to-Peer Network Topologies
Alexander Semenov, University of Jyväskylä, Finland

Abstract: The goal of the present research is to investigate vulnerability and robustness of peer-to-peer (p2p) network topologies formed by blockchain. Blockchain is a distributed database that maintains a continuously growing list of records (blocks) linked to each other. Blockchain database is secure by design, and

once the block is recorded there, it cannot be modified retroactively. Blockchain relies on a p2p network without any central coordinating node; each node of the network may access entire blockchain database. The first conceptualization of blockchain was presented in 2008 in a paper that introduced Bitcoin cryptocurrency. Since 2008 market cap of Bitcoin grew, and other blockchain based cryptocurrencies appeared. We developed a crawler-like software capable to gather entire p2p network formed by Bitcoin, and collected nearly 50 snapshots of the network over the period of one month. We present detailed analysis of topologies of these networks, explore their robustness properties, and investigate the dynamics.

Exact Algorithms on Reliable Routing Problems under Uncertain Topology Using Aggregation Techniques for Exponentially Many Scenarios
Qipeng “Phil” Zheng, University of Central Florida

Abstract: Network routing problems are often modeled with the assumption that the network structure is deterministic, though they are often subject to uncertainty in many real-life scenarios. In this paper, we study the traveling salesman and the shortest path problems with uncertain topologies modeled by arc failures. We present the formulations that incorporate chance constraints to ensure reliability of the selected route considering all arc failure scenarios. Due to the computational complexity and large scales of these stochastic network optimization problems, we consider two cutting plane methods and a Benders decomposition algorithm to respectively solve them.We also consider to solve the reformulations of the problems obtained by taking the logarithm transformation of the chance constraints. Numerical experiments are performed to obtain results for comparisons among these proposed methods.

11:30-1:00 Luncheon

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

Hybrid State Estimation Applied to Adversarial Team Monitoring
Michael McCourt, University of Florida

Abstract: This research direction is motivated by the problem of two adversarial networked teams that collect information about each other and make decisions based on this information. The decision making criteria is assumed to be given but may be according to team or individual agent cost functions or a game theoretic approach. Some applications of this research direction include network security, economic decision making, and robotic soccer. From the perspective of one team, the quality of decision making can be improved with better methods of aggregating available measurements of the other team and estimating unknown information about that team. This paper presents an approach for estimating the underlying strategy of an opposing team based on limited observations. This includes estimating continuous states of the other team (position, velocity, etc.) as well as discrete states which can be agent behaviors or collective team strategies. Combining these continuous and discrete states, the opposing team can be modeled as a hybrid system with continuous and discrete measurable outputs. A sequential estimation algorithm is developed which simultaneously estimates both continuous and discrete states. An example is provided which illustrates the application of this algorithm to estimating the formation of an opposing team from incomplete information.

Sensor Compromise Detection in Multi-Target Tracking Systems
J. Pablo Ramirez-Paredez, University of Florida

Abstract: Tracking multiple targets using a single estimator is a problem that is commonly approached within a trusted framework. There are many weaknesses that an adversary can exploit if it gains control over the sensors. Since the number of targets that the estimator has to track is not known with anticipation, an adversary could not only cause loss of information or a degradation in tracking precision, but also the introduction of false targets, which would result in a waste of computational and material resources depending on the application. We study the problem of detecting compromised or faulty sensors in a multiple target tracker, starting with the single sensor case and then considering the multiple sensor scenario. Then, we consider the conditions for detecting some of the possible attacks on the estimator. Finally, we offer an algorithm to detect a variety of attacks in the multi-sensor case, via the application of finite set statistics (FISST) and consensus estimation concepts.

Landmark Identification Using Magnetic Fingerprints
Grant Huang, University of Florida

Abstract: Nowadays, many applications offer location-based services (LBS) enabled by satellite based positioning technologies such as the U.S. global positioning system (GPS) and other global navigation satellite systems (GNSSs). Standalone GPS/GNSS receivers perform well outdoor with a clear view of sky, while assisted-GPS/GNSS (A-GPS/GNSS) and other hybrid solutions help receiver operations in signal challenging areas. However, positioning technologies have been reported their vulnerability to potential security risks, such as spoofing and jamming threats. The issue of providing reliable location information should be addressed particularly in life-critical applications. This work presents a signboard-like GNSS-free methodology to address this issue by identifying target landmarks using location-dependent geomagnetic fingerprints in potential spoofing environments. The measurement campaign employs a cost-efficient sensor, mobile phone with built-in magnetometers, to capture geomagnetic fingerprints, including all location-dependent fluctuations and anomalies of geomagnetic fields from both natural and man-made sources on a traveling vehicle. This methodology can serve as an additional layer of integrity validating supports in the-state-of-the-art GNSS receivers.

Bioinspired Magnetic Navigation Using Magnetic Waypoints
Brian K. Taylor, AFRL

Abstract: Diverse taxa use Earth's magnetic field in conjunction with other sensor modes to accomplish navigation tasks that range from local homing to long-distance migration across continents and ocean basins. However, despite extensive research, animal magnetoreception remains a poorly understood, and active research area. Concurrently, Earth's magnetic field offers a signal that engineered systems can leverage for navigation and localization in environments where man-made systems such as GPS are either unavailable or unreliable. Using a proxy for Earth's magnetic field, and inspired by migratory animal behavior, this work implements behavioral strategies to navigate through a series of magnetic waypoints. The strategies are able to navigate through a closed set of points, in some cases running through several "laps". Successful trials were observed in both a range of environmental parameters, and varying levels of sensor noise. The study explores several of these parameter combinations in simulation, and presents preliminary results from a version of the strategy implemented on a mobile robot platform. Alongside success, limitations of the simulated and hardware algorithms are discussed. The results illustrate the feasibility of either an animal, or engineered platform to use a set of waypoints based on the magnetic field to navigate. Additionally, the work presents an engineering/quantitative biology approach that can garner insight into animal behavior while simultaneously illuminating paths of development for engineered algorithms and systems.

1:00-2:30 Session C2 (Room 117)

Community Detection in a Temporal Network
Jongeun Kim, University of Florida

Abstract: Detecting a community in a network is one of the major problems in network analysis. Although most of works have been done in a static network, most of real-world networks are not static and keep changing in time. Connections in a network are not continuously active. We define interactive community which every member in a community is able to reach to others. A mixed-integer formulation to find the maximum cardinality interactive community is proposed and we suggest an iterative method for large instances.

Vulnerability of Interdependent Networks Under Heterogeneous, Multi-Timescale Cascade
Tianyi Pan, University of Florida

Abstract: The vulnerability of interdependent networks has recently drawn much attention. Yet, most of the existing works only considered a single cascade model with fixed networks. Thus, the existing works can hardly depict the actual networks and there is a need for more accurate models and analysis. In this paper, we aim at accurately analyzing the vulnerability in the interdependent power/communication networks. However, as the networks follow heterogeneous cascade models, it is challenging to even calculate the cascade failures, as it requires the interplay among different models, as well as understanding the features of each model, not to say analyzing the vulnerability. Also, including timescales into the context can further increase the complicacy of network interdependency. To better depict the vulnerability of complicated interdependent networks, we first propose an SVM based method to learn a deterministic threshold (DLT) diffusion model from historical cascade data in the power network and alleviate the need of calculating complicated power network dynamics. Next, we introduce message passing equations to generalize the DLT model in the power network and the percolation model in the communication network. Then we analyze the vulnerability of the network by revealing the most critical nodes based on efficiently solving the linearization of the equations. We demonstrate the efficiency of the proposed solution in various datasets.

Parameter Inference for Optimal Decentralized Network Formation using a Continuous-Time Actor-Oriented Model
Abhinav Perla, University at Buffalo

Abstract: Network formation problems have typically assumed complete network information, which is not always practical. Usually, the actors in a network have access to partial information, i.e., the information about its local neighborhood – this could potentially arise when establishing a communication network between actors (e.g., Unmanned Aerial Vehicles) that either do not have access to the central hub or prefer not to use this transmission channel. Under this setting, we propose a continuous-time actor-oriented model that describes the behavior of autonomous agents. We analyze the steady state of the networks formed using this model and track the objective function based on the number of edges in the network and the average closeness centrality. Optimal model parameters are found which minimize the objective function and lead to a robust communication network structure.

Stochastic Programming for Facility Location Problem with Lagrangian Relaxation and Subgradient Method
Mengnan Chen, University of Central Florida

Abstract: This project is based on facility location problem with decision dependent assignment. We model this problem as a two-stage optimization problem. In the first stage, depending on the customs' preferences,

which is relative to their characteristics and provider's attributes, we want to find the best providers scheduling to satisfy the customs demand. In the second stage, for different we match customs' preferences and providers scheduling. Using discrete choice model, we estimate the probability for customs preferences. Let the scenario is the different combination of customs' preferences, then we can develop a stochastic mixed-integer programming to solve the facility location problem. The numerical study is in healthcare system which is involved with patient, physician and location clinics, which is a large-scale problem. To reduce the computation complexity, we firstly use Benders decomposition to separate the scenarios to different subproblem, then relax the subproblem by using Lagrangian decomposition to add complicating constraints to the objective function.

2:30-2:45 Coffee Break

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

Interferometric Enhancement for Forward-Looking Synthetic Aperture Radar Target Imaging
Matthew Burfeindt, AFRL

Abstract: Forward-looking synthetic aperture radar (SAR) is a technique for forming radar images when the imaging scene is near the radar velocity vector, i.e., when the squint angle approaches 90°. Geometrical data estimated from extreme high-squint SAR imagery can be used for a variety of applications, including forward-looking reconnaissance or obstacle avoidance.
Two-dimensional SAR images of three-dimensional structures necessarily suffer from a loss of target geometrical information. Interferometric SAR is a technique for overcoming this limitation that involves forming coherent images for multiple spatially separated receivers and using the scatterer response phase differences between images to estimate the elevation coordinates for each of the target's scattering features.
In a forward-looking data collection geometry, the range from radar to the imaging scene may change significantly as the radar moves through the synthetic aperture. The phase relationship between receivers will therefore also change significantly on a pulse-by-pulse basis. This changing phase difference will impose a relative slow-time phase modulation between the receivers. After slow-time compression, the modulation may result in a phase difference between receiver target images that differs significantly from the conventionally expected relationship.
We present a technique for interferometric SAR processing that explicitly takes into account the change in range to the target on a pulse-by-pulse basis, thereby significantly reducing interferometric error associated with high squints and long synthetic apertures. We formulate a cost function for the difference between the interferometric phase extracted from the processed images and a back projection-based model. We then use Gauss-Newton optimization to solve for the elevation that minimizes the cost function. We apply both the proposed technique and the conventional interferometric technique to simulated SAR data acquisitions using both point scatterers and extended scatterers as imaging targets. The results show that the conventional technique, as expected, suffers from significant estimation errors as the synthetic aperture length or scatterer elevation increase. The proposed technique, in contrast, is robust to synthetic aperture length, scatterer elevation, and unknown scatterer dimension.

Nonlinear Adaptive Control of an Air-to-Air Missile Using Closed-Loop Reference Models
James Cloutier, AFRL

Abstract: An adaptive nonlinear autopilot is designed to control an air-to-air missile. The autopilot uses closed-loop reference models in the outer and inner loops. The autopilot is developed from the nonlinear system dynamics and the state-dependent Riccati equation (SDRE) method of nonlinear control is used to stabilize the reference models. The autopilot is evaluated in a six-degrees-of-freedom simulation using acceleration command doublets and performance and robustness results are presented.

On a Calibration of a Reaction Rate Model for Explosive by a DSD-informed Method
Sunhee Yoo, AFRL

Abstract: The theory of detonation shock dynamics (DSD) applies to a model of an explosive with a specified reactant equation of state (EOS), products EOS, and a reaction rate law for reaction progress variable for the change from reactants to products. Given the assumed forms for the EOS, closure for the components and reaction rate law, a "DSD-informed" calibration uses experimental shock Hugnoiot data, plane shock initiation data, and shock curvature data and or diameter effect data. It has been found that DSD-informed reactive flow models are predictive of experimentally observed shock dynamics over a wide-range of conditions, once determined [1,2]. This paper discusses how to calibrate the EOS and reaction rate of Ignition & Growth (I&G) coupled with the reactive flow model. Previous methods of calibration generated a detonation shock speed, curvature relation (D-kappa) from theory and compared with an experimentally determined D-kappa relation. Our new procedure generates a shock shape across a rate stick from theory and compares it with shock shapes obtained from experiments. The procedure is carried out based on the sensitivity of completion term in the I&G model to D-kappa relation and of the reactant equation of state to the local shock shape at wall in a cylindrical explosive.
References:
[1]. David E. Lambert, D. Scott Stewart, Sunhee Yoo and Bradley L. Wescott, "Experimental validation of detonation shock dynamics in condensed explosives,? *J. Fluid Mech.,* 546, 227-253, (2006).
[2]. B. L. Wescott, D. Scott Stewart and W. C. Davis, "Equation of state and reaction rate for condensed-phase explosives," *J. Appl. Phys.,* 98, 053514 (2005).

Distributed Stochastic Gradient Descent for Big Data Analytics
Liqiang Wang, University of Central Florida

Abstract: The proliferation of massive datasets and necessity of interpreting and analyzing big data have enabled a wide variety of novel distributed platforms such as Hadoop and Spark. It is becoming increasingly important to implement big data analytics and machine learning algorithms on top of these distributed platforms. However, a major challenge to support these complex algorithms on parallel and distributed platforms is the expensive iterative processes because of time-consuming data synchronization and communication, especially on big data computing systems like Hadoop and Spark. MLlib is Spark's scalable library consisting of common machine learning algorithms, many of which employ Stochastic Gradient Descent (SGD) to find minima or maxima by iteration. However, the computation could be very slow if the gradient data are synchronized on each iteration.
In this work, we optimize the original implementation of SGD in Spark's MLlib to reuse each partition multiple times in one iteration to find a better candidate weights. The number of local iterations with each partition is determined by the 68-95- 99.7 rule, which is used to decide if the data have normal (bell-shaped) distribution. We also design a variant of momentum algorithm to find the optimal step size on every iteration.

This method uses a new adaptive rule that decreases the step size whenever the neighboring gradients have been shown in different directions. The experiments show that our algorithm is more efficient and reaches convergence faster than the MLlib library.

Thursday, August 3

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

An Introduction to Recurrent Neural Networks and Reinforcement Learning
Adrian Barbu, Associate Professor, Florida State University

Abstract: This talk will present an overview of Recurrent Neural Networks, the main issues concerning their design and two architectures that address these issues: LSTM (Long Short Term Memory) and GRU (Gated Recurrent Unit). It will also present some interesting applications in language modeling. The second part of the talk will go over the main problem of reinforcement learning and how deep learning was used in this context to train a competitive algorithm for playing Go.

9:45-10:00 Coffee Break

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

Cascade Prediction in Social Networks via Euclidean Embedding
Wondi Geremew, Stockton University

Abstract: This paper develops a Euclidean embedding approach for explaining and predicting the propagation of information cascades in social networks. The designed model casts social media content-sharing individuals into the space of latent features reflecting the individuals' interests, and thus, traits of the content they will tend to post and repost. The likelihood optimization problem, formulated to fit the model to observed cascade diffusion data, employs a difference of convex functions (DC) methods. Experimental results, reported with both synthetic and large-scale real world data, showcase the strong predictive power of the model.

Integrated Network Flows Optimization and Scheduling in Time-expanded Layered Networks with Applications to the Health Internet-of-Things
Alla Kammerdiner, New Mexico State University

Abstract: The Internet-of-Things can greatly reduce costs and improve health outcomes of chronic disease. Through use of the Internet-of-Things in healthcare, the focus of improving healthcare services and operations will change from managing doctors and caregivers to managing devices and data. Despite advances in wearable sensors technologies, sensors and other devices in the health Internet-of-Things applications have limitations in energy and storage capacities, processing capabilities, and lifetime. In fact, a key operational challenge in the context of the health Internet-of-Things is managing tradeoff in limited power and storage of sensing devices and the need for continuing surveillance of vital indicators of patient's health. We formulate the problem of simultaneously deciding when to recharge or replace sensors and how to send sensor data from the patients as the integrated network flows and scheduling problem. The problem belongs to an emerging class of mixed-integer programming problems that integrate scheduling decisions and network flow optimiza-

tion decisions. We construct and solve some small instances of this computationally challenging problem. The health Internet-of-Things is a new application domain for the integrated network flow and scheduling problems.

Acceptable Risks and Related Decision Problems with Multiple Risk-averse Agents
Getachew Befekadu, NRC & University of Florida

Abstract: In this talk, we consider a risk-averse decision problem for systems governed by controlled-diffusion processes, with dynamic risk measures, in which multiple risk-averse agents make their decisions in such a way to minimize their individual accumulated risk-costs over a finite-time horizon. In particular, we introduce multi-structure dynamic risk measures induced from conditional g-expectations, where the latter are associated with the generator functionals of certain BSDEs that take into account the risk-cost functionals of the agents. Here, we also assume that the solutions for such BSDEs *almost surely* satisfy a stochastic viability property w.r.t. a certain given closed convex set. Moreover, using a result similar to that of the Arrow-Barankin-Blackwell theorem, we establish the existence of consistent optimal decisions for the risk-averse agents, when the set of all Pareto optimal solutions, in the sense of viscosity, for the associated dynamic programming equations is dense in the given closed convex set. Finally, we briefly comment on the characteristics of acceptable risks vis-á-vis some uncertain future costs or outcomes, where results from the dynamic risk analysis constitute part of the information used in the risk-averse decision criteria.

11:30-1:00 Luncheon

1:00-1:45 Plenary Session C (Auditorium)

Networks (and Data Science) in Brain Research
Panos M. Pardalos, Distinguished Professor, University of Florida

Abstract: Biomedical Informatics is the interdisciplinary science of acquiring, structuring, analyzing and providing access to biomedical data, information and knowledge. Some of the basic tools of Biomedical Informatics include optimization, networks, control, data mining, and knowledge discovery techniques. In this talk we are going to cover a spectrum of biomedical problems in computational neuroscience.

1:45-2:00 Coffee Break

2:00-3:30 Session D1 (Auditorium)

RSSI-Based Supervised Learning for Uncooperative Direction-Finding
Tathagata Mukherjee, Intelligent Robotics

Abstract: This paper studies supervised learning algorithms for the problem of uncooperative direction finding of a radio emitter using the received signal strength indicator (RSSI) from a rotating and uncharacterized antenna. Radio Direction Finding (RDF) is the task of finding the direction of a radio frequency emitter from which the received signal was transmitted, using a single receiver. We study the accuracy of radio direction finding for the 2.4 GHz WiFi band, and restrict ourselves to applying supervised learning algorithms for RSSI information analysis. We designed and built a hardware prototype for data acquisition using off-the-shelf hardware. During the course of our experiments, we collected more than three million RSSI values. We show that we can reliably predict the bearing of the transmitter with an error bounded by 11 degrees, in both indoor and outdoor environments. We do not explicitly model the multi-path, that inevitably arises in such situations and hence one of the major challenges that we faced in this work is that of automatically compensating for the multi-path and hence the associated noise in the acquired data.

Hierarchical Learning For FM Radio Based Aerial Localization Using RSSI
Andreas Adolfson, Intelligent Robotics

Abstract: Received Signal Strength Indicator (RSSI) based large scale positioning systems are beginning to gain traction as coarse positioning systems when GPS is unavailable. In this paper we present a system for automatic positioning of an unmanned aerial system using broadcast FM radio. Our method is data driven, and uses machine learning techniques to improve its accuracy. The techniques are easy to extend to other terrestrial static radio transmitters. Using our algorithms, we can localize with a minimum error of 172 meters and mean error less than 3000 meters.

Image Based Localization Using Deep Learning & Compound-Eye Approach
Orhan Akal, Florida State University

Abstract: Convolutional neural networks(CNN) have been employed by researchers in the last few years in the field of computer vision for image based localization, classification, detection and segmentation purposes. Among those four, the need for image based localization has been skyrocketed in recent years because self-driving cars, unmanned aerial vehicles(UAV)s etc needs accurate location information to maneuver to the targeted point, especially in GPS denied locations. Image based localization can be described as approximating the location and orientation of the device at the time of query image is taken based on location of the features in the query image and regressing it with the location of the same features on training images. Researchers have been using CNN with stereo camera images for localization. We employed CNN to do the same at an indoor environment using 4 non-stereo camera images and training on compound eye which is combination of 4 camera images and treating it as a single camera image.

Video Streaming over SDR for Enhanced QoE: From Theory to Practice
Debashri Roy, University of Central Florida

Abstract: Guaranteeing quality of service (QoS) over wireless networks has always been a challenge due to the inherent wireless channel characteristics. The problem is even more aggravated for real time video transmissions since it requires strict delay and bandwidth requirements. Moreover, the limited bandwidth available for cellular and WiFi networks, energy constraints in mobile devices, and time-varying characteristics of wireless channels, are becoming a bottleneck for high bandwidth requirement of HD videos. Though the concept of dynamic spectrum access (DSA), facilitated by Software defined radios (SDR), provides some relief to the bandwidth shortage problem, it is yet to be seen if end users would be happy with high quality video transmissions over wireless networks. Also, use of feedback loops and real-time adaptation to changing network and radio conditions remain an implementational challenge.

In this project, we proposed source and channel adaption models with a feedback control mechanism from the receiver to the encoder for it to adapt the coding parameters e.g., encoding bitrate, frame-rate for better video quality experience. The objective of the proposed adaption technique is to keep the video streaming

uninterrupted by changing source coding parameters based on channel conditions at the receiver. Our novelty lies in modifying the H.264 codec to continuously tune parameters at any time granularity. Though such extremely fast adaption is desirable, we are limited by the hardware capabilities. Thus, instead of changing the encoding rates with the slightest channel fluctuations, we use a multi-level threshold based mechanism for determining the encoding rate. The multi-level threshold is based on the probability density function of the received power at the receiver. Moreover, we tune the transmitting frequency to the most desirable channel between the transmitter-receiver pair based on the spectrum energy sensing reports at the receiver. If the current channel is found to be noisy, then the transmitter and receiver hop to another channel.
Our theoretical propositions have been validated on an experimental testbed using universal software radio peripheral (USRP) and GNU Radio. We used the 902 - 928 MHz ISM band to create 26 channels of 1 MHz each. Live video captured via a webcam was encoded using open source software libraries as H.264 encoders and streamed using Gstreamer. The video transport streams were transmitted using USRP B210. Gaussian Minimum Shift Keying (GMSK) modulation with omni-directional antennas were used. The encoding rate and the transmitting frequency were changed based on the feedback form the receiver. We used two objective metrics (PSNR and SSIM) and one subjective metric (MOS) to measure the video quality. Results show that the proposed source and channel adaption techniques are able to substantially improve the quality of video displayed at the receiver.