

# **4<sup>th</sup> Semiannual Workshop on Control Systems**

**THE FACULTY OF ENGINEERING AND COMPUTER SCIENCE**

**CONCORDIA UNIVERSITY**

**May 12-13, 2011**

The Control Systems Chapter of the IEEE Montreal Section in conjunction with Concordia University held a two-day workshop for the student authors of the 2011 American Control Conference. Students who had accepted paper in this conference were given the opportunity to present their papers to other local students and researchers in this workshop. Two invited speakers (as well as some professors from local universities) were present to give feedback to the students to improve their presentations. The student presentations were held in exactly the same time-frame as the real conference, with just five added minutes for discussion and feedback from the audience and the invited speakers, who started the workshop on each day with a one-hour presentation. Partial funding up to \$300 was provided to the students (from IEEE Control Systems Society under Outreach Program) to facilitate the transportation for those students coming from other cities.

About 35 people attended each presentation of the workshop: 11 student authors, 21 researchers from Montreal area, and two invited speakers from the US. Four of the student authors were from Montreal area, and seven of them from other cities. The invited speaker for the first day was Dr. Mehran Mesbahi, Professor of Aeronautics and Astronautics at the University of Washington. Five student authors also presented their papers in the first day of the workshop. Dr. Reza Olfati-Saber, Assistant Professor of Engineering at the Thayer School of Engineering, presented the first talk of the second day of the workshop, followed by 6 student presentations.

# **4<sup>th</sup> Semiannual Workshop on Control Systems**

**THE FACULTY OF ENGINEERING AND COMPUTER SCIENCE  
CONCORDIA UNIVERSITY  
May 12-13, 2011**

## **SPONSORS**

The Faculty of Engineering and Computer Science, Concordia University  
IEEE Montreal Section  
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## **ORGANIZING COMMITTEE**

Amir G. Aghdam (Chair)  
Amir Ajorlou (Co-Chair), Mohammad Mehdi Asadi (Co-Chair),  
Hamid Mahboubi (Co-Chair)

# Program Summary

May 12-13, 2011

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**Thursday May 12**

**Place: EV11.119, Concordia University, 1515 St. Catherine W. Montreal, QC H3G 2W1**

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12:00pm to 1:00pm - Lunch

**Seminar 1** - 1:00pm to 2:30pm

**Invited Speaker: Dr. Mehran Mesbahi**

“Towards a System Theory on Networks”

**Seminar 2** – 2:30pm to 3:00pm

**Mr. Syed Ali Abbas Zaidi**

“Sufficient Conditions for Closed-Loop Control Over a Gaussian Relay Channel”

**Seminar 3** – 3:00pm to 3:30pm

**Mr. Xiaosong Lu**

“Decentralized Learning in Two-Player Zero-Sum Games: A LR-I Lagging Anchor Algorithm”

**Seminar 4** – 3:30pm to 4:00pm

**Mr. Ashraf Ul Haque**

“Comparing the Performance of Three Soft Computing Algorithms for Short-term Wind Speed Forecasting”

**Seminar 5** – 4:00pm to 4:30pm

**Ms. Mahsa Golkar**

“Convergence Analysis and Controller Design for a Team of Mobile Robots Subject to Measurement Error”

**Seminar 6** – 4:30pm to 5:00pm

**Mr. Amir Ajorlou**

“A Connectivity Preserving Containment Control Strategy for a Network of Single Integrator Agents”

**Friday May 13**

**Place: EV11.119, Concordia University, 1515 St. Catherine W. Montreal, QC H3G 2W1**

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9:15am to 9:30am - Light Breakfast

**Seminar 1** - 9:30am to 11:00am

**Invited Speaker: Dr. Reza Olfati-Saber**

“Cooperative Autonomous Driving for Vehicular Networks”

**Seminar 2** – 11:00am to 11:30am

**Dr. Ahmadreza Momeni**

“Relaxed Convergence Conditions for Multi-Agent Systems under a Class of Consensus Algorithms”

**Seminar 3** – 11:30am to 12:00pm

**Mr. Kian Jaleleddini**

“An Identification Algorithm for Hammerstein Systems Using Subspace Method”

12:00pm to 1:00pm - Lunch

**Seminar 4** – 1:00pm to 1:30pm

**Mr. Hadi Zibaeenejad**

“A Framework for Blocking Analysis in Ring Networks of Arbitrary Size”

**Seminar 5** – 1:30pm to 2:00pm

**Mr. Wujie Chao**

“Representation of Supervisory Controls using State-Tree Structures, Binary Decision Diagrams, Automata, and SupervisorReduction”

**Seminar 6** – 2:00pm to 2:30pm

**Mr. Ali Asadian**

“Dynamic Modeling of Distributed Friction in Needle-Tissue Interaction with Applications to Needle Steering in Percutaneous Interventions”

**Seminar 7** – 2:30pm to 3:00pm

**Mr. Hamid Mahboubi**

“Self-Deployment Algorithms for Field Coverage in a Network of Nonidentical Mobile Sensors: Vertex-Based Approach”

**Thursday May 12**

**Lunch at 12:00pm**

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**INVITED SPEAKER: Dr. Mehran Mesbahi – Professor of Aeronautics and  
Astronautics at the University of Washington**

**TIME: Thursday May 12, 1:00pm to 2:30pm**

**TITLE:** Towards a System Theory on Networks

**ABSTRACT:** In this talk, I will explore certain results and observations at the intersection of systems and control and the theory of networks that hint at the emergence of yet another sub-discipline in control theory. Along the way, we will discuss security of diffusion-based networks, identification of networks, the role of adaptation and randomness, as well as connections to certain problems in robotic networks, quantum networks, and biological networks.

**BIOGRAPHY:** Mehran Mesbahi received his Ph.D. from USC in 1996. He was a member of the Guidance, Navigation, and Analysis group at JPL from 1996-2000 and an Assistant Professor of Aerospace Engineering and Mechanics at University of Minnesota from 2002-2002. He is currently a Professor of Aeronautics and Astronautics at the University of Washington in Seattle. He was the recipient of NSF CAREER Award in 2001, NASA Space Act Award in 2004, UW Distinguished Teaching Award in 2005, and UW College of Engineering Innovator Award in 2008. His research interests are distributed and networked systems, systems and control theory, and engineering applications of optimization and combinatorics.

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**SPEAKER: Mr. Syed Ali Abbas Zaidi– Royal Institute of Technology**

**TIME: Thursday May 12, 2:30pm to 3:00pm**

**TITLE:** Sufficient Conditions for Closed-Loop Control Over a Gaussian Relay Channel

**ABSTRACT:** The problem of remotely stabilizing a noisy first order linear time invariant system with an arbitrary distributed initial state over a general half-duplex white Gaussian relay channel is addressed. We propose to use linear and memoryless communication and control strategies which are based on the Schalkwijk-Kailath coding scheme. By employing the proposed scheme over the general half-duplex Gaussian relay channel, we derive sufficient conditions for mean square stability of the noisy first order linear time invariant dynamical system.

**SPEAKER: Mr. Xiaosong Lu– Carleton University**

**TIME: Thursday May 12, 3:00pm to 3:30pm**

**TITLE:** Decentralized Learning in Two-Player Zero-Sum Games: A LR-I Lagging Anchor Algorithm

**ABSTRACT:** This paper presents a LR-I lagging anchor algorithm that meets the requirement as a decentralized learning algorithm. We prove that this decentralized learning algorithm can guarantee the convergence to the Nash equilibrium in both pure and fully mixed strategies for two-player two-action zero-sum matrix games.

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**SPEAKER: Mr. Ashraf Ul Haque – University of New Brunswick**

**TIME: Thursday May 12, 3:30pm to 4:00pm**

**TITLE:** Comparing the Performance of Three Soft Computing Algorithms for Short-term Wind Speed Forecasting

**ABSTRACT:** Wind energy is the world's fastest growing renewable energy source of electricity generation. The increase in penetration of this renewable energy source has resulted in a large-scale wind power generation industry. Wind power forecasting is one of the most critical aspects in wind power integration and operation. However, unique challenges faced by power system utilities are the variability, intermittency and non-schedulable nature of wind speed. Given the cubic relationship between wind speed and wind power, accurate forecasting of wind speed is imperative for the estimation of future wind power generation output. This study presents and compares the performance of three different short-term wind speed prediction models based on soft computing methods using back-propagation neural network (BP-NN), radial basis function (RBF), and adaptive neuro-fuzzy inference systems (ANFIS). All forecasting methods first utilize a similarity technique which considers similar historical information corresponding to the forecasting day in order to evaluate similar wind speed days. The output of similarity technique is then fed into the soft computing model(s), which also takes into account the interaction of wind speed and other weather parameters such as wind direction, temperature and pressure. The simulation results show that the proposed soft computing models, utilizing the similarity technique, perform effectively in transforming the given numerical weather data into wind speed predictions with a significant reduction in forecasting errors.

**SPEAKER: Ms. Mahsa Golkar– École Polytechnique de Montréal**

**TIME: Thursday May 12, 4:00pm to 4:30pm**

**TITLE:** Convergence Analysis and Controller Design for a Team of Mobile Robots Subject to Measurement Error

**ABSTRACT:** This paper deals with the steady-state error analysis in the formation control of wheeled mobile robots with leader follower structure. A nonholonomic model is considered for each robot, and it is assumed that each follower is capable of measuring its relative distance and relative velocity with respect to the leader. However, these measurements are assumed to be subject to error. A control law is proposed, and its convergence properties are investigated. Using the linear matrix inequalities (LMI) approach, the upper bounds of the steady state position and velocity errors due to the measurement error are minimized. Simulations demonstrate the efficacy of the results.

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**SPEAKER: Mr. Amir Ajorlou– Concordia University**

**TIME: Thursday May 12, 4:30pm to 5:00pm**

**TITLE:** A Connectivity Preserving Containment Control Strategy for a Network of Single Integrator Agents

**ABSTRACT:** This paper is concerned with the distributed connectivity preserving containment control strategies for a group of single integrator agents with static leaders. The information flow graph of the underlying multi-agent network is assumed to be static, undirected, and connected. A control strategy is proposed which is shown to have the strict connectivity preservation property. The containment of the followers by leaders is subsequently proved by using the LaSalle invariance principle. The effectiveness of the proposed strategy is demonstrated by simulations.

**Friday May 13**

**Light Breakfast at 9:15am**

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**INVITED SPEAKER: Dr. Reza Olfati-Saber – Assistant Professor of Engineering at the Thayer School of Engineering**

**TIME: Friday May 13, 9:30am to 11:00am**

**TITLE:** Cooperative Autonomous Driving for Vehicular Networks

**ABSTRACT:** The existing transportation systems are mostly controlled by humans who are prone to making errors causing collisions, fatalities, and unnecessary traffic congestion. More than 1.3 million road accident fatalities occur world-wide every year. Some of the main causes of traffic accidents are 1) weather and road conditions; 2) drivers and pedestrians being distracted or intoxicated; and 3) the inability of human drivers to predict and react to imminent treats.

Our objective is to design the first generation of “safety-aware transportation systems” in which the vehicles are equipped with embedded sensing, control, computing, and communication devices. The embedded sensors enable the vehicles to detect and track the roads, dividers, and the surrounding pedestrians, bikers, and vehicles (i.e. targets).

In this talk, we demonstrate that driving on a lane is a nontrivial task for a fleet of vehicles requiring beyond pairwise inter-vehicle interactions. Furthermore, a safe way of passing slower vehicles requires a detailed set of considerations and actions similar to manual driving by humans. Our approach to design of autonomous driving algorithms is more inspired by flocking behavior of birds during migrations than human behavior. Using tools from distributed control theory for networked multi-agent systems and nonlinear control, we design novel driving algorithms that enable vehicular networks to autonomously perform tasks such as lane-driving, lane-changing, passing, handling intersections, and braking. We present both experimental and analytical results that illustrate the effectiveness of our cooperative autonomous driving algorithms.

**BIOGRAPHY:** Dr. Olfati-Saber received his PhD and SM degrees from Massachusetts Institute of Technology in 2001 and 1997, respectively, in Electrical Engineering and Computer Science. He was a postdoctoral scholar at California Institute of Technology (2001-04) and a visiting scientist at UCLA (2004-05) prior to joining Dartmouth. He is currently an assistant professor of engineering at the Thayer School of Engineering. Dr. Olfati-Saber is the recipient of the 2010 PECASE (Presidential Early Career Award for Scientists and Engineers) and the 2008 NSF CAREER award. His research interests include distributed control and estimation, robotics, cyber-physical systems, and social and financial networks.

**SPEAKER: Dr. Ahmadreza Momeni – University of New Brunswick**

**TIME: Friday May 13, 11:00am to 11:30am**

**TITLE: Relaxed Convergence Conditions for Multi-Agent Systems under a Class of Consensus Algorithms**

**ABSTRACT:** This paper presents sufficient conditions for the convergence for a group of single integrator agents with a directed and static information flow graph, under a special class of control inputs. Using a novel approach based on the smallest order of the nonzero derivative, it is shown that under some mild conditions the convex hull of the agents will be contracting. The finite intersection property is then used to prove the convergence of the agents to a common fixed point. The results obtained in this work are more general than the ones reported in the literature. An illustrative example is provided to verify the proposed convergence conditions.

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**SPEAKER: Mr. Kian Jalaeddini – McGill University**

**TIME: Friday May 13, 11:30am to 12:00pm**

**TITLE: An Identification Algorithm for Hammerstein Systems Using Subspace Method**

**ABSTRACT:** This paper describes a new algorithm for the identification of single-input single-output Hammerstein systems using the multivariable output error state space (MOESP) class of subspace identification algorithms. The algorithm consists of three main steps. First, the MOESP algorithm is used to determine the system order and estimate two of the state space model matrices. Second, a least squares problem is solved to minimize the prediction error. Finally, the global search optimization is needed to be used to estimate optimal values for the remaining parameters. Performance of the model was evaluated by simulating a model of ankle joint reflex stiffness, a well known Hammerstein system. The results demonstrate that the algorithm estimated the model parameters very accurately in the presence of additive, output noise.

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**Lunch at 12:00pm**



**SPEAKER: Mr. Hadi Zibaenejad– University of Waterloo**

**TIME: Friday May 13, 1:00pm to 1:30pm**

**TITLE: A Framework for Blocking Analysis in Ring Networks of Arbitrary Size**

**ABSTRACT:** Communicating Multi-Process networks appear in many real-life applications. Parameterized Discrete Event Systems (PDES) is a convenient way of modeling these networks. Unfortunately, checking nonblocking property in these systems is undecidable. In this paper, we consider only networks with a ring topology – processes are arranged in a ring, and interact directly only with their immediate neighbors in the ring. Blocking in such networks is generally undecidable [1], but here we introduce assumptions on the structure of processes that render analysis more tractable. Specifically, our assumptions ensure that, while both immediate neighbors may prevent a process from executing shared events, only one neighbor can permanently prevent an event from occurring; in that sense, control only flows around the ring in one direction. The structural assumptions are formulated in terms of two key properties: weak simulation of one process by another; and invariant weak simulation. These can serve to ensure that one neighbor of a process has a structure that is sufficiently similar to the process's own structure that it will not permanently prevent any mutually shared events. We prove in this paper that our assumptions of invariant weak simulation have this desired result.

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**SPEAKER: Mr. Wujie Chao– University of Toronto**

**TIME: Friday May 13, 1:30pm to 2:00pm**

**TITLE: Representation of Supervisory Controls using State-Tree Structures, Binary Decision Diagrams, Automata, and Supervisor Reduction**

**ABSTRACT:** In the synthesis of an optimal nonblocking supervisor for a discrete-event system, the problem of state explosion is a well-known computational obstacle. This problem can often be managed successfully by the use of state-tree structures (STS) and Binary decision diagrams (BDDs). Unfortunately BDD control functions may become quite large, and as such difficult to represent and interpret. In some cases it may, therefore, be convenient to convert an STS/BDD controller to automaton form, and then apply a well known algorithm for supervisor reduction. In this paper we illustrate the advantage of this approach with concrete examples.

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**SPEAKER: Mr. Ali Asadian– Lawson Health Research Institute, University Hospital**

**TIME: Friday May 13, 2:00pm to 2:30pm**

**TITLE: Dynamic Modeling of Distributed Friction in Needle-Tissue Interaction with Applications to Needle Steering in Percutaneous Interventions**

**ABSTRACT:** In this study, a new approach to account for distributed friction in needle insertion in soft tissue is presented. As is well known, friction is a complex nonlinear phenomenon, and it appears that classical or static models are unable to capture some of the observations in systems subject to significant frictional effects in minimally invasive surgery. To characterize dynamic features when (1) the needle is very flexible and friction plays an important role in bending mechanics or (2) a stop-and-start path planning scenario is implemented at low insertion velocities, a distributed LuGre model can be adopted. Experimental results using an artificial phantom illustrate that the proposed method is capable of representing the main features of friction which is a major force component in needle-tissue interaction during percutaneous interventions.

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**SPEAKER: Mr. Hamid Mahboubi– Concordia University**

**TIME: Friday May 13, 2:30pm to 3:00pm**

**TITLE: Self-Deployment Algorithms for Field Coverage in a Network of Nonidentical Mobile Sensors: Vertex-Based Approach**

**ABSTRACT:** In this paper, efficient deployment algorithms are proposed for a mobile sensor network to enlarge the coverage area. The proposed algorithms calculate the position of the sensors iteratively based on existing coverage holes in the field. To this end, the multiplicatively weighted Voronoi (MW-Voronoi) diagram is used for a network of mobile sensors with different sensing ranges. Under the proposed procedures, the sensors move in such a way that the coverage holes in the network are reduced. Simulation results are provided to demonstrate the effectiveness of the deployment schemes proposed in this paper.