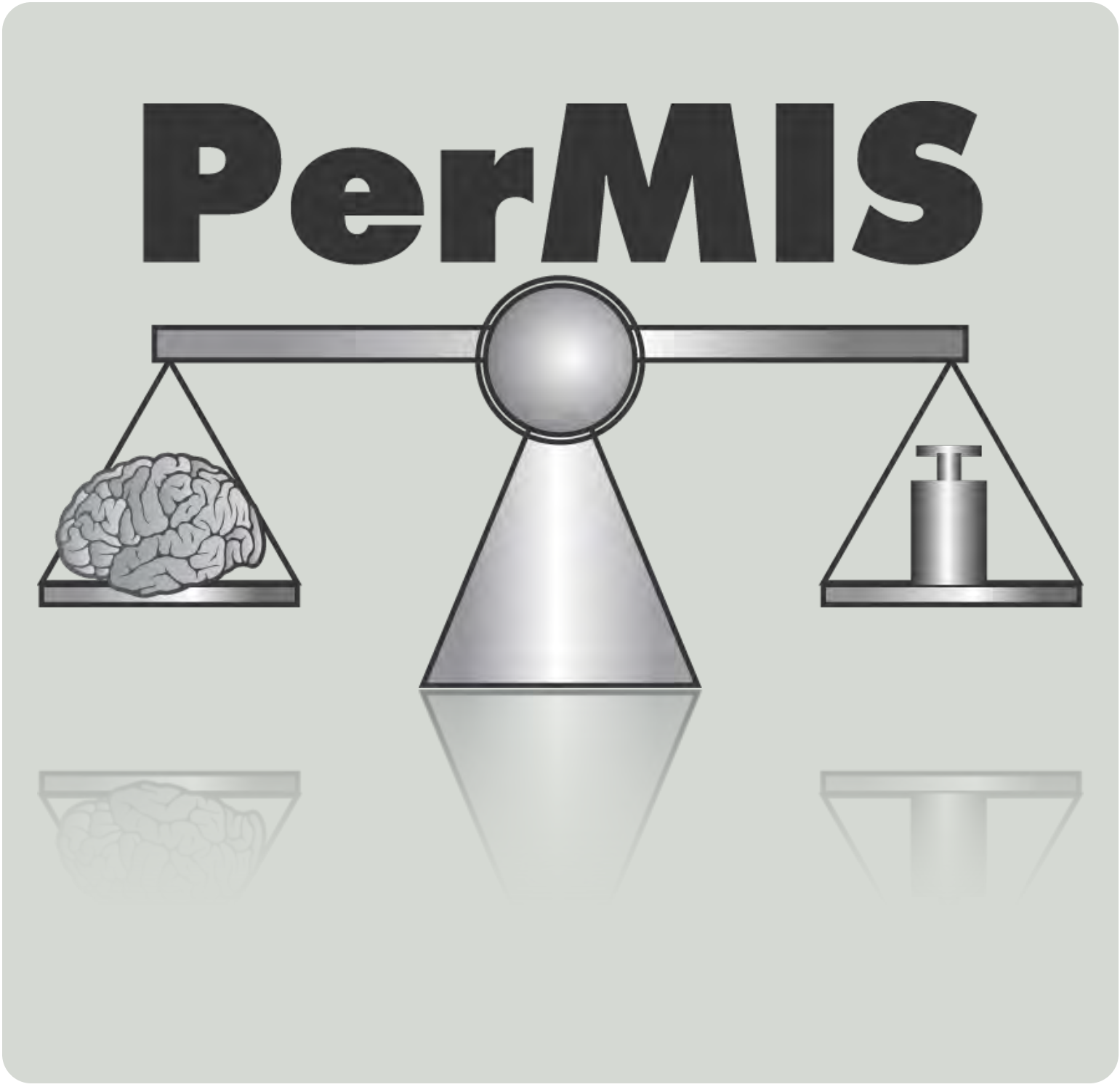
PERFORMANCE METRICS
FOR
INTELLIGENT SYSTEMS (PERMIS) WORKSHOP

The Marriott Inn & Conference Center, College Park, MD USA
March 20 - 22, 2012



FOREWORD

Welcome to PerMIS'12!

As software and hardware become increasingly interwoven, new opportunities and challenges emerge. The field of Cyber-Physical Systems (CPS) – hybrid networked cyber and engineered physical elements co-designed to create adaptive and predictive systems for enhanced performance – focuses on the technology gaps and research challenges that cross cut many new highly-advanced products and processes, such as intelligent transportation systems, autonomous robots, the smart grid, and smart manufacturing systems. Given the importance of ensuring that the resulting products and processes are intelligent, reliable, safe, and secure, cyber-physical systems that people can bet their lives on, performance metrics and evaluation become especially important. Therefore, the 2012 Performance Metrics for Intelligent Systems workshop's theme of *methodologies and techniques of performance measurement for developing and engineering the next generation of cyber physical systems that facilitate seamless human-machine collaboration* is both timely and necessary.

The plenary speakers address cyber-physical systems as well as related topics, particularly robotics, which is a salient example of a CPS. We are fortunate to have George Arnold, SK Gupta, Edward Lee, Jim Overholt, Mark Rice, and Holly Yanco give plenary talks this year. A special session is devoted to discussing Cyber-Physical Systems, with panelists from academia and federal agencies.

Spread over three days, PerMIS'12, the eleventh iteration of the series, features technical presentations organized into two parallel tracks on each day. We thank the special session organizers for proposing interesting topics and assembling researchers related to their sessions. With one of the special sessions, we honor the memory of two of the prime forces that helped forge the PerMIS series and were so influential to the general field of intelligent systems: Jim Albus and Alex Meystel. Our gratitude goes out to the Program Committee members for publicizing the workshop and the reviewers for providing feedback to the authors, and for helping us to put together an interesting program.

PerMIS'12 is sponsored by NIST, DARPA, NSF and the Maryland Robotics Center, with technical co-sponsorship of the IEEE Washington Section Sensors Council Chapter, and in cooperation with the Association for Computing Machinery (ACM) Special Interest Group on Artificial Intelligence (SIGART). The Defense Advanced Research Projects Agency Information Processing Technology Office graciously provided funding to help support the workshop. Special thanks are due to the National Science Foundation for providing funding to allow undergraduate and graduate students to participate in a special poster session this year. We also thank Professor Ani Hsieh of Drexel University for organizing the NSF new student poster grants program and Professor Holly Yanco of the University of Massachusetts – Lowell for facilitating support for some alumni of prior student poster sessions to return as mentors. We gratefully acknowledge the support of all of our sponsors. The proceedings of PerMIS will be indexed by INSPEC and Compendex and will be available through ACM's Digital Library, as well as being released as a NIST Special Publication.

It is our sincere hope that you will enjoy the presentations, the social programs, renew old relationships, and forge new ones at PerMIS'12!

Elena Messina
General Chair

Raj Madhavan
Program Chair

PROGRAM COMMITTEE

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PLENARY SPEAKERS

Prof. Holly Yanco, University of Massachusetts Lowell

Evaluate Early, Evaluate Often: A Design Process for Creating Better Robot Systems

Tue. 8:30 am

ABSTRACT
System evaluations have been conducted in robotics and human-robot interaction for many years. These evaluations usually take place after a robot system has been designed and built as a way to validate the completed system. However, by performing evaluation only at the end of the development cycle, we lose opportunities to create systems with even better performance. Taking inspiration from human-computer interaction, we can design more effective robot systems for human-robot interaction by incorporating user feedback in the initial design phase. This talk will present a number of such formative evaluations from a variety of robotics domains, including assistive robotics and telepresence robot systems.

BIOGRAPHY
Dr. Holly Yanco is Professor and Associate Chair of Computer Science at the University of Massachusetts Lowell. Her research interests include human-robot interaction, multi-touch computing, interface design, robot autonomy, fostering trust of autonomous systems, evaluation methods for human-robot interaction, and the use of robots in K-12 education to broaden participation in computer science. Her research has been funded by the National Science Foundation, including a Career Award, the Army Research Office, Microsoft, and the National Institute of Standards and Technology. Dr. Yanco is the General Chair of the 2012 ACM/IEEE International Conference on Human-Robot Interaction. She served on the Executive Council of the Association for the Advancement of Artificial Intelligence (AAAI) from 2006-2009 and was the Symposium Chair for AAAI from 2002-2005. She was awarded senior membership in AAAI in 2011. Dr. Yanco has a PhD and MS in Computer Science from the Massachusetts Institute of Technology (MIT) and a BA in Computer Science and Philosophy from Wellesley College.

Mark Rice, Maritime Applied Physics Corporation

Geographic Information Systems (GIS) as an Environment for Intelligent Systems Performance Measurement

Tues. 2:00 pm

ABSTRACT
Many intelligent systems work in spatial and temporal environments where Geographic Information Systems (GIS) provide the environment for enabling control and measuring performance. Whether the application involves an automated highway, an unmanned marine vessel, or an unmanned air vehicle, there are GIS based options for the intelligent system designer. This talk will review recent examples of GIS use in unmanned systems where control and performance measurement are enabled by GIS.

BIOGRAPHY
Mark is President of the Maritime Applied Physics Corporation (MAPC, www.mapcorp.com). He has a BA in Physics from the University of Maine and is a licensed Professional Engineer. Mark's first experience with unmanned systems occurred in 1978 when he was the operations officer for the Navy's first 20,000 foot unmanned submersible. Since that time, he has worked as an engineer on various unmanned land, air, and sea systems. Mark formed Maritime Applied Physics Corporation in 1986 and has overseen its growth from a 1 person company to its current 75-person staff. MAPC has both R&D and production work with offices in Baltimore, Maryland, Arlington, Virginia and Brunswick, Maine. MAPC currently designs and manufactures electro-mechanical systems that range from submarine and surface ship components to unmanned systems. Mark is a member of the Maryland/D.C. District Export Council and is the Chair of the National Advisory Board to the NIST Manufacturing Extension Partnership.

Jim Overholt, U.S. Army Tank Automotive Research Development and Engineering Center

Practical to Tactical: Making the Case for a Shift in Ground Vehicle Robotics

Wed. 8:30 am

ABSTRACT

Army ground robotics has been a strategic research and development focus for well over 20 years. In the past 10 years, over 8,000 robotic systems (at its peak in 2010) have been fielded in Southwest Asia. This figure is impressive, especially when you consider that in 2004 it required 5separate vendors to provide 162 robots for only a few select missions. Currently, these systems are used for a variety of critical combat activities but mobile robots are rarely (if ever)used state-side for CONUS operations. In addition, as much as robots have contributed to the War fighters success in various scenarios (most notably in EOD activities in Iraq and Afghanistan), the primary mode of operation of our current robot fleet is still either RemoteControl or Tele-Operation. This is in stark contrast to the intelligent navigation capabilities being shown at our leading universities and other robot OEMs. So where is the disconnect?

This talk will focus on addressing this very question from various points of view; including new efforts to heavily leverage DOT programs and commercial automotive S&T to facilitate robotics on military base and installations, and to segment the potential robotics mission work-space into 2 simple classifications of environmental features and human intent of the indigenous population. This will lead to some interesting findings in the minimum barriers of technology entry and whether or not advanced autonomy is really needed at all.

BIOGRAPHY

In March 2010, James L. Overholt, Ph.D. was appointed to a Scientific and Professional service position (ST), a system equal to Senior Executive Service, designed for specifically qualified scientific and professional personnel engaged in research and development. As the Senior Research Scientist in Robotics for the Department of Defense, Department of the Army, Dr. Overholt is responsible for defining the strategic vision for robotics science and technology and for conducting, mentoring, and sponsoring cutting edge robotics research. In his nearly 30 years of service to the Army, Dr. Overholt has held numerous lead research positions. Dr. Overholt was the U.S. co-chair of the Multi Autonomous Ground-robotics International Challenge (MAGIC) event held in Australia in November 2010. In 2009 Dr. Overholt was appointed Director of the Office of the Secretary of Defense (OSD) Joint Ground Robotics Enterprise (JGRE), where he was responsible for providing science and technology guidance to the OSD with an emphasis on closing gaps between war fighter requirements and technology, and coordinating efforts between Services to ensure interoperability and commonality among unmanned systems and supporting the strategic goals of the OSD and the Office of the Undersecretary of Defense for Acquisition, Technology and Logistics (AT&L). From 2007 to May 2009, Dr. Overholt served as the Director of the Joint Center for Robotics (JCR) at the U.S. Army Research Development and Engineering Command (RDECOM) Tank Automotive Research and Development Center (TARDEC). He was responsible for establishing a portfolio of programs that strived to rapidly transition robotics technology into the hands of the Soldier, leveraging industry and academia. From October 2006 to May 2007, Dr. Overholt was detailed to the Army Research Office (ARO) as the acting PM for all academic extra-mural robotics and intelligent controls research programs.

Dr. Overholt earned a BS in Physics from the Lawrence Institute of Technology, and a MS in Systems Engineering from Oakland University. He earned his Ph. D. from Oakland University in 1999, emphasizing the development of neural-fuzzy sensor fusion behavioral architectures for unmanned vehicles. His current research interests are machine intelligence and high-speed mobile robot navigation and control. Dr. Overholt is the co-author of more than 50 scientific papers, and was awarded the Bronze Medal at the 2006 Army Science Conference for his contributions in writing “High Speed Hazard Avoidance for Unmanned Ground Vehicles in Emergency Situations.”

Satyandra K. Gupta, Maryland Robotics Center Mechanical Engineering Department and Institute for Systems Research University of Maryland, College Park

Simulation-Based Design and Evaluation of Physics-Aware Planners for Robotic Operations in Challenging Environments

Wed. 2:00 pm

ABSTRACT

Physically challenging environments require robots to be able to negotiate around dynamically moving objects, cope with significant uncertainties in the outcome of action execution, sensor limitations, and the presence of intelligent adversaries. Physics-aware planners are needed in such environments. Unfortunately, exhaustive evaluation of planners using only physical tests is not possible in these applications. This presentation describes how simulations can be successfully used to design and evaluate physics-aware planners. I plan to cover the following four topics. First, I will describe a physics-aware planner that integrates task planning, behavior selection, and trajectory planning in a seamless manner to successfully handle physically challenging environments. This approach provides the right balance between deliberative planning and reactive behaviors during the execution of complex tasks in a dynamic uncertain environment. Second, I will describe our work in the area of physically accurate computationally efficient simulations to enable physics-aware planning and evaluate planners. Third, I will describe computational synthesis techniques for automatically generating sophisticated reactive behaviors using simulations. Finally, the following applications will be used to illustrate simulation-based design and evaluation of planners: (1) guarding of a valuable asset by autonomous unmanned sea surface vehicles, (2) assembly of micro particles in a fluidic medium using holographic optical tweezers, and (4) supply mission on a rugged terrain by unmanned ground vehicles.

BIOGRAPHY

Dr. Satyandra K. Gupta is a Professor in the Mechanical Engineering Department and the Institute for Systems Research at the University of Maryland, College Park. He is the director of the Maryland Robotics Center. Prior to joining the University of Maryland, he was a Research Scientist in the Robotics Institute at Carnegie Mellon University. He received a Bachelor of Engineering (B.E.) degree in Mechanical Engineering from the University of Roorkee (currently known as Indian Institute of Technology, Roorkee) in 1988, a Master of Technology (M. Tech.) degree in Production Engineering from Indian Institute of Technology, Delhi in 1989, and a Ph.D. in Mechanical Engineering from the University of Maryland in 1994.

Dr. Gupta's interest is broadly in the area of automation. He is specifically interested in automation problems arising in Engineering Design, Manufacturing, and Robotics. His current research focus is mainly on simulation-based computational synthesis and automated planning. He is a fellow of the American Society of Mechanical Engineers (ASME). He has served as an Associate Editor for IEEE Transactions on Automation Science and Engineering, ASME Journal of Computing and Information Science in Engineering, and SME Journal of Manufacturing Processes.

Dr. Gupta has authored or co-authored more than two hundred forty articles in journals, conference proceedings, and book chapters. Awards received by Dr. Gupta include a Best Paper Award in 1994 ASME International Conference on Computers in Engineering, a Best Paper Award in 1999 ASME Design for Manufacturing Conference, a Young Investigator Award from Office of Naval Research in 2000, a Robert W. Galvin Outstanding Young Manufacturing Engineer Award from Society of Manufacturing Engineers in 2001, a CAREER Award from National Science Foundation in 2001, a Presidential Early Career Award for Scientists and Engineers (PECASE) in 2001, a Best Paper Award in 2006 ASME Computers and Information in Engineering Conference, and a Best Paper Award in 2010 ASME Mechanism and Robotics Conference. He received Kos Ishii-Toshiba Award from ASME in 2011.

Edward Lee, UC Berkeley

Time for High-Confidence Cyber-Physical Systems

Thur. 8:30 am

ABSTRACT

All widely used software abstractions lack temporal semantics. The notion of correct execution of a program written in every widely-used programming language today does not depend on the temporal behavior of the program. But temporal behavior matters in almost all systems, particularly in networked systems. Even in systems with no particular real-time requirements, timing of programs is relevant to the value delivered by programs, and in the case of concurrent and distributed programs, also affects the functionality. In systems with real-time requirements, including most embedded systems, temporal behavior affects not just the value delivered by a system but also its correctness.

This talk will argue that time can and must become part of the semantics of programs for a large class of applications. It will argue that temporal behavior is not always just a performance metric, but is often rather a correctness criterion. To illustrate that this is both practical and useful, we will describe recent efforts at Berkeley in the design and analysis of timing-centric software systems. In particular, we will focus on two projects, PRET, which seeks to provide computing platforms with repeatable timing, and PTIDES, which provides a programming model for distributed real-time systems.

BIOGRAPHY

Edward A. Lee is the Robert S. Pepper Distinguished Professor in the Electrical Engineering and Computer Sciences (EECS) department at U.C. Berkeley. His research interests center on design, modeling, and analysis of embedded, real-time computational systems. He is a director of Chess, the Berkeley Center for Hybrid and Embedded Software Systems, and is the director of the Berkeley Ptolemy project. From 2005-2008, he served as chair of the EE Division and then chair of the EECS Department at UC Berkeley. He is co-author of nine books (counting second and third editions) and numerous papers. He has led the development of several influential open-source software packages, notably Ptolemy and its various spinoffs. He received the B.S. degree in Computer Science from Yale University, New Haven, CT, in 1979, the S.M. degree in EECS from the Massachusetts Institute of Technology (MIT), Cambridge, in 1981, and the Ph.D. degree in EECS from the University of California Berkeley, Berkeley, in 1986. From 1979 to 1982 he was a member of technical staff at Bell Telephone Laboratories in Holmdel, New Jersey, in the Advanced Data Communications Laboratory. He is a co-founder of BDTI, Inc., where he is currently a Senior Technical Advisor, and has consulted for a number of other companies. He is a Fellow of the IEEE, was an NSF Presidential Young Investigator, and won the 1997 Frederick Emmons Terman Award for Engineering Education.

George Arnold, NIST

Performance and New Paradigms for the Electric Power System

Thur. 2:00 pm

ABSTRACT
The structure of the world's power system has not changed much since the era of Thomas Edison: it is characterized by the one-way flow of electricity from controllable carbon-producing centralized power generation plants to users who have little awareness of how much energy they consume and how they can be more efficient. This talk will describe how the Smart Grid will eventually enable a new paradigm - the dynamic, two-way flow of electricity and information that will support growing use of distributed green generation sources (such as wind and solar), widespread use of electric vehicles, and ubiquitous intelligent appliances and buildings that can dynamically adjust power consumption in response to conditions on the grid. Modeling, forecasting, and control strategies that reflect new dynamic operational paradigms will be essential to realizing the environmental and energy efficiency benefits enabled by the smart grid.

BIOGRAPHY
George Arnold was appointed National Coordinator for Smart Grid Interoperability at the National Institute of Standards and Technology (NIST) in April 2009. He is responsible for leading the development of standards underpinning the nation's Smart Grid. In October 2011 he assumed an additional responsibility as Director, Smart Grid and Cyber-Physical Systems Program Office in the NIST Engineering Laboratory. Dr. Arnold joined NIST in September 2006 as Deputy Director, Technology Services, after a 33-year career in the telecommunications and information technology industry.

Dr. Arnold served as Chairman of the Board of the American National Standards Institute (ANSI), a private, non-profit organization that coordinates the U.S. voluntary standardization and conformity assessment system, from 2003 to 2005. He served as President of the IEEE Standards Association in 2007-2008 and was Vice President-Policy for the International Organization for Standardization (ISO) during 2006-2009, where he is responsible for guiding ISO's strategic plan.

Dr. Arnold previously served as a Vice-President at Lucent Technologies Bell Laboratories where he directed the company's global standards efforts. His organization played a leading role in the development of international standards for Intelligent Networks and IP-based Next Generation Networks. In previous assignments at AT&T Bell Laboratories he had responsibilities in network planning, systems engineering, and application of information technology to automate operations and maintenance of the nationwide telecommunications network.

Dr. Arnold received a Doctor of Engineering Science degree in Electrical Engineering and Computer Science from Columbia University in 1978. He is a Fellow of the IEEE.

Time	Tuesday March 20		Wednesday March 21		Thursday March 22
8:00-8:30	Welcome/Overview		Overview		Overview
8:30-9:30	**Plenary 1: Holly Yanco**		**Plenary 3: Jim Overholt**		**Plenary 5: Edward Lee**
9:30-10:00	*Coffee Break*		*Coffee Break*		*Coffee Break*
10:00 -12:30	TUE-AM1: *Performance Evaluation*	TUE-AM2: *Session Honoring the Legacy of Jim Albus & Alex Meystel*	WED-AM1: *Human-Robot Collaboration & Interaction*	WED-AM2: *Technology Readiness for Randomized Bin Picking Solutions*	THU-AM: *CPS Panel Discussion*
12:30-14:00	*Lunch*		*Lunch*		*Lunch*
14:00 - 15:00	**Plenary 2: Mark Rice**		**Plenary 4: SK Gupta**		**Plenary 6: George Arnold**
15:00-15:30	*Coffee Break*		*Coffee Break*		*Coffee Break*
15:30 -17:30	TUE-PM1: *Performance Measures & Metrics*	TUE-PM2: *Performance Evaluation and Advanced Algorithms for Static & Dynamic 6DOF*	WED-PM1: *Performance Characterization* (15:30-18:00)	WED-PM2: *Field Testing & Standard Test Methods* (15:30-18:00)	THU-PM: *Performance Testing & Validation*
	(18:00 – 20:00) ***Reception & Poster Session***		*(18:30 – 20:00)* ***Banquet***		

March 20

TUESDAY

PROGRAM

PERMIS

08:00	**Welcome & Overview - Brian Darmody, Associate Vice President for Research & Economic Development, University of MD**
08:30	***Plenary Presentation:*** ***Holly Yanco*** ***Evaluate Early, Evaluate Often: A Design Process for Creating Better Robot Systems***
09:30	**Coffee Break**
10:00	**TUE-AM1 Performance Evaluation** *Chairs: Greg Dudek and Craig Schlenoff* • Performance Evaluation of Robotic Knowledge Representations (PERK) [Craig Schlenoff, Sebti Foufou, Stephen Balakirsky] • A Hybrid Approach to 2D Robotic Map Evaluation [Ross Creed, Kristiyan Georgiev, Rolf Lakaemper] • An Overview of Robot-Sensor Calibration Methods for Evaluation of Perception Systems [Mili Shah, Roger Eastman, Tsai Hong] • On the Performance Evaluation of a Vision-Based Human-Robot Interaction Framework [Junaed Sattar, Gregory Dudek] • Functional Requirements of a Model for Kitting Plans [Stephen Balakirsky, Zeid Kootbally, Thomas Kramer, Raj Madhavan, Craig Schlenoff, Michael Shneier]
12:30	**Lunch**
14:00	***Plenary Presentation:*** ***Mark Rice*** ***Geographic Information Systems (GIS) as an Environment for Intelligent Systems Performance Measurement***
15:00	**Coffee Break**
15:30	**TUE-PM1 Performance Measures and Metrics** *Chairs: Rolf Lakaemper and Michael Del Rose* • A New Method for Measuring Absolute Threshold of Haptic Force Feedback [Michal Baczynski] • Approach for Defining Intelligent Systems Technical Performance Metrics [Wael Hafez] • Metrics for Planetary Rover Planning & Scheduling Algorithms [Juan Delfa Victoria, Nicola Policella, Marc Gallant, Oskar von Stryk, Alessandro Donati, Yang Gao] • Measures for UGV to UGV Collaboration [Michael Del Rose, Anthony Finn, Robert Kania]
18:00	**Reception & Poster Session**

PERMIS PROGRAM

March 20

TUESDAY

08:00	**Welcome & Overview - Brian Darmody, Associate Vice President for Research & Economic Development, University of MD**
08:30	***Plenary Presentation:*** ***Holly Yanco*** ***Evaluate Early, Evaluate Often: A Design Process for Creating Better Robot Systems***
09:30	**Coffee Break**
10:00	**TUE-AM2 Special Session I: Session Honoring the Legacy of Jim Albus and Alex Meystel** *Organizers: Alberto Lacaze and Elena Messina* • Army-NIST Robotics Teaming: A Thirty Year Retrospective [Charles Shoemaker, U. S. Army Communications-Electronics Research, Development, and Engineering] • ATR's DoD programs with RoboCrane Technologies [Jackson Yang, Advanced Technology and Research Corporation] • Mind, Brain, and Intelligence: A Krasnow Institute Perspective on the Jim Albus Legacy [Kenneth DeJong, Alexei Samsonovich, James Olds, Krasnow Institute for Advanced Study, GMU] • Understanding 'Intelligence': in Pursuit of Multi-Resolutional Hierarchies [Predrag Filipovic, Agora Creative Solutions Inc.] • Measurable and Scalable Methods for Modern Knowledge Processing [Michael Meystel, The Vanguard Group and Cognisphere Inc.] • Birth of an Architecture [Alberto Lacaze, Robotic Research LLC.]
12:30	**Lunch**
14:00	***Plenary Presentation:*** ***Mark Rice*** ***Geographic Information Systems (GIS) as an Environment for Intelligent Systems Performance Measurement***
15:00	**Coffee Break**
15:30	**TUE-PM2 Special Session II: Performance Evaluation and Advanced Algorithms for Static and Dynamic 6DOF** *Organizers: Chad English and Jane Shi* • 2011 Solutions in Perception Challenge Performance Metrics and Results [Jeremy Marvel, Tsai Hong, Elena Messina] • Development of an Apparatus for Characterizing the Measurement Latency of a Dynamic 3D Tracking System [Kamel Saidi] • Shape-based Pose Estimation Evaluation using Expectivity Index Artifacts [Chad English, Galina Okouneva, Aradhana Choudhuri] • Ground Truth for Evaluating 6 Degrees of Freedom Pose Estimation Systems [Jeremy Marvel, Joe Falco, Tsai Hong] • Performance Measurement with 6DOF Laser Tracker Technologies [Zach Ryan, Aaron Sabino]
18:00	**Reception & Poster Session**

March

PROGRAM

PERMIS

21

WEDNESDAY

08:15	**Overview**
08:30	***Plenary Presentation:*** ***Jim Overholt*** ***Practical to Tactical: Making the Case for a Shift in Ground Vehicle Robotics***
09:30	**Coffee Break**
10:00	**WED-AM1 Human-Robot Collaboration and Interaction** *Chairs: Jane Shi and Kate Tsui* • A Proxemic-Based HRI Testbed [Zachary Henkel, Robin Murphy, Vasant Srinivasan, Cindy Bethel] • Synergistic Methods for Using Language in Robotics [Ching Teo, Yezhou Yang, Cornelia Fermuller, Yiannis Aloimonos] • Reusable Semantic Differential Scales for Measuring Social Response to Robots [Lilia Moshkina] • Levels of Human and Robot Collaboration for Automotive Manufacturing [Jane Shi, Glenn Jimmerson, Tom Pearson, Roland Menassa] • Towards Measuring the Quality of Interaction: Communication through Telepresence Robots [Katherine Tsui, Munjal Desai, Holly Yanco]
12:30	**Lunch**
14:00	***Plenary Presentation:*** ***Satyandra K. Gupta*** ***Simulation-Based Design and Evaluation of Physics-Aware Planner for Robotic Operations in Challenging Environments***
15:00	**Coffee Break**
15:30	**WED-PM1 Performance Characterization** *Chairs: Damian Lyons and Hui-Min Huang* • Characterizing Performance Guarantees for Multiagent, Real-Time Systems Operating in Noisy and Uncertain Environments [Damian Lyons, Ronald Arkin, Stephen Fox, Shu Jiang, Prem Nirmal, Munzir Zafar] • Design, Fabrication and Characterization of the Single-Layer Out-of-Plane Electrothermal Actuator for a MEMS XYZ Stage [Yong-Sik Kim, Nicholas Dagalakis, Satyandra Gupta] • Intelligent Energy Management: Impact of Demand Response and Plug-in Electric Vehicles in a Smart Grid Environment [Seshadri Raghavan, Alireza Khaligh] • Characterization of Forward Rectilinear-Gait Performance for a Snake-Inspired Robot [James Hopkins, Satyandra Gupta] • Emergency Response Robot Evaluation Exercise [Adam Jacoff, Hui-Min Huang, Ann Virts, Anthony Downs, Raymond Sheh]
18:30	**Banquet**

PERMIS PROGRAM

March 21

WEDNESDAY

08:15	**Overview**
08:30	***Plenary Presentation:*** ***Jim Overholt*** ***Practical to Tactical: Making the Case for a Shift in Ground Vehicle Robotics***
09:30	**Coffee Break**
10:00	**WED-AM2 Special Session III: Panel Discussion: Technology Readiness for Randomized Bin Picking Solutions** *Organizers: Jeremy Marvel, Tsai Hong, Gerry Cheok, Elena Messina* *Moderator: Roger Eastman* • The NASA-developed TRL Methodology [Karen McNamara] • Challenges of bin-picking [Jeremy Marvel] • A round-table panel discussion moderated by Roger Eastman from NIST/Loyola University, featuring James Wells (General Motors), Joyce Guthrie (US Postal Service), Bob Bollinger (Procter & Gamble), Eric Hershberger (Cognex), Carlos Martinez (ABB Inc.), Paul Evans (Southwest Research Institute), and Karen McNamara (NASA)
12:30	**Lunch**
14:00	***Plenary Presentation:*** ***Satyandra K. Gupta*** ***Simulation-Based Design and Evaluation of Physics-Aware Planner for Robotic Operations in Challenging Environments***
15:00	**Coffee Break**
15:30	**WED-PM2 Field Testing and Standard Test Methods** *Chairs: Barry Bodt and Roger Bostelman* • Test Method for Measuring Station-Keeping With Unmanned Marine Vehicles Using Sonar or Optical Sensors [Asish Ghoshal, Avinash Parnandi, Robin Murphy] • Standard Test Procedures and Metric Development for Automated Guided Vehicle Safety Standards [Roger Bostelman, William Shackleford, Geraldine Cheok, Richard Norcross] • Integrating Occlusion Monitoring into Human Tracking for Robot Speed and Separation Monitoring [William Shackleford, Sandor Szabo, Richard Norcross, Jeremy Marvel] • Robotics Collaborative Technology Alliance (RCTA) 2011 Baseline Assessment [Barry Bodt, Richard Camden, Marshal Childers] • Using Competitions to Advance the Development of Standard Test Methods for Response Robots [Adam, Jacoff, Raymond Sheh, Ann Virts, Tetsuya Kimura, Johannes Pellenz, Soren Schwertfeger, Jackrit Suthakorn]
18:30	**Banquet**

March 22

PROGRAM

PERMIS

THURSDAY

08:15	**Overview**
08:30	***Plenary Presentation:*** ***Edward Lee*** ***Time for High-Confidence Cyber-Physical Systems***
09:30	**Coffee Break**
10:00	**THU-AM Cyber-Physical Systems Panel Discussion** *Organizers: Richard Voyles, NSF and Elena Messina, NIST* *Moderator: Albert Wavering, NIST* • Clare Allocca, NIST • Panos Antsaklis, U. of Notre Dame • George Arnold, NIST • Edward Lee, U. of California-Berkeley • Suzanne Lightman, NIST • Rahul Mangharam, U. of Pennsylvania
12:30	**Lunch**
14:00	***Plenary Presentation:*** ***George Arnold*** ***Performance and New Paradigms for the Electric Power System***
15:00	**Coffee Break**
15:30	**THU-PM Performance Testing and Validation** *Chairs: Brian Weiss and Venkat Krovi* • Validation of the Dynamics of an Humanoid Robot in USARSim [Sander van Noort, Arnoud Visser] • Evaluation of Robotic Minimally Invasive Surgical Skills using Motion Studies [Seung-Kook Jun, Madusudanan Sathianarayanan, Abeer Eddib, Pankaj Singhal, Sudha Garimella, Venkat Krovi] • Multi-Relationship Evaluation Design: Modeling an Automatic Test Plan Generator [Brian Weiss, Linda Schmidt] • An IEEE 1588 Performance Testing Dashboard for Power Industry Requirements [Julien Amelot, Ya-Shian Li-Baboud, Clement Vasseur, Jeffrey Fletcher, Dhananjay Anand, James Moyne]
17:30	**Adjourn**

PERMIS

PROGRAM

March 22

THURSDAY

08:15	**Overview**
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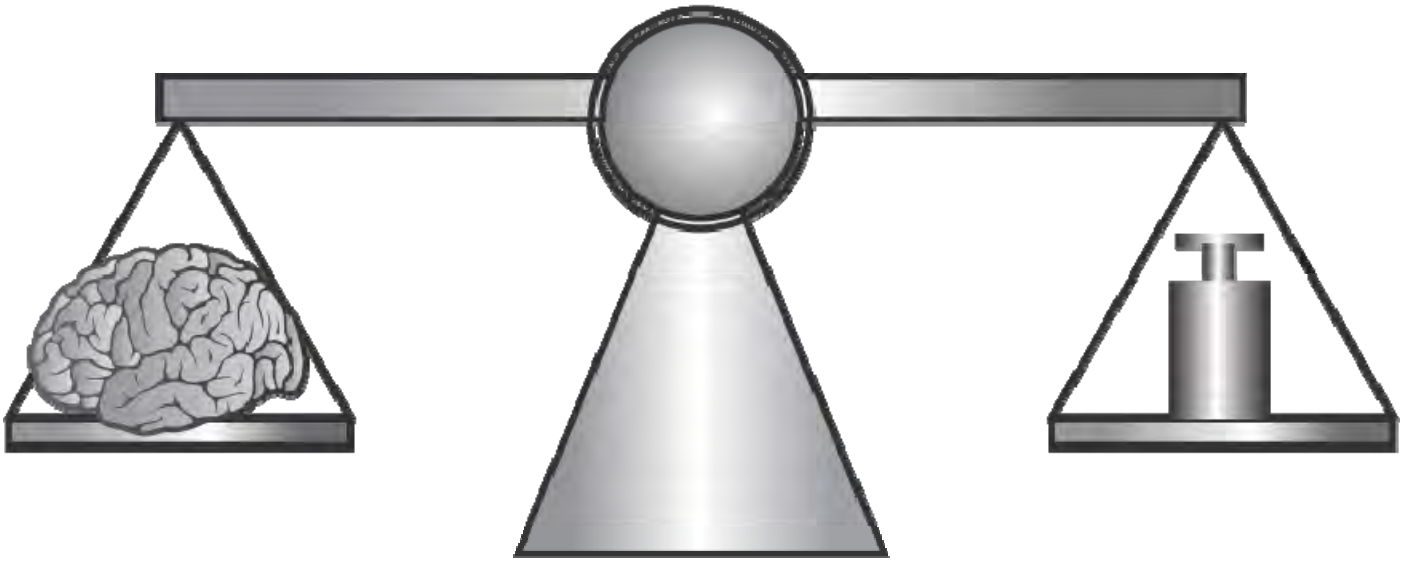
14:00	***Plenary Presentation:*** ***George Arnold*** ***Performance and New Paradigms for the Electric Power System***
15:00	**Coffee Break**
15:30	**THU-PM Performance Testing and Validation** *Chairs: Brian Weiss and Venkat Krovi* • Validation of the Dynamics of an Humanoid Robot in USARSim [Sander van Noort, Arnoud Visser] • Evaluation of Robotic Minimally Invasive Surgical Skills using Motion Studies [Seung-Kook Jun, Madusudanan Sathianarayanan, Abeer Eddib, Pankaj Singhal, Sudha Garimella, Venkat Krovi] • Multi-Relationship Evaluation Design: Modeling an Automatic Test Plan Generator [Brian Weiss, Linda Schmidt] • An IEEE 1588 Performance Testing Dashboard for Power Industry Requirements [Julien Amelot, Ya-Shian Li-Baboud, Clement Vasseur, Jeffrey Fletcher, Dhananjay Anand, James Moyne]
17:30	**Adjourn**

PerMIS



Digests

TUE-AM1
Performance Evaluation
Chairs: Greg Dudek & Craig Schlenoff

Performance Evaluation of Robotic Knowledge Representation (PERK)

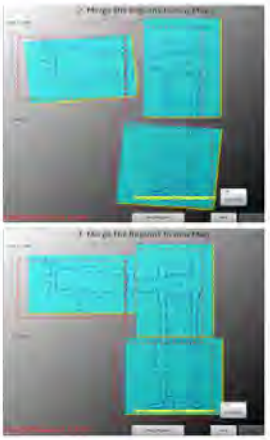
Craig Schlenoff[1,2], Sebti Foufou[2,3], Stephen Balakirsky[1]
[1]National Institute of Standards and Technology (NIST)
[2]University of Burgundy
[3]Qatar University

- We explore some ways in which symbolic knowledge representations have been evaluated in the past
- We provide some thoughts on what should be considered when applying and evaluating these types of knowledge representations for real-time robotics applications
- Robotic applications require real-time access to information which has not been one of the aspects measured in traditional symbolic representation evaluation approaches.

A Hybrid Approach for 2D Robotic Map Evaluation

Ross Creed, Kristiyan Georgiev, Rolf Lakaemper
Temple University

- The necessity for flexible and quantifiable robotic map evaluation will be discussed
- Advantages/disadvantages of pose-based and grid-based techniques will be presented
- Previous evaluation strategies are extended into a new hybrid measure
- The Temple Map Evaluation Toolkit (TMET) will be introduced
  - Methodologies and Theory of the Hybrid Measure
  - Implementation using JavaFX for web-portability
- Live demonstration of use cases and results from TMET will be shown.

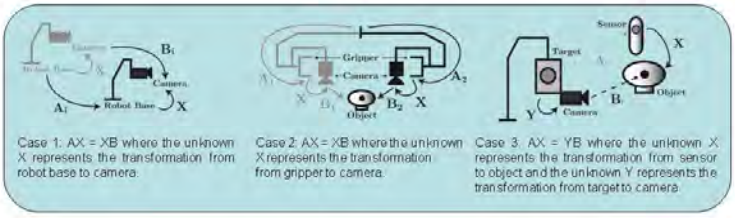


An Overview of Robot-Sensor Calibration Methods for Evaluation of Perception Systems

Mili Shah, Roger D. Eastman, Tsai Hong
Loyola University Maryland and National Institute of Standards and Technology

Goal:
Give an overview of methods that solve the robot – sensor calibration problem of the forms: AX = XB and AX = YB.

Method:
-Each form will be split into three groups
  -Separable closed-form solutions
  -Simultaneous closed-form solutions
  -Iterative solutions
-Advantages and disadvantages of each of the solutions in the case of evaluation of perception systems will be discussed.



Case 1: AX = XB where the unknown X represents the transformation from robot base to camera.

Case 2: AX = XB where the unknown X represents the transformation from gripper to camera.

Case 3: AX = YB where the unknown X represents the transformation from sensor to object and the unknown Y represents the transformation from target to camera.

On the Performance Evaluation of a Vision-based Human-Robot Interaction Framework

Junaed Sattar and Gregory Dudek
Center for Intelligent Machines, McGill University, Canada.

- A vision based HRI framework is presented.
- Explicit vs Implicit algorithms are discussed.
- A visual programming algorithm and a dialog for task confirmations is presented
- Expressive visual programming and risk avoidance
- User interface studies performed for evaluation in controlled laboratory settings
- Field trials performed

Functional Requirements of a Model for Kitting Plans

Stephen Balakirsky, Zeid Kootbally, Thomas Kramer,
Rajmohan Madhavan, Craig Schlenoff, Michael Shneier
National Institute of Standards and Technology

- Industrial assembly of manufactured products often involves bringing parts together in a kit and then moving the kit to the assembly area
- Kitting, the process of building kits, has not yet been automated in many industries. Consequently, the cost of building kits is higher than it could be.
- This paper examines the knowledge required to operate an automated kitting workstation
  - Non-executable information about a kitting workstation
    - Information about a robot, parts, kit designs, grippers, etc.
  - Executable plans for building kits
    - The plans will be used by execution systems that control robots and other mechanical devices to build kits
  - Functional requirements and what model constructs are needed to enable meeting those requirements

Sample kit. Image courtesy of LittleMachineShop.com

```
<ProcessPlan>
 <About>
  <PlanId>kitABCPlan</PlanId>
  <PlanVersion>1.0</PlanVersion>
  ...
  <TargetSKU>kitABC</TargetSKU>
 </About>
 <PlanRequirements>
  <PlanRequirement>
   <Name>boxOfEmptyTrays</Name>
   <Type>LargeContainer</Type>
   <SkuRef>Box1</SkuRef>
   <ContentsType>
    <SkuRef>kitTrayX</SkuRef>
   </ContentsType>
  </PlanRequirement>
  ...
```

Segment of process plan

TUE-AM2
Special Session I: Session Honoring the Legacy of Jim Albus & Alex Meystel
Organizers: Alberto Lacaze & Elena Messina

Jim Albus

Alex Meystel

- Army-NIST Robotics Teaming: A Thirty Year Retrospective
  [Charles Shoemaker, U.S. Army Communications-Electronics Research, Development, and Engineering]

- ATR's DoD programs with RoboCrane Technologies
  [Jackson Yang, Advanced Technology and Research Corporation]

- Mind, Brain, and Intelligence: A Krasnow Institute Perspective on the Jim Albus Legacy
  [Kenneth DeJong, Alexei Samsonovich, James Olds, Krasnow Institute for Advanced Study, GMU]

- Understanding 'Intelligence': in Pursuit of Multi-Resolutional Hierarchies
  [Predrag Filipovic, Agora Creative Solutions Inc.]

- Measurable and Scalable Methods for Modern Knowledge Processing
  [Michael Meystel, The Vanguard Group and Cognisphere Inc.]

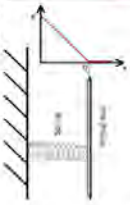
- Birth of an Architecture
  [Alberto Lacaze, Robotic Research LLC.]

TUE-PM1
Performance Measures and Metrics
Chairs: Rolf Lakaemper & Michael Del Rose

The new method for measuring absolute threshold of haptic force feedback

Michal Baczynski, Ph.D.
Samsung Electronics Polska, Poland R&D Center

New fast and accurate method of measuring absolute threshold for haptic force feedback has been proposed. The classic, widely published methods applied to measure force absolute threshold are time consuming because of time consumed by measurement procedure and time necessary for user training. The proposed method of measurement is very intuitive, thus it does not require trainings. The author has done researches using different methods and as a result stated that new method is not worse in terms of accuracy than classic ones.

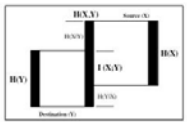


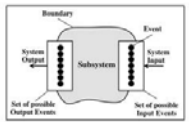
Method	Result [N]
Constant stimuli method	0.342
Limits method	0.320
Adjustment technique	0.351
Flexible Wall Technique	0.314
Average	0.332

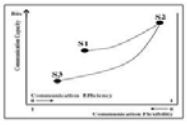
Approach for Defining Intelligent Systems Technical Performance Metrics

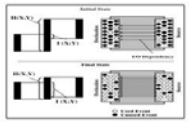
Wael Hafez
Independent Researcher

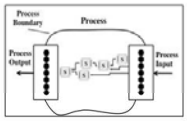
- Challenges with quantifying intelligent systems performance are discussed.
- Approach for *what* needs to be measured to capture intelligent systems performance is discussed.
- Application of communication theory to quantify intelligent systems performance is introduced.
- Three parameters for capturing intelligent system performance are developed:
  - System communication capacity
  - System communication efficiency
  - System communication flexibility
- How the three parameters are related to capture intelligent system performance is discussed.
- CPS example is discussed to indicate *how* to apply the approach.

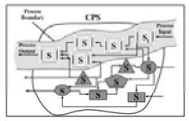








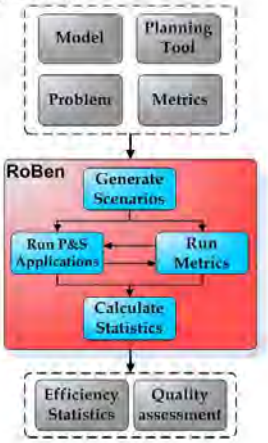




Metrics for Planetary Rover Planning & Scheduling Algorithms

J. M. Delfa[1,2,3], N. Policella[3], M. Gallant[3], O. von Stryk[1], A. Donati[3], Y. Gao[2]
[1]Technische Universität Darmstadt (Germany), [2]University of Surrey (UK)
[3] ESA-ESOC, European Space Agency (Germany)

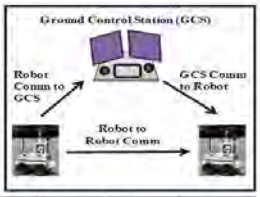
- The use of Automated Planning and Scheduling (P&S) is growing in the field of space robotics.
- Assessing and validating P&S algorithms is important due to their complexity and criticality.
- We introduce the benchmarking tool *RoBen* that evaluates the efficiency of P&S algorithms using metrics that measure problem complexity and performance.
- *RoBen* automatically generates synthetic scenarios to be solved by P&S algorithms.
- The current work and preliminary results are discussed.



Measures for UGV to UGV Collaboration

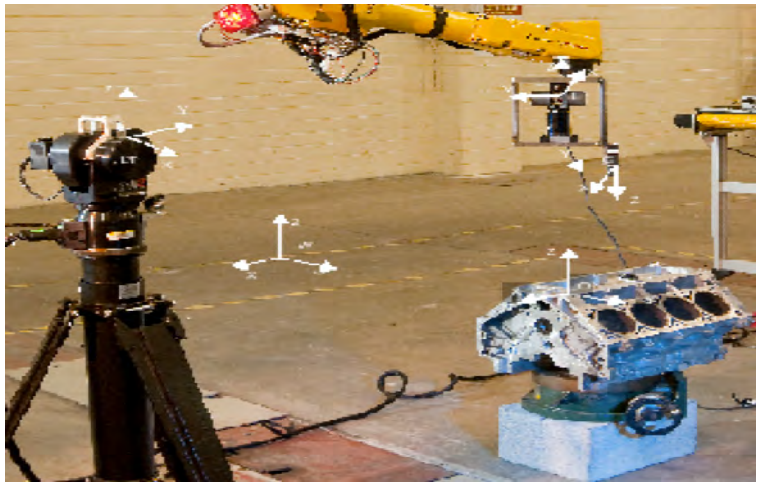
Michael Del Rose, Anthony Fin, Robert Kania

This paper discusses the metrics for assessing an unmanned vehicles level of collaboration with other vehicles. Collaboration between unmanned vehicles is an important function when complex or time sensitive missions are desired. These collaboration levels are designed to test and compare other vehicles. Test cases on the MAGIC 2010 competition and a few U.S. Army programs are summarized.



	COMM data	Hold data/world model	Analize data	Decisions	COMM decisions	Overwatch
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Human
2	Human with some SMI	Human with some SMI	Human	Human	Human	Human
3	Vehicle to SMI	SMI	SMI/Human	Human	Human	Human
4	Vehicle to SMI	SMI	SMI/Human	SMI/Human	SMI/Human	Human
5	Vehicle to SMI with some to vehicle	Vehicle/SMI	Vehicle/SMI	SMI	SMI	Human
6	Vehicle to Vehicle and SMI	Vehicle/SMI	Vehicle	Vehicle	Vehicle	SMI/Human
7	Vehicle to Vehicle	Vehicle	Vehicle	Vehicle	Vehicle	None

TUE-PM2
Special Session II: Performance Evaluation and Advanced Algorithms for Static & Dynamic 6DOF
Organizers: Chad English & Jane Shi



- 2011 Solutions in Perception Challenges Performance Metrics and Results
  [Jeremy Marvel, Tsai Hong, Elena Messina]

- Development of an Apparatus for Characterizing the Measurement Latency of a Dynamic 3D Tracking System
  [Kamel Saidi]

- Shape-based Pose Estimation Evaluation using Expectivity Index Artifacts
  [Chad English, Galina Okouneva, Aradhana Choudhuri]

- Ground Truth for Evaluating 6 Degrees of Freedom Pose Estimation Systems
  [Jeremy Marvel, Joe Falco, Tsai Hong]

- Performance Measurement with 6D Laser Tracker Technologies
  [Zach Ryan, Aaron Sabino]

WED-AM1
Human-Robot Collaboration and Interaction
Chairs: Jane Shi & Kate Tsui

A Proxemic-Based HRI Testbed

Zachary Henkel, Robin Murphy, Vasant Srinivasan, Cindy Bethel
Texas A&M University & Mississippi State University

Numerous human-robot interaction studies have established the importance of proxemics in establishing trust and social consonance, but each has used a robot capable of only some component, for example gaze but not audio style.

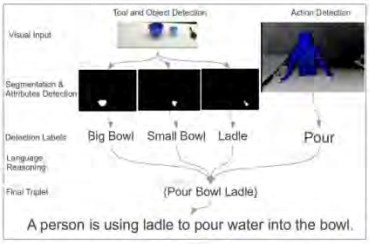
The Survivor Buddy proxemics testbed is expected to serve as blueprint for duplication or inspire the creation of other robots, enabling researchers to rapidly develop and test new schemes of proxemic based control.

Synergistic Methods for using Language in Robotics

Ching L. Teo, Yezhou Yang, Cornelia Fermüller, Yiannis Aloimonos
University of Maryland Institute for Advanced Computer Studies

Why Language for Robotics?

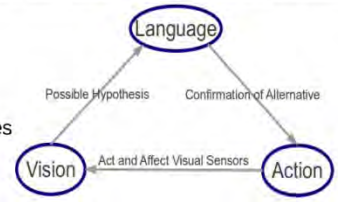
- Language acts as a contextual system;
- Language acts as a high level prior knowledge system;
- Language acts as part of a reasoning process;
- Language acts as part of an attention mechanism.



We demonstrate the integration of vision and language in three applications:

- Attributes-Based Object Recognition;
- Action Recognition;
- Scene Description.

An integrated robot system that observes and recognizes human manipulation actions has been built and tested.



Reusable Semantic Differential Scales for Measuring Social Response to Robots

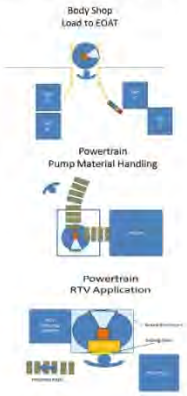
Lilia Moshkina
NRC Post-Doctoral Research Associate, Naval Research Lab

- As a new field, HRI is in need of replicable measurement tools.
- 8 novel reusable scales for measuring social response to robots are presented:
  - Persuasiveness, Understandability, Naturalness, Appropriateness, Welcome, Appeal, Unobtrusiveness and Ease
- Tested in 2 live HRI studies:
  - 43 participants in a Search-and-Rescue scenario (3 between-subject conditions)
  - 30 participants in a Robot-as-a-Guide scenario (2 between-subject conditions)
- Each scale had acceptable or better internal consistency reliability (Cronbach's alphas > 0.7)

Levels of Human and Robot Collaboration for Automotive Manufacturing

J. Shi*, G. Jimmerson**, T. Pearson***, R. Menassa*
*General Motors Global R&D Center, General Motors LLC
***Ford Motor Company, **United States Consortium for Automotive Research (USCAR)

- United States Consortium for Automotive Research (USCAR) conducted a concept feasibility study in 2010-2011 to investigate critical requirements to implement fenceless (the long term goal) or minimally fenced (the short term goal) robotics work cells in automotive manufacturing plants.
- Robotic systems are categorized for low, medium and high levels of human and robot collaboration with current state application examples in automotive manufacturing.
- Future potential human and robot collaboration applications are proposed for sensors to closely integrate with robotic systems for a tighter and more dynamic system response.
- The successful implementation probabilities are assessed for the low, medium, and high levels of human and robot collaborative applications.



Towards Measuring the Quality of Interaction: Communication through Telepresence Robots

Katherine M. Tsui, Munjal Desai, and Holly A. Yanco
University of Massachusetts Lowell

- Telepresence robots provide mobility to video conferencing. Remote operators can explore a space and converse without being restricted to a single vantage point.
- The benefit of this technology seems intuitive, yet metrics to explicitly quantify interaction through a telepresence robot do not exist.
- We examined audio and video technical requirements.
- We investigated quantitative and qualitative performance measures from HCI, communications, and psychology. Potential performance measures are independent of interpersonal relationships and communication task.

WED-AM2
Special Session III: Panel Discussion: Technology Readiness for Randomized Bin Picking Solutions
Organizers: Jeremy Marvel, Tsai Hong, Gerry Cheok & Elena Messina
Moderator: Roger Eastman

Image Courtesy Adil Shafi, ADVENOVATION, Inc.

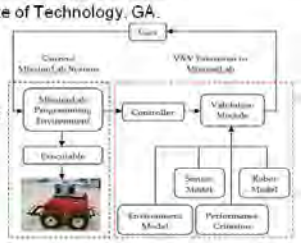
- Component acquisition from a randomized bin of parts is a major challenge in modern manufacturing
- An outline of technology readiness levels (TRL) will be presented
- The bin picking challenge will be discussed, and the issues regarding the classification of levels of difficulty highlighted
- An expert panel of users, vendors and integrators will lead a group discussion regarding next-generation bin picking opportunities and solutions

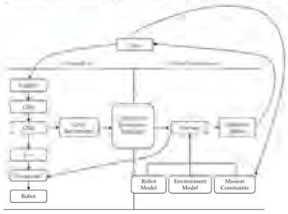
WED-PM1
Performance Characterization
Chairs: Damian Lyons & Hui-Min Huang

Characterizing Performance Guarantees for Multiagent, Real-Time Systems Operating in Noisy and Uncertain Environments

D.M. Lyons*, R.C. Arkin**, S.D. Fox*, S. Jiang**, P. Nirmal*, M.Zafar**
*Fordham University NY. **Georgia Institute of Technology, GA.

- To effectively deploy an autonomous robot or robot team to search and locate weapons of mass destruction (C-WMD), it is important to have performance specifications and guarantees available for the equipment.
- A software framework for verifying C-WMD performance guarantees is presented that is
  - based on extensions to the *MissionLab* mission specification system and on
  - a novel process algebra approach to represent robot programs and operating environments.
- Using a simple example scenario, we look at the implications of uncertainty in sensor and actuators, as well as uncertainty in the environment, on the performance guarantee.

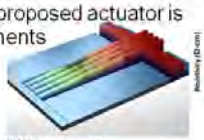


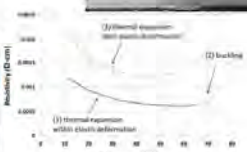


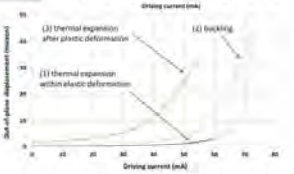
Design, fabrication and characterization of a single-layer out-of-plane electrothermal actuator for SOI-MEMS applications

Y. Kim, N. Dagalakis, S. Gupta
Intelligent Systems Division, National Institute of Standards and Technology (NIST)
Department of Mechanical Engineering, University of Maryland at College Park

- The current problems of out-of-plane actuator based on MEMS is discussed.
- The actuator is proposed based on its analytic relationships and a series of FEA
- The characterization of the proposed actuator is made by a series of experiments
  - Pure thermal expansion
  - Buckling
  - Plastic deformation
- The system integration capability of the proposed actuator for higher-DOF motion:
  - Based on standard Silicon-On-Insulator Multi-Users Multi-Processes



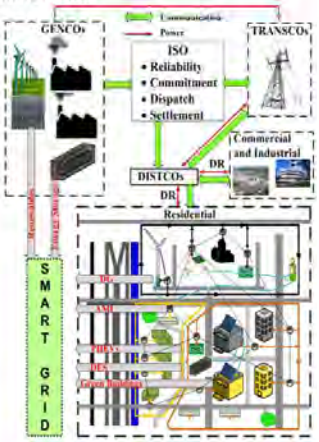




Intelligent Energy Management: Impact of Demand Response and Plug-in Electric Vehicles in a Smart Grid Environment

S. Srinivasa Raghavan and A. Khaligh
Power Electronics, Renewable Energy Harvesting and Renewable Energies Laboratory
University of Maryland, College Park

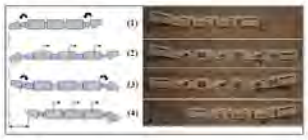
- Role of Demand Side Management (DSM) within Smart Grid environment is presented.
- Importance of enabling technologies in exploiting the benefits of DSM is analyzed.
- Demand Response (DR): Definition, Types, and economic impacts of demand response are explored.
- Scope of Plug-in electric vehicle penetration within the power market is studied.
- Case study on how DR can mutually benefit the utility as well as the consumer is illustrated.



Characterization of Forward Rectilinear-Gait Performance for a Snake-Inspired Robot

J. Hopkins, S.K. Gupta
Department of Mechanical Engineering and Institute for Systems Research
University of Maryland at College Park

- A new mechanical design and locomotion gait class are discussed that enables high speed motion for a snake-inspired robot.
- Four new parallel mechanism concepts are introduced, evaluated and a best option selected for the final robot design.
- A complete robotics analysis is presented for the selected parallel mechanism:
  - Forward and Inverse Kinematics
  - Jacobian Analysis
  - Inverse Dynamics Analysis
- A prototype of the final snake-inspired design is fabricated and evaluated using several performance metrics and experimental data.
- Future work for this design is discussed.



Emergency Response Robot Evaluation Exercise

Adam Jacoff, Hui-Min Huang, Ann Virts, Anthony Downs, Raymond Sheh
NIST, Robolit LLC

• Thirty emergency responders from across the country participated in DHS/NIST Response Robot Evaluation Exercises were hosted at the Disaster City in Texas, Half representing DHS FEMA Urban Search and Rescue teams and half representing bomb squads. They helped validate emerging standard robot test methods, became familiar with robot capabilities, and advised robot developers operational requirements.

• Ground, aquatic, and small aerials robots were all invited and identified capabilities within test methods, familiarized and trained responders with the capabilities, then were deployed with responders to perform operational tasks in practice scenarios.

WED-PM2
Field Testing and Standard Test Methods
Chairs: Barry Bodt & Roger Bostelman

Test Method for Measuring Station-Keeping With Unmanned Marine Vehicles Using Sonar or Optical Sensors

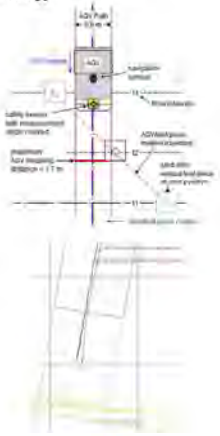
Asish Ghoshal, Avinash Parnandi, Robin R. Murphy
Texas A&M University

- Proposes a test method for measuring the ability of a USV or ROV to fixate on an underwater object, i.e., station-keeping.
- The test method uses the Lucas-Kanade optical flow algorithm in OpenCV to track an inexpensive raised plywood and wire fiducial.
- The rotational, translational, and root mean square (RMS) error is measured over a 3 minute period as well as number of image frames in which the fiducial was not visible.
- The method was demonstrated using a DIDSON acoustic camera, but is generalizable to other types of sonars and underwater video cameras.

Standard Test Procedures and Metrics Development for Automated Guided Vehicle Safety Standards

Roger Bostelman, Will Shackleford, Geraldine Cheok, Richard Norcross
National Institute of Standards and Technology

- NIST Mobile Autonomous Vehicles for Manufacturing Project has been researching automated guided vehicle (AGV) control based on advanced two-dimensional (2D) imaging sensors that detect dynamic, standard test pieces representing humans towards improving AGV safety standards.
- Experiments and results are presented in this paper showing the measurement of dynamic standard test pieces from an automated guided vehicle as compared to ground truth.
- Experimental results will be used to develop standard test methods and to recommend improved standard stopping distance exception language to AGV standards.



Integrating Occlusion Monitoring into Human Tracking for Robot Speed and Separation Monitoring

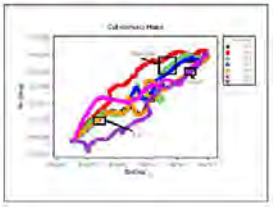
Shackleford W., Szabo S., Norcross R., Marvel J.
Intelligent Systems Division, National Institute of Standards and Technology (NIST)

- Introduction to collaborative robots and TC 184/SC 2/WG 3 Industrial Safety group within the International Standards Organization (ISO).
- NIST Robot Safety Test bed
- Speed and Separation Monitoring(SSM) Controller.
- Human Tracking with Laser Line-scanners.
- Occlusion Monitoring
  - Graph Algorithm
- Ground Truth Sampling.
- Performance Metrics
- Simulation Results
- Real Sensor Results
- Occlusion Mitigation Strategies

Robotics Collaborative Technology Alliance (RCTA) 2011 Baseline Assessment

B. Bodt*, R. Camden**, M. Childers*
*U.S. Army Research Laboratory and **MPRI

- A study to establish baseline autonomous performance for a small UGV in an urban setting is discussed.
- MAGIC RASR Team Talon
- Experimental approach features
  - Relevant conditions at the Combined Arms Collective Training Facility, FTIG, PA.
  - Systematic exploration of 8 distinct vignettes: surfaces, cul-de-sac, pedestrians, market-place, alley, doorway, drop-off, and stairs.
- Metrics: completed runs, time, speed, path analysis, and observations.
- Analysis highlights many successes and some limitations. A short video illustrates the vignettes.



Using Competitions to Advance the Development of Standard Test Methods for Response Robots

Adam Jacoff, Raymond Sheh, Ann-Marie Virts
National Institute of Standards and Technology

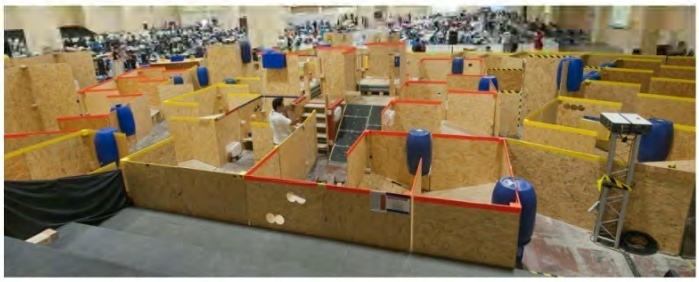
Tetsuya Kimura
Nagaoka University of Technology

Johannes Pellenz
Bundeswehr Tech. Ctr. For Engineer and General Field Equipment (WTD 51)

Sören Schwertfeger
Jacobs University Bremen

Jackrit Suthakorn
Mahidol University

Competitions can be a valuable asset in the standards development process. In this paper we discuss how the RoboCupRescue Robot League has played a crucial role in the development of standard test methods for response robots. We also explain how the League and community has been managed to best leverage its impact on research, both in terms of standards development as well as in the field of response robots.



THU-AM
Cyber-Physical Systems Panel Discussion
Organizers: Richard Voyles, NSF and Elena Messina, NIST
Moderator: Albert Wavering, NIST

Panel Members:

- Clare Allocca, NIST
- Panos Antsaklis, University of Notre Dame
- George Arnold, NIST
- Edward Lee, University of California-Berkeley
- Suzanne Lightman, NIST
- Rahul Mangharam, University of Pennsylvania

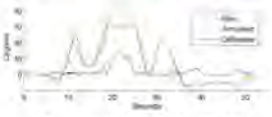
THU-PM
Performance Testing and Validation
Chairs: Brian Weiss & Venkat Krovi

Validation of the dynamics of an humanoid robot in USARSim

Sander van Noort & Arnoud Visser
Universiteit van Amsterdam, The Netherlands

- A realistic simulation allows rapid prototyping and stress testing of robot control algorithms.
- USARSim (based on Unreal) provides a powerful environment editor, which allows to define the experimental conditions precisely.
- The humanoid robot Nao is prototype for a whole class of robots with many moving parts and a dynamic balance.
- A series of experiments has been performed, starting from first principles (gravity constant), via constrained rigid body motion, complex maneuvers (Thai Chi, kick, walk) until a full application (soccer game between 4 players).
- This validation effort is an distinctive example how the dynamics of a robot should be tested.

Nao in USARSim performing balancing act (Thai Chi Chuan)



Movement of the ankle of the Nao during the balancing act

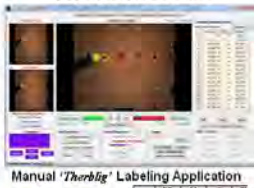
Evaluation of Robotic Minimally Invasive Surgical Skills using Motion Studies

Seung-Kook Jun, Madusudanan S Narayanan, Abeer Eddib *MD*, Pankaj Singhal MD, Sudha Garimella *MD*, Venkat Krovi
University at Buffalo (SUNY)

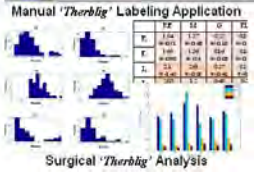
Minimally Invasive Surgical (MIS) skill evaluation

- Significance of skill assessment for MIS is discussed
- Novel performance metrics to characterize surgical expertise, dexterity and efficacy.
- Task-level segmentation of modular sub-procedures called "*Therbligs*" is presented
- The methods and results are analyzed
  - Motion analysis of simulated task as well as real surgical procedures using da Vinci robot demonstrate the applicability of the method
  - Measures for time-to-completion for each subtask, dexterity and effective motions corroborate with the 'true' expertise level

Da Vinci Robot/ Simulator



Manual '*Therblig*' Labeling Application

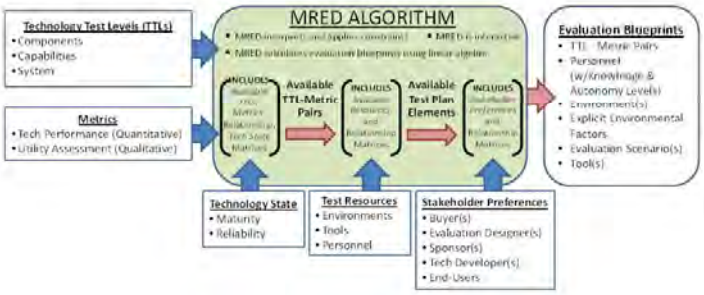


Surgical '*Therblig*' Analysis

Multi-Relationship Evaluation Design: Modeling an Automatic Test Plan Generator

Brian A. Weiss[1] and Linda C. Schmidt[2]
National Institute of Standards and Technology[1], University of Maryland – College Park[2]

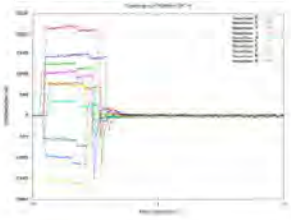
- Multi-Relationship Evaluation Design (MRED)
  - Automatically generates evaluation blueprints given multiple inputs
  - Interactive algorithm supporting input from multiple stakeholders
  - Invokes relationships among the inputs and the impacts the inputs have on the outputs



An IEEE 1588 Performance Testing Dashboard for Power Industry Requirements

J. Amelot[1], Y. Li-Baboud[1], C. Vasseur[1], J. Fletcher[2], D. Anand[2], J. Moyne[2]
[1]NIST, Software and Systems Division, Information Technology Laboratory
[2]University of Michigan, Engineering Research Center for Reconfigurable Manufacturing Systems

- The requirements of the Power Industry profile for IEEE 1588 is discussed.
- The design and implementation of the dashboard, a Graphical User Interface to tests the IEEE 1588 devices on the network is discussed.
- The different test methods used:
  - Holdover
  - Convergence
  - Security
  - Traffic injection
  - Interoperability
- The performance results using the dashboard are presented.



SPONSORS

ACKNOWLEDGMENTS

These people provided essential support to make this event happen. Their ideas and efforts are very much appreciated.

Website and Proceedings
Debbie Russell

Local Arrangements
Debbie Russell
Jeanenne Salvermoser
Sarah Standifer

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