PERFORMANCE METRICS FOR INTELLIGENT SYSTEMS WORKSHOP

Courtyard Gaithersburg Washingtonian Center, Gaithersburg, Maryland USA

August 28 - 30, 2007

FOREWORD

Welcome to the 2007 Performance Metrics for Intelligent Systems (PerMIS) Workshop!

PerMIS'07 is being held at the Courtyard Gaithersburg Washingtonian Center from August 28–30. This is the seventh installment of PerMIS that started in 2000 targeted at defining measures and methodologies of evaluating performance of intelligent systems, and it focuses on applications of performance measures to practical problems in commercial, industrial, homeland security, and military applications. The cardinal theme of this year's workshop is the ***interplay between autonomy and intelligence***, i.e. how does autonomy influence intelligence and vice versa. Topic areas include, but are not limited to:

Defining and measuring aspects of a system:

- The level of autonomy
- Human-robot interaction
- Collaboration

Evaluating components within intelligent system

- Sensing and perception
- Knowledge representation, world models, ontologies
- Planning and control
- Learning and adaption
- Reasoning

Infrastructural support for performance evaluation

- Testbeds and competitions for intercomparisons
- Instrumentation and other measurement tools
- Simulation and modeling support

Technology readiness measures for intelligent systems

Applied performance measures in various domains, e.g.,

- Intelligent transportation systems
- Emergency response robots (search and rescue, bomb disposal)
- Homeland security systems
- De-mining robots
- Defense robotics
- Hazardous environments (e.g., nuclear remediation)
- Industrial and manufacturing systems
- Space/Aerial robotics
- Medical Robotics & Assistive devices

We have assembled an exciting program for this year consisting of four plenary addresses, one featured presentation, four special sessions, and two panel discussions. In addition to these, there will be five general technical sessions. All of these presentations will address, in one way or another, performance metrics, evaluation, and analysis of intelligent systems in diverse domains ranging from space robotics to manufacturing, from mobile robotic systems to human machine interaction, to name a few.

PerMIS'07 is sponsored by NIST with technical co-sponsorship of the IEEE Washington Section Robotics and Automation Society Chapter and in-cooperation with the Association for Computing Machinery (ACM) Special Interest Group on Artificial Intelligence (SIGART). We would also like to acknowledge the financial support of the IEEE Washington Section.

There are several firsts to this year's workshop. The proceedings of PerMIS'07 will be indexed by INSPEC, Ei Compendex, ACM's Digital Library, and are released, as in previous years, as a NIST Special Publication. These indexing services will enable your work to reach a wider audience for increased references and citations. Springer Publishers will be hosting a booth on the last two days of the workshop during which time some of the displayed books will be raffled off. We thank Springer for their participation and hope that this is the beginning of many years of their support.

We would like to thank all members of the PerMIS'07 Program Committee, and the reviewers for contributing to the success of the workshop. Most importantly, we thank all authors for their valuable submissions and the attendees for their participation. We sincerely hope that you enjoy the presentations and ensuing discussions, while forging new relationships and renewing old ones. It is our great pleasure to host all the attendees. Enjoy the workshop!

Raj Madhavan
Program Chair

Elena Messina
General Chair

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PLENARY SPEAKER

Prof. Maria Gini

University of Minnesota, USA

Methodology for Experimental Research in Multi-robot Systems with Case Studies

Tue. 08:30

ABSTRACT

Fully repeatable and controllable experiments are essential to enable a precise comparison of multi-robot systems. Using different case studies, we describe a general methodology for conducting experimental activities for multi-robot systems. This is a first step toward the goal of fostering the practice of replicating experiments in order to compare different methods and assess their strengths and weaknesses.

In the first case study, we examine the problem of building a geometrical map of an indoor environment using multiple robots. The map is built by integrating partial maps made of segments without using any odometry information. We show how to improve the repeatability and controllability of the experimental results and how to compare different mapping systems.

We then present a case study of auction-based methods for the allocation of tasks to a group of robots. The robots operate in a 2D environment for which they each have a map. Tasks are locations in the map that must be visited by one robot. Robots bid to obtain tasks, but unexpected obstacles and other delays may prevent a robot from completing its allocated tasks. We show how to compare our experimental results with other published auction-based methods.

BIOGRAPHY

Maria Gini is a Professor at the Department of Computer Science and Engineering of the University of Minnesota. Before joining the University of Minnesota, she was a Research Associate at the Politecnico of Milan, Italy, and a Visiting Research Associate at Stanford University. Her work has included motion planning for robot arms, navigation of mobile robots around moving obstacles, unsupervised learning of complex behaviors, coordinated behaviors among multiple robots, and autonomous economic agents. She has coauthored over 200 technical papers. She is currently the chair of ACM Special Interest Group on Artificial Intelligence (SIGART), a member of the Association for the Advancement of Artificial Intelligence (AAAI) Executive Council and of the board of the International Foundation of Autonomous Agents and Multi-Agent Systems. She is on the editorial board of numerous journals, including Autonomous Robots, the Journal of Autonomous Agents & Multi-Agent Systems, Electronic Commerce Research and Applications, Integrated Computer-Aided Engineering, and Web Intelligence and Agent Systems.

PLENARY SPEAKER

Dr. Eric Krotkov

Griffin Technologies, USA

Measuring Ground Robot Performance

Tue. 14:00

ABSTRACT

This talk first describes several approaches to measure the performance of ground robots. It is easy enough to measure quantities such as speed and reliability. It is more challenging to define metrics for perception, planning, and autonomy. The talk then presents selected results of applying the approaches to systems developed by several Government programs.

BIOGRAPHY

Dr. Krotkov is the President of Griffin Technologies, a consulting and software firm specializing in robotics and machine perception. Before founding Griffin, he worked in industry as an executive in a medical imaging technology start-up, in government as a program manager at DARPA, and in academia as a faculty member of the Robotics Institute at Carnegie Mellon University. Dr. Krotkov earned his Ph.D. degree in Computer and Information Science in 1987 from the University of Pennsylvania, for pioneering work in active computer vision.

PLENARY SPEAKER

Prof. Illah Nourbakhsh

Carnegie Mellon University, USA

Formalizing Educational Human-Robot Collaboration

Wed. 08:30

ABSTRACT

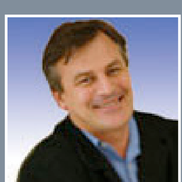
Designing human-robot collaboration systems is an inherently multidisciplinary endeavor aimed at providing humans with rich, effective and satisfying interactions. Over the past ten years, my laboratory has focused on educational collaboration, wherein the purpose of the interaction is to provide measurable learning for humans through exploration and discovery. We propose that the creation of a successful human-robot collaboration system requires innovation in several areas: robot morphology; robot behavior; social perception; interaction design; human cognitive models and evaluation of educational effectiveness. Our iterative process for collaboration design extends evaluation techniques from the informal learning field together with underlying technical advances in robotics. This talk describes our research methodology, technical contributions and experimental outcomes for three fielded robot systems that push on developing a generalizable, formal approach to educational human-robot collaboration. For the past several months, our group has been laying the groundwork for large-scale dissemination of our technology and curricular instruments.

I will describe the robot “community” we wish to help spawn, and the ingredients that may help to catalyze a broad form of technologically empowered community, including the Telepresence Robot Kit and the Global Connection Project.

BIOGRAPHY

Illah R. Nourbakhsh is an Associate Professor of Robotics and head of the Robotics Masters Program in The Robotics Institute at Carnegie Mellon University. He was on leave for the 2004 calendar year and was at NASA/Ames Research Center serving as Robotics Group lead. He received his Ph.D. in computer science from Stanford University in 1996. He is co-founder of the Toy Robots Initiative at The Robotics Institute, director of the Center for Innovative Robotics and director of the Community Robotics, Education and Technology Empowerment (CREATE) lab. He is also co-PI of the Global Connection Project, home of the Gigapan project. He is also co-PI of the Robot 250 city-wide art+robotics fusion program in Pittsburgh. His current research projects include educational and social robotics and community robotics. His past research has included protein structure prediction under the GENOME project, software reuse, interleaving planning and execution and planning and scheduling algorithms, as well as mobile robot navigation. At the Jet Propulsion Laboratory he was a member of the New Millenium Rapid Prototyping Team for the design of autonomous spacecraft. He is a founder and chief scientist of Blue Pumpkin Software, Inc., which was acquired by Witness Systems, Inc. Illah recently co-authored the MIT Press textbook, Introduction to Autonomous Mobile Robots.

PLENARY SPEAKER



Dr. Alex Zelinsky

CSIRO ICT Centre, Australia

Building Autonomous Systems of High Performance, Reliability and Integrity

Thu. 08:30

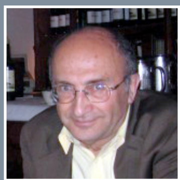
ABSTRACT

Commercial applications for the everyday deployment of autonomous systems based on robotic and intelligent systems technologies require the highest levels of performance, reliability and integrity. The general public expects intelligent machines to be fully operational 100% of the time. People expect autonomous technologies to operate at higher levels of performance and safety than people themselves exhibit. For example smart car technologies are expected to cause ZERO accidents while human errors kill more 150,000 people on our roads every year! This talk will describe the design principles that have been developed over of the last 10 years through exhaustive trial and error testing to underpin autonomous systems that are suitable for real-world deployment. Currently, it is not yet possible to realise an autonomous system that doesn't fail periodically. Even if the mean rate between failures is days or weeks, a single failure could have catastrophic consequences. The approach we have adopted to address this situation has been to build-in monitoring systems that continually check all key system parameters and variables. If the monitored parameters move outside tightly defined bounds the system will safely shutdown, and alert the human supervisor. The failure conditions are logged and then further testing and debugging is performed. The value and appropriateness of our approach will be shown by a number of real-world studies. We will show that how it is possible to design computer vision systems for human-machine applications can operate with over 99% reliability, in all lighting conditions, for all types of users irrespective of age, race or visual appearance. These systems have been used in automotive and sports applications. We have also show how this approach has been used to design field robotic systems that have deployed in automobile safety systems and 24/7 mining applications.

BIOGRAPHY

Dr. Alex Zelinsky is a well-known scientist, specialising in robotics and computer vision and is widely recognised as an innovator in human-machine interaction. Dr. Zelinsky is currently Group Executive, Information and Communication Sciences and Technology, and Director, CSIRO Information Communication Technology (ICT) Centre. Before joining CSIRO in July 2004, Dr. Zelinsky was CEO of Seeing Machines, a company dedicated to the commercialisation of computer vision systems. Dr. Zelinsky co-founded Seeing Machines in June 2000, the company is now publicly listed on the London Stock Exchange. The technology commercialised by Seeing Machines was developed at the Australian National University where Dr. Zelinsky was Professor and Head of the Department of Systems Engineering (1996 -2000). Prior to joining the Australian National University, Dr. Zelinsky worked as an academic at the University Wollongong (1984-1991) and as a research scientist in the Electrotechnical Laboratory, Japan (1992-1995). Dr. Zelinsky is an active member of the robotics community and has served on the editorial boards of the International Journal of Robotics Research and IEEE Robotics and Automation Magazine, he also founded the Field & Services Robotics conference series. Dr. Zelinsky's contributions have been recognised by awards in Australia and internationally. These include the Australian Engineering Excellence Awards, US R&D magazine Top 100 Award and Technology Pioneer at the World Economic Forum.

FEATURED PRESENTATION



Dr. Vladimir Lumelsky

NASA-Goddard Space Center, USA

Human-Robot Interaction in Physical Proximity: Issues and Prospects

Wed. 14:00

ABSTRACT

After spectacular successes, in 1970s-1980s, in the use of robotics in highly structured environments - e.g. automotive assembly, welding, and painting lines - the penetration of "serious" robots (those large and powerful enough to be harmful) into new applications has slowed down markedly. User manuals of most robot arm manipulators warn that under no circumstance can people enter the workspace of an operating robot. The reason is simple - due to intended use these robots are strong enough to endanger a human, yet their sensing and intelligence is "too dumb" to be trusted for human safety. In the roboticists' parlance, today's robots are not designed to operate in unstructured environments, that is settings not created specifically for the robot's operation. It is not the function the robot is built for that is the problem - it is the robot's interaction with its environment. The problem is lesser with robot rovers but quite pronounced with arm manipulators.

The way to break this barrier is to design robots fully capable of operating in an unstructured environment, in places where things are unpredictable and must be perceived and decided upon on the fly. This is a new terrain - the required hardware and intelligence are to be more complex and sophisticated than what we know today. In this talk we will review related technical and scientific issues.

BIOGRAPHY

Dr. Vladimir Lumelsky is the head of the Laboratory of Robotics for Unstructured Environments at NASA-Goddard Space Center, and is Adjunct Professor of Computer Science at the University of Maryland-College Park. The long-term goal of the laboratory is to develop robots capable of operating in the uncertain and changing settings likely to arise in future NASA missions. This work builds upon Dr. Lumelsky's work on large sensitive robot skin systems prior to joining NASA in 2004, as a professor at Yale University and later at the University of Wisconsin-Madison (where he was The Consolidated Papers Professor of Engineering). Dr. Lumelsky is the author of three books and over 200 professional papers covering the areas of robotics, computational intelligence, human-machine interaction, human spatial reasoning, massive sensor arrays, bio-engineering, control theory, kinematics, pattern recognition, and industrial automation. He has held a variety of positions in both the public and private sectors: he was Program Director at the National Science Foundation, and has led large technical projects, including development of a universal industrial robot controller at General Electric (GE Research Center), and a joint robot skin development effort with Hitachi Corporation. Dr. Lumelsky also has held temporary positions at the Science University of Tokyo (Japan), Weizmann Institute (Israel) and US South Pole Station, Antarctica. He is the founding Editor-in-Chief of the IEEE Sensors Journal, and has served on editorial boards of other professional journals. He has been guest editor of special issues at professional journals; served on the Administrative Committees of IEEE Robotics Society and Sensors Council; chaired technical committees and working groups; and chaired and co-chaired major international conferences, workshops and special sessions. Dr. Lumelsky has served as a technical expert in legal cases, including multinational litigation. He frequently gives talks at US and foreign universities, government groups, think tanks, and in industry. He is a member of several professional societies, and is a Fellow of IEEE.

August

TUESDAY 28

PROGRAM

PERMIS

08:15	Welcome & Overview
08:30	**Plenary Presentation:** **Maria Gini** ***Methodology for Experimental Research in Multi-robot Systems with Case Studies***
09:30	Coffee Break
10:00	**TUE-AM1 Mobile Robot Performance Evaluation I** ***Chairs: C. Schlenoff & M. Childers*** • Evaluation of Navigation of an Autonomous Mobile Robot [N. Muñoz, J. Valencia, N. Londoño] • Assessing the Impact of Bi-directional Information Flow in UGV Operation: A Pilot Study [M. Childers, B. Bodt, S. Hill, R. Dean, W. Dodson, L. Sutton] • Standard Operator Control Unit Color Scheme for Mobile Robots [M. Shneier, R. Bostelman, J. Albus, W. Shackleford, T. Chang, T. Hong] • How DoD's TRA Process Could be Applied to Intelligent Systems Development [D. Sparrow, S. Cazares] • A Brief History of PRIDE [C. Schlenoff, Z. Kootbally, R. Madhavan]
12:30	Lunch on your own
14:00	**Plenary Presentation:** **Eric Krotkov** ***Measuring Ground Robot Performance***
15:00	Coffee Break
15:30	**TUE-PM1 Mobile Robot Performance Evaluation II** ***Chairs: S. Balakirsky & C. Lundberg*** • Assessment of Man-portable Robots for Law Enforcement Agencies [C. Lundberg, H. Christnesen] • Performance Metrics and Evaluation of a Path Planner based on Genetic Algorithms [G. Giardini, T. Kalmar-Nagy] • The Evolution of Performance Metrics in the RoboCup Rescue Virtual Robot Competition [S. Balakirsky, C. Scrapper, S. Carpin] • Robot Simulation Physics Validation [C. Pepper, S. Balakirsky, C. Scrapper] • Design and Validation of a Whegs Robot in USARSim [B. Taylor, S. Balakirsky, E. Messina, R. Quinn]
18:30	Reception

08:15	Welcome & Overview
08:30	**Plenary Presentation:** **Maria Gini** ***Methodology for Experimental Research in Multi-robot Systems with Case Studies***
09:30	Coffee Break
10:00	**TUE-AM2 Special Session I: Autonomy Levels for Unmanned Systems** ***Organizer: Hui-Min Huang (NIST)*** • Autonomy Levels for Unmanned Systems (ALFUS) Framework: Safety and Application Issues [H-M. Huang] • Evaluation of Autonomy in Recent Ground Vehicles Using the Autonomy Levels for Unmanned Systems (ALFUS) Framework [G. McWilliams, M. Brown, R. Lamm, C. Guerra, P. Avery, K. Kozak, B. Surampudi] • A Methodology for Testing Unmanned Vehicle Behavior and Autonomy [D. Gertman, C. McFarland, T. Klein, A. Gertman, D. Bruemmer] • Standardizing Measurements of Autonomy in the Artificially Intelligent [A. Hudson, L. Reeker] • Autonomous Level Density And Distribution [D. Brayman]
12:30	Lunch on your own
14:00	**Plenary Presentation:** **Eric Krotkov** ***Measuring Ground Robot Performance***
15:00	Coffee Break
15:30	**TUE-PM2 Special Session II: Human Robot Interface Issues** ***Organizers: Salvatore Schipani & Brian Antonishek (NIST)*** • Maze Hypothesis Development in Assessing Robot Performance During Teleoperation [S. Schipani, E. Messina] • Human System Performance Metrics for Evaluation of Mixed-Initiative Heterogeneous Autonomous Systems [L. Billman, M. Steinberg] • Concepts of Operations for Robot-Assisted Emergency Response and Implications for Human-Robot Interaction [J. Scholtz, B. Antonishek, B. Stanton, C. Schlenoff] • Multimodal Displays to Enhance Human Robot Interaction On-the-Move* [E. Haas, C. Stachowiak]
18:30	Reception

*A multi-modal information system will be demonstrated.

August 29 WEDNESDAY

PROGRAM

PERMIS

08:15	Overview
08:30	**Plenary Presentation:** **Illah Nourbakhsh** ***Formalizing Educational Human-Robot Collaboration***
09:30	Coffee Break
10:00	**WED-AM1 Autonomy Vs Intelligence** ***Chairs: J. Gunderson & J. Evans*** • Autonomy (What's it Good for?) [J. Gunderson, L. Gunderson] • Definitions and Measures of Intelligence in Deep Blue and the Army XUV [J. Evans] • Automotive Turing Test [S. Kalik, D. Prokhorov] • Autonomous Robots with Both Body and Behavior Self-Knowledge [B. Gordon] • A Cognitive-based Agent Architecture for Autonomous Situation Analysis [G. Berg-Cross, W-T. Fu, A. Kwon]
12:30	Lunch on your own
14:00	**Featured Presentation:** **Vladimir Lumelsky** ***Human-Robot Interaction in Physical Proximity: Issues and Prospects***
15:00	Coffee Break
15:30	**WED-PM1 Human Machine Interaction** ***Chairs: N. Dagalakis & A. Steinfeld*** • Evaluation of an Integrated Multi-Task Machine Learning System with Humans in the Loop [A. Steinfeld, S. Bennett, K. Cunningham, M. Lahut, P-A. Quinones, D. Wexler, D. Siewiorek, J. Hayes, P. Cohen, J. Fitzgerald, O. Hansson, M. Pool, M. Drummond] • Survey Measures for Evaluation of Cognitive Assistants [A. Steinfeld, P-A. Quinones, J. Zimmerman, S. Bennett, D. Siewiorek] • Development of Tools for Measuring the Performance of Computer Assisted Orthopaedic Hip Surgery Systems [N. Dagalakis, Y. Kim, D. Sawyer, C. Shakarji] • Haptic Feedback System for Robot-Assisted Surgery [J. Desai, G. Tholey, C. Kennedy]
19:30	Banquet (Adam Jacoff, NIST)

August 29 WEDNESDAY

08:15	Overview
08:30	**Plenary Presentation:** **Illah Nourbakhsh** ***Formalizing Educational Human-Robot Collaboration***
09:30	Coffee Break
10:00	**WED-AM2 Panel Discussion I: Can the Development of Intelligent Robots be Benchmarked? Concepts and Issues from Epigenetic Robotics** ***(Moderator: Gary Berg-Cross, EM & I)*** • Douglas Blank, Bryn Mawr College • James Marshall, Sarah Lawrence College • Lisa Meeden, Swarthmore College • Charles Kemp, Georgia Tech. • Chad Jenkins, Brown University
12:30	Lunch on your own
14:00	**Featured Presentation:** **Vladimir Lumelsky** ***Human-Robot Interaction in Physical Proximity: Issues and Prospects***
15:00	Coffee Break
15:30	**WED-PM2 Special Session III: Space/Aerial Robotics** ***Organizer: Edward Tunstel (JPL)*** • Prototype Rover Field Testing and Planetary Surface Operations [E. Tunstel] • Planning to Fail - Reliability as a Design Parameter for Planetary Rover Missions [S. Stancliff, J. Dolan, A. Trebi-Ollennu] • A Decision Space Compression Approach for Model Based Parallel Computing Processes [R. Bonneau, G. Ramseyer] • TBD [E. Atkins]
19:30	Banquet (Adam Jacoff, NIST)

August

THURSDAY 30

PROGRAM

PERMIS

08:15	Overview
08:30	**Plenary Presentation:** **Alex Zelinsky** ***Building Autonomous Systems of High Performance, Reliability and Integrity***
09:30	Coffee Break
10:00	**THU-AM1 Performance Assessment of Algorithms** ***Chairs: R. Lakaemper & S. Spetka*** • Analyzing the Performance of Distributed Algorithms [R. Lass, E. Sultanik, W. Regli] • An Agent Structure for Evaluating MAS Performance [C. Dimou, A. Symeonidis, P. Mitkas] • Information Management for High Performance Autonomous Intelligent Systems [S. Spetka, S. Tucker, G. Ramseyer, R. Linderman] • Efficient Monte Carlo Computation of Fisher Information Matrix using Prior Information [S. Das, J. Spall, R. Ghanem] • Performance of 6D LuM and FFS SLAM -- An Example for Comparison using Grid and Pose Based Evaluation Methods [R. Lakaemper, A. Nuchter, N. Adluru, L. Latecki]
12:30	Lunch on your own
14:00	**THU-PM Panel Discussion II: (Re-)Establishing or Increasing Collaborative Links Between Artificial Intelligence and Intelligent Systems** ***(Moderator: Brent Gordon, NASA-Goddard)*** • James Albus, Senior Fellow, Intelligent Systems Division, NIST • Ella Atkins, Associate Professor, University of Michigan • Henrik Christensen, Director, Center for Robotics and Intelligent Machines, Georgia Tech. • Larry Reeker, Computer Scientist, Information Technology Laboratory, NIST
15:30	Coffee Break
16:00	Adjourn

PERMIS

PROGRAM

August

THURSDAY 30

08:15	Overview
08:30	**Plenary Presentation:** **Alex Zelinsky** ***Building Autonomous Systems of High Performance, Reliability and Integrity***
09:30	Coffee Break
10:00	**THU-AM2 Special Session IV: Smart Assembly Systems** ***Organizers: Robert Tilove (GM) & John Slotwinski (NIST)*** • Smart Assembly: Industry Needs and Challenges [R. Tilove, J. Slotwinski] • Hybrid Emulation for Manufacturing Automation Controls: Needs and Challenges [S. Biller, F. Gu, C. Yuan] • Science based Information Metrology for Engineering Informatics [S. Rachuri] • Evaluating Manufacturing Control Language Standards: An Implementer's View [T. Kramer] • Interoperability Testing for Shop-Floor Inspection [J. Falco, J. Horst, T. Kramer, J. Michaloski, F. Proctor, W. Rippey] • A Virtual Environment-Based Training Systems for Mechanical Assembly Operations [S. Gupta, D. Anand, J. Brough, R. Kavetsky, M. Schwartz]
12:30	Lunch on your own
14:00	**THU-PM Panel Discussion II: (Re-)Establishing or Increasing Collaborative Links Between Artificial Intelligence and Intelligent Systems** ***(Moderator: Brent Gordon, NASA-Goddard)*** • James Albus, Senior Fellow, Intelligent Systems Division, NIST • Ella Atkins, Associate Professor, University of Michigan • Henrik Christensen, Director, Center for Robotics and Intelligent Machines, Georgia Tech. • Larry Reeker, Computer Scientist, Information Technology Laboratory, NIST
15:30	Coffee Break
16:00	Adjourn

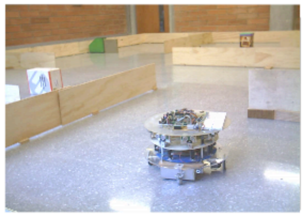

DIGESTS

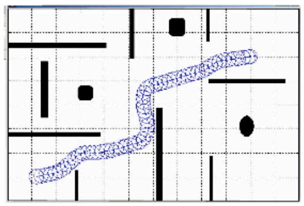
TUE-AM1
Mobile Robot Performance Evaluation I
Chairs: C. Schlenoff & M. Childers

Evaluation of Navigation of an Autonomous Mobile Robot

N. D. Muñoz, J. A. Valencia, N. Londoño
Polytechnic Jaime Isaza Cadavid, University of Antioquia - Colombia

- The navigation of an autonomous mobile robot is evaluated.
- Several metrics are described; These metrics, collectively, provide an indication of the quality of the navigation, useful for comparing and analyzing control architectures of mobile robots.
- Two control architectures are simulated and compared in an autonomous navigation mission.





How DoD's Technology Readiness Assessment (TRA) Process could be Applied to Intelligent Systems development

D. A. Sparrow, S. Cazares
Science and Technology Division, Institute for Defense Analyses (IDA)

- DoD has instituted a TRA process to ensure technology development is mature prior to product development.
- Metrics used are NASA's Technology Readiness Levels (TRLs), with some modification for software systems.
- Determination of TRLs requires a defined of a *relevant environment*.
- The TRA approach may be useful in Intelligent Systems development, but further modification to TRLs may be needed.
- Defining the relevant environment for Intelligent Systems presents new challenges, as will be discussed.

Current Hardware TRLs 4 - 6

4. Component and/or breadboard validation in a lab. environment.
5. Component and/or breadboard validation in a relevant environment.
6. System/subsystem model or prototype demonstration in a relevant environment.

Current Software TRLs 4 - 6

4. Module and/or subsystem validation in a lab. environment.
5. Module and/or subsystem validation in a relevant environment
6. Module and/or subsystem validation in a relevant end-to-end environment

Assessing the Impact of Bi-directional Information Flow in UGV Operation: A Pilot Study

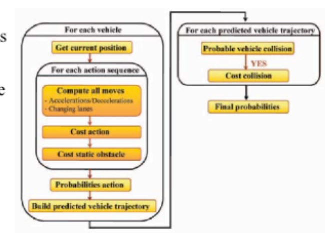
M. Childers, B. Bodt, S. Hill, U.S. Army Research Laboratory
R. Dean, W. Dodson, L. Sutton, General Dynamics Robotics Systems

- A June 2007 exploratory assessment was conducted to assess how bi-directional information flow impacts Unmanned Ground Vehicle (UGV) operation.
- The purposes of the pilot study were to frame scenarios, protocol, infrastructure, and metrics for a more formal experiment planned for the Fall of 2007.
- The technologies under evaluation are designed to send sensed terrain data to a deliberative (global) planning layer which in turn transmits mobility costs down to the perceptive (local) layer for improved route planning.
- Runs were conducted in two areas at Ft. Indiantown Gap, PA that feature rolling vegetated, open, and wooded terrain. Routes were designed to challenge these technologies which reason about mission constraints to include mobility, time, and exposure to threats.
- Plots of the route traveled were made for each of the runs in the study and together with summary statistics and operator narratives collected during each run allowed for interpretation of events.
- The potential impacts on operator performance are considered.

A Brief History of PRIDE

C. Schlenoff, Z. Kootbally, and **R. Madhavan**
Intelligent Systems Division, National Institute of Standards and Technology (NIST)

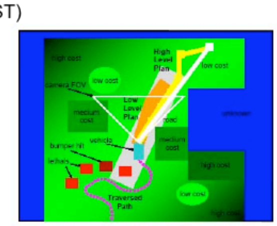
- PRIDE (Prediction in Dynamic Environments) is a framework that provides an autonomous vehicle's planning system with information that it needs to perform path planning in the presence of moving objects
- The underlying concept is based upon a multi-resolutional, hierarchical approach that incorporates multiple prediction algorithms into a single, unifying framework.
- This framework supports the prediction of the future location of moving objects at various levels of resolution, thus providing prediction information at the frequency and level of abstraction necessary for planners at different levels.
- This paper takes the reader through a chronology of the development of the PRIDE framework, starting back in 2003 when the concept was first conceived.

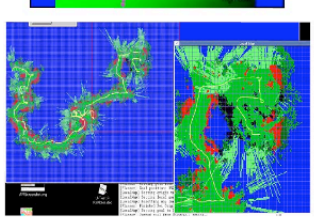


Standard Operator Control Unit Color Scheme for Mobile Robots

M. Shneier, R. Bostelman, J. S. Albus, W. Shackleford, T. Chang, T. Hong
Intelligent Systems Division, National Institute of Standards and Technology (NIST)

- NIST was asked by the DARPA LAGR program to provide a standard operator control unit (OCU) color scheme for all LAGR teams to use
- The standard color scheme simplifies performance evaluation of each of the teams using their own OCUs
- NIST developed the color scheme based on real-world conventions and the desire to accommodate as much of the teams' existing color schemes as possible
- Since red lights mean stop and green lights mean go, obstacles were colored red and traversable ground green
- Other colors were produced for features such as unknown regions, bumper hits, roads, planned paths (top figure on right)
- Vehicle modes were also indicated such as: Normal Control, Aggressive, Backing, Stopped, and Manual modes.
- The bottom figure on the right shows the appearance of the color scheme on one team's OCU.



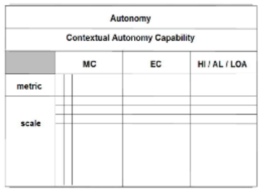


TUE-AM2
Special Session I: Autonomy Levels for Unmanned Systems
Organizer: H-M. Huang

Autonomy Levels for Unmanned Systems (ALFUS) Framework: Safety and Application Issues

Hui-Min Huang
Intelligent Systems Division, National Institute of Standards and Technology (NIST)

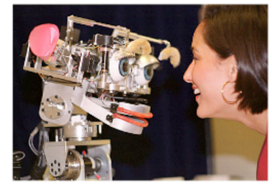
- ALFUS aims at providing standard terms, definitions, metrics, and tools to characterize unmanned systems (UMS).
- UMS's autonomous capability is characterized by the capable missions, in certain environments, and required / allowed human interface.
- Deficiency in autonomous capability leads to risk and safety concerns.
- ALFUS is applicable to manufacturing. Production orders, work environment, and operators are main concerns. More domains: Defense, Urban Search and Rescue (US&R), Security.
- Simulation with Virtual UMS may be cost saving.

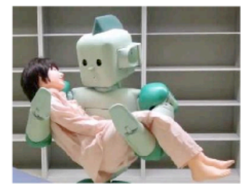


Standardizing Measurements of Autonomy in the Artificially Intelligent

A. Hudson, L. Reeker
Information Technology Laboratory, National Institute of Standards and Technology (NIST)

- The importance of autonomy in information technology today is stressed.
- Autonomy is broken into five areas to measure: learning, communication, maintenance, mobility, and creation.
- Scales and rubrics are suggested and discussed to quantify these areas.

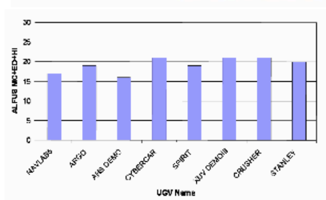




Evaluation of Autonomy in Recent Ground Vehicles Using the Autonomy Levels for Unmanned Systems Framework

G. McWilliams, M. Brown, R. Lamm, C. Guerra, P. Avery, K. Kozak, B. Surampudi
Southwest Research Institute

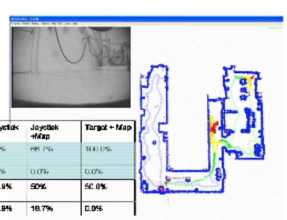
- Vehicle autonomy exists in many different markets, such as passenger vehicles, transit and freight, extraterrestrial rovers, and military vehicles.
- The ALFUS framework has been developed to compare the autonomy levels discussed in these vehicles.
- The autonomy in each category is discussed and a case study is evaluated against the ALFUS framework.
- The results of each case are presented and the cases are compared with one another.
- A conclusion assesses the current state of vehicle autonomy, and summarizes the evaluation process using the ALFUS framework.



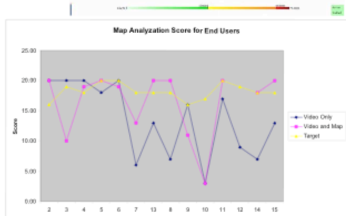
A Methodology for Testing Unmanned Vehicle Behavior and Autonomy

Gertman, D.[1], McFarland, C.[2], Klein, T. A.[3], Gertman, A. E.[4], and Bruemmer, D. J.[1]
[1]Robotic and Human Systems Department, Idaho National Laboratory (INL) [2]Johns Hopkins University, Department of Engineering,
[3]Oregon State University, Department of Engineering [4]Albertson College of Idaho, Department of Mathematics

- Discussion of metrics used across several experiments including:
  - Landmine detection and marking;
  - Mapping and localization;
  - Radiation characterization and
  - Urban search and rescue.
- Three factors key to holistic human-robot performance assessment:
  - Comprehensive planning;
  - Inclusion of end users in experiment design, execution and analysis;
  - Combining automated data collection with subjective measures.



		Joystick	Joystick +Map	Target + Map
LOU	% Excellent	57%	88.7%	100.0%
	% Fail	28%	0.0%	0.0%
CST	% Excellent	42.9%	50%	50.0%
	% Fail	42.8%	16.7%	0.0%

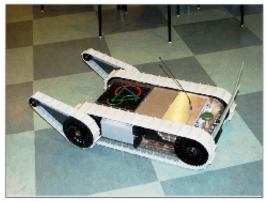


TUE-PM1
Mobile Robot Performance Evaluation II
Chairs: S. Balakirsky & C. Lundberg

Assessment of Man-portable Robots for Law Enforcement Agencies

Carl Lundberg[a], Henrik I. Christensen[b]
[a]National Defence College, [b]Georgia Institute of Technology

- This project has trialed a Packbot Scout within a SWAT-police unit during five months.
- The purpose was to explore the tactical benefits of the system and to trial the robot's technical performance. It was also an objective to compare results obtained during military training, with results from deployment during true risk.
- The SWAT-team, trained and equipped with the robot, brought the robot with them on regular missions whenever possible.
- The robot was estimated to be of most benefit during negotiation, long-time surveillance, and for the deployment of non-lethal weapons.
- Desired improvements include two-way audio, increased field of view, motion detection, and image cropping. Price threshold was estimated to 30'000-50'000 USD.



Robot Simulation Physics Validation

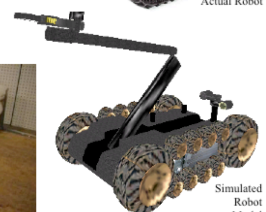
C. Pepper, S. Balakirsky, C. Scrapper
Intelligent Systems Division, National Institute of Standards and Technology (NIST)

- Six standard test methods are discussed that are used to analyze robot performance, and are introduced as a method of determining simulation model performance.
- The process of constructing and validating the simulated test methods is covered.
- Robot model accuracies and inaccuracies are identified and corrected using the validated test methods through comparison of performance data with that of the actual robot.

Actual Robot

Simulated Test Method

Actual Test Method

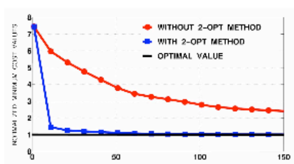


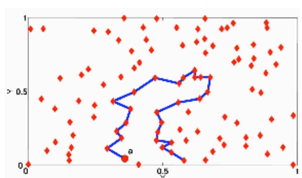
Simulated Robot Model

Performance Metrics and Evaluation of a Path Planner based on Genetic Algorithms

Giovanni Giardini and Tamás Kalmár-Nagy
Department of Aerospace Engineering, Politecnico di Milano
Department of Aerospace Engineering, Texas A&M University

- **Path Planning Problem**: reaching *N* targets in the shortest possible way
  - Solving this problem could be seen as a particular **Traveling Salesman Problem (TSP)**
- A **Planning System** for an autonomous vehicle, based on ***Genetic Algorithms***, has been developed
- To solve the TSP and to improve the solutions:
  - a **new set of genetic operators** has been designed;
  - The GA has been coupled with an **Heuristic method**
- An extensive campaign of tests have been conducted in order to evaluate the performance of the algorithm.

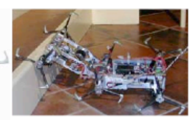


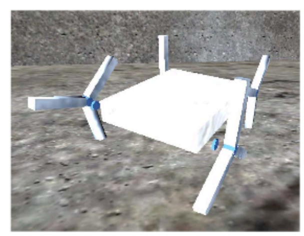


Design and Validation of a Whegs Robot in USARSim

B.K. Taylor[1], S. Balakirsky[2], E. Messina[2], R.D. Quinn[1]
1) Biologically Inspired Robotics Laboratory, Case Western Reserve University
2) Intelligent Systems Division, National Institute of Standards and Technology

- A Whegs™ robot is developed in the Urban Search and Rescue Simulation (USARSim) environment
- Behavioral characteristics found on the real robot such as passive torsional compliance in each axle and proper wheel-leg phasing are implemented in the virtual robot to aid in tasks such as climbing and navigating changing and adverse terrain
- The virtual robot is tested, evaluated, and compared to the real robot to make sure that both vehicles exhibit the same performance





The Evolution of Performance Metrics in the RoboCup Rescue Virtual Robot Competition

S. Balakirsky[1], C. Scrapper[1], S. Carpin[2]

- The 2nd annual RoboCup Rescue Virtual Robot Competition was held this year in Atlanta, GA.
- This year's competition featured three different research tracks.
- The metrics have evolved to allow researchers involved in different research tracks to compete without advantage.
- The specific metrics and scoring equations will be discussed along with the way in which the competition was run and organized.
- Steps toward automatic judging and standardization will be presented.

1 – National Institute of Standards and Technology
2 – University of California, Merced

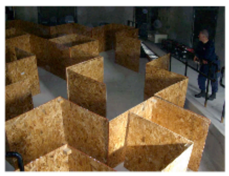
TUE-PM2
Special Session II: Human Robot Interface Issues
Organizers: S. Schipani & B. Antonishek

Maze Hypothesis Development In Assessing Robot Performance During Teleoperation

S. Schipani & E. Messina
National Institute of Standards and Technology (NIST)

- Performance standards for Urban Search and Rescue (USAR) designated robots do not exist, thus little guidance may be offered local, state, or federal agencies regarding their purchase or use.
- A precursor to successful robot operation is the ability to teleoperate. When driving, vestibular and kinesthetic feedback provide additional cues, but during teleoperation the *only* cues available are presented visually. The task is further intensified by being on-the-move. To establish one performance metric, a maze test configuration was hypothesized, employed and tested as an exercise in navigation.

- Data collected included time to complete the maze, time required for gaining situation awareness when entrapped in isolation points, recordings of wall encounters, and errors made in direction of travel. Participants were engineering professionals representing a respective product, while fourteen potential USAR candidate robots were evaluated.



- Results revealed significant differences in time to gain situation awareness (p = 0.001), encounters with walls (p = 0.001), and errors made in directions of traverse (p = 0.048). Also uncovered was that increased times spent in making decisions correlated (r = 0.67) with erroneous directions of travel subsequently selected, supporting the notion that the longer it took to make a navigational decision the more this decision could be found incorrect. Finally, encounters with walls correlated highly (r = 0.864) with errors made in directions of traverse, revealing confusion as a result of post-collision trauma.
- Given results of this effort, utilization of a maze test approach in evaluating robot teleoperation appears rational, as the scenario elicited data appropriate for examining performance as required.

Multimodal Displays to Enhance Human Robot Interaction On the Move

E. Haas, C. Stachowiak
U.S. Army Research Laboratory

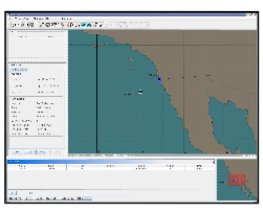
- Some Army concepts propose that robot control operations take place in highly mobile vehicles such as the HMMWV
- A U.S. Army Research Laboratory field study was conducted to determine the extent to which the audio, tactile, and combination audio + tactile displays affect soldier situation awareness in a visual HRI target search task in a moving HMMWV
- 12 civilian males performed an HRI target search task at engine idle, and while traveling 10-15 mph on gravel and cross-country terrain

- Combination audio + tactile displays were rated as having the lowest level of workload, and no one display modality provided significantly lower response times
- Performance time and workload with multimodal displays were not adversely limited by vehicle movement, noise, or vibration
- Multimodal displays can enhance user performance in HRI tasks on the move

Human System Performance Metrics for Evaluation of Mixed-Initiative Heterogeneous Autonomous Systems

L. Billman*, and M. Steinberg**
*ARINC Engineering Services, **Naval Air Systems Command/Office of Naval Research

- A set of human system performance metrics are described that were used in a series of operator experiments for mixed initiative control of multiple heterogeneous unmanned systems.
- The focus of the work is on technologies that support the control of five to ten air, sea, and undersea vehicles with a common human interface.



- Several evaluations of different user interfaces and autonomous systems components are described that have been conducted to elicit unmanned vehicle operator feedback on the systems, and to evaluate the human performance metrics from the Toolset.
- The lessons learned from these evaluations, and plans for continued research on the Metrics Toolset are discussed.

Concepts of Operations for Robot-Assisted Emergency Response and Implications for Human-robot Interaction

J. Scholtz, B. Antonishek, B. Stanton, C. Schlenoff
Information Access Division, National Institute of Standards and Technology (NIST)

- A multi-day field exercise was conducted at Disaster City, Texas in March 2006.
- Various concepts of operations in a number of disaster scenarios were tried by First Responders and robot developers.
- Observations, video data, and questionnaire data was analyzed.

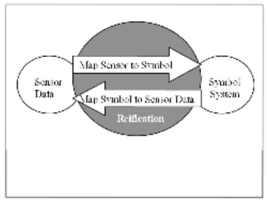
- Based on this analysis, some guidelines as well as future research areas for human-robot interaction are proposed.
- Also included are design implications from other literature, both laboratory and field studies.

WED-AM1
Autonomy Vs Intelligence
Chairs: J. Gunderson & J. Evans

Autonomy (What's it Good For?)

J. P. Gunderson, L. F. Gunderson
Gamma Two, Inc.

- The contrast between intelligence and autonomy is explored from a functional perspective
- The technical, environmental, and social requirements for enabling autonomy are presented, and an analysis of the costs associated with autonomy are detailed.
- The need for an autonomous system to be able to correctly interpret the situations it encounters is analyzed, and a candidate technology (reification) is presented to meet the need.
- Rough criteria for guiding the decision to implement an autonomous solution for a given domain and task are presented.



Autonomous Robots with Both Body and Behavior Self-Knowledge

B.B. Gordon
NASA Goddard Space Flight Center

- Last year, Gage suggested autonomous robots log "all sensory inputs, internal states, and behaviors," but required humans to interpret data.
- To discover possible benefit to robot, analyze biological analogy.
  - Review human somatosensory system.
  - Review architecture of multiple linked pairs of forward & inverse models in cerebellum, as model of sensorimotor control.
  - Humans use these for better sensorimotor simulation, and anomaly detection & handling.
- Consider a Robot Proprioception Modeler for a behavior-based autonomous robot.
  - It can do better sensorimotor simulation, and anomaly detection.
  - But anomaly handling requires additional cognitive ability.

Definitions and Measures of Intelligence In Deep Blue and the Army XUV

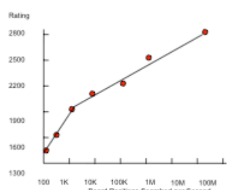
John M. Evans
John M. Evans LLC

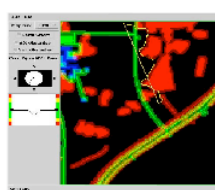
•Definitions of intelligence by Turing, Searle and Hawkins are reviewed

•Deep Blue and the Army XUV are shown to have shown elements of intelligent behavior

•FIDE rating is a performance metric for chess players; the relation of rating points to computer power is shown

•There is no comparable performance metric for autonomous vehicles. Approaches to developing objective performance evaluation methods for such vehicles are discussed.

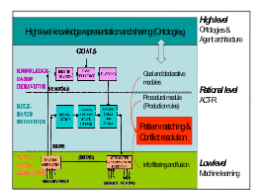


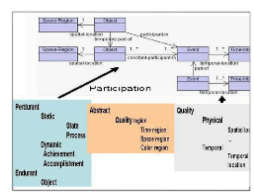


A Cognitive-based Agent Architecture for Autonomous Situation Analysis

Gary Berg-Cross, EM&I
Wai-Tat Fu, University of Illinois
Augustine Kwon, ICF International.

We present a multi-level approach to cognitive agent situational understanding and awareness (SAW). The first level of performance analysis helps to understand cognitive criteria underlying success with SAW and points out potentially problem areas RT issues and with agent knowledge which can be addressed by improved ontology.
These can brought together with an ACT-R cognitive architecture which provides key SAW capability for emergency/disaster operations, especially where sensor information is harvested from heterogeneous data sources.
Existing situational ontologies and vocabularies can be supplemented by using DOLCE's formal ontology. This serves as a meta-level ontology to relate different ontology modules and generate new categories to extend an ontology (by agent learning) as needed.
A Descriptions & Situations ontology provides a theory of ontological contexts capable of describing various types of context including non- physical situations, plans, beliefs.
Performance measurement of a cognitive based distributed multi-agent systems (MAS) offers challenges that must be explicitly addressed in agent infrastructure. The challenge of future research is how to expand on built-in performance measurement capabilities to integrate ACT-R based cognitive plug-ins models to provide a more flexible autonomous & situation analysis platform.





Automotive Turing Test

Steven F. Kalik and Danil V. Prokhorov
Toyota Technical Center, TEMA, USA

- We propose automotive Turing test to assess driving behavior of robot drivers and intelligent vehicles.
- We discuss several forms of the test, including tests on a real vehicle and in a virtual reality simulator.
- We also discuss various measures of intelligence produced by different forms of the test and point out their differences.

WED-AM2

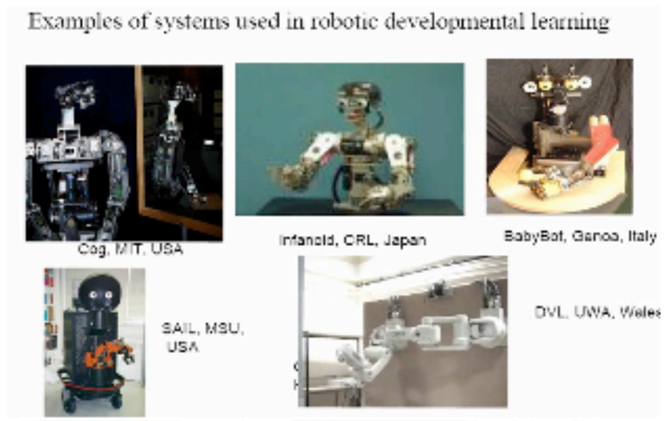
Panel Discussion I: Can the Development of Intelligent Robots be Benchmarked? Conepts and Issues from Epigenetic Robotics

Moderator: G. Berg-Cross, EM&I

Can the Development of Intelligent Robots be Benchmarked? Concepts and Issues from Developmental/Epigenetic Robotics

Lisa Meeden (Swarthmore College) Douglas Blank (Bryn Mawr College)
James Marshall (Sarah Lawrence College), Odest Chadwicke (Chad) Jenkins (Brown University), Charles C. Kemp (Georgia Tech)

- Developmental robotics is a newly emerging subfield of AI that studies how autonomous robots can learn to acquire behavior and knowledge on their own, strictly through their interactions with the surrounding environment.
- How do we understanding how innate mechanisms for abstraction, prediction, and self-motivation can be realized in such autonomous systems?
- What aspects of autonomous robot behavior should be preprogrammed as fixed policies and what aspects should be considered latent variable to be learned and adapted over time?
- How can the field reach consensus on the methods by which developmental robotic research should be evaluated, and progress benchmarked, and what is the relationship of developmental robotics to autonomous robot manipulation?



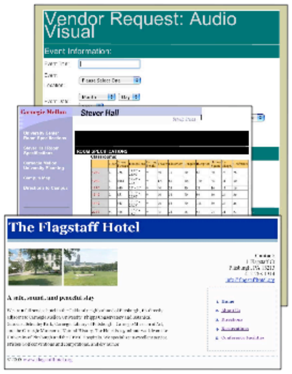
Our Speakers & Their "Developments"

WED-PM1
Human Machine Interaction
Chairs: N. Dagalakis & A. Steinfeld

Evaluation of an Integrated Multi-Task Machine Learning System with Humans in the Loop

Aaron Steinfeld, S. Rachael Bennett, Kyle Cunningham, Matt Lahut, Pablo-Alejandro Quinones, Django Wexler, Dan Siewiorek*
Jordan Hayes†, Paul Cohen‡, Julie Fitzgerald**, Othar Hansson†, Mike Pool††, Mark Drummond
* School of Computer Science, Carnegie Mellon University, Pittsburgh, PA, USA
† Bitway, Inc; ‡U. of Southern California; **JSF Consulting; ††IET; ‡‡SRI International

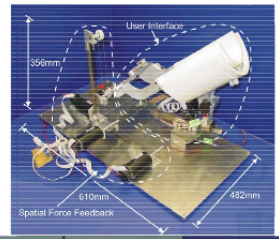
- A test was developed to measure the impact of integrated machine learning when used by a human user in a real world setting.
- A cognitive personal assistant, RADAR, consisting of multiple machine learning components was tested.
- Three conditions were evaluated in a large-scale, between-subjects study:
  - Conventional tools,
  - Radar without learning, and
  - Radar with learning.
- Integrated machine learning produced a positive impact on overall performance.

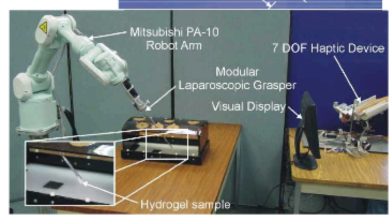


Haptic Feedback System for Robot-Assisted Surgery

Jaydev P. Desai, Gregory Tholey, and Christopher Kennedy
Robotics, Automation, Manipulation, and Sensing (RAMS) Laboratory
University of Maryland, College Park, MD, USA

- Development of accurate robot-arm dynamic models (using model-based control) with the goal of minimizing unwanted tool-tissue interaction forces in robot-assisted surgery
- Development of an ergonomic 7-DOF haptic feedback system
- Development of a laparoscopic grasper with force feedback capability attached to the end of the robot arm and controlled by the haptic device

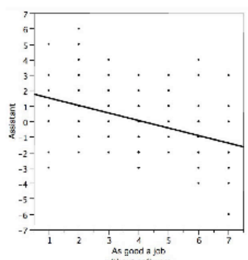


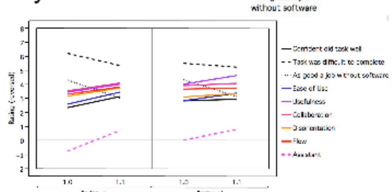


Survey Measures for Evaluation of Cognitive Assistants

A. Steinfeld, P.-A. Quinones, J. Zimmerman, S. R. Bennett, D. Siewiorek
School of Computer Science, Carnegie Mellon University

- A survey was compiled to measure subject perception of benefit, ease of use, usefulness, collaboration, disorientation, flow, and assistance
- The survey was used to evaluate two releases of an integrated machine learning cognitive assistance system
- The design and validity of this evaluation survey is discussed in the context of an information overload experiment

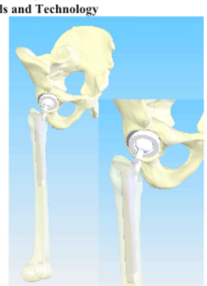




DEVELOPMENT OF TOOLS FOR MEASURING THE PERFORMANCE OF COMPUTER ASSISTED ORTHOPAEDIC HIP SURGERY SYSTEMS

Nicholas G. Dagalakis, Yongsik Kim, Daniel Sawyer, Craig Shakarji
Manufacturing Engineering Laboratory, National Institute of Standards and Technology

In the late seventies a sensor was invented, which could track the movement of athlete body parts. In the early eighties an improved version of this sensor was introduced, by a group of NIST researchers, for the calibration and the performance testing of industrial robots. In the late eighties people experimented with the use of these sensors for human brain operations and in the early nineties these sensors were introduced to orthopaedic operations and the field of Computer Assisted Orthopaedic Surgery (CAOS) was born. Although significant progress has been made in the design and use of these sensors for medical applications, there are still sources of accuracy errors that must be addressed. This paper describes our work on the development of tools for the calibration and performance testing of CAOS systems, which can be used inside operating rooms.



We will describe the use of common and inexpensive precision engineering and industrial robot calibration tools for the design of an artifact (phantom), which may be used for measuring the performance of CAOS systems inside operating rooms. This phantom can also be used for the calibration of CAOS systems.

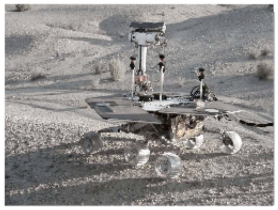
We have designed and fabricated a horizontal joint computer assisted orthopaedic hip surgery phantom (artifact). This device appears to be working very well and it was recently calibrated and sent to a medical research group for testing. Calibration and testing results will be reported in future publications.

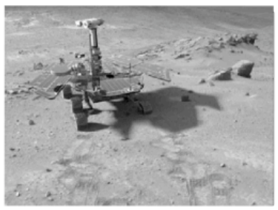
WED-PM2
Special Session III: Space/Aerial Robotics
Organizer: E. Tunstel

Prototype Rover Field Testing and Planetary Surface Operations

E. Tunstel
Advanced Robotic Controls Group, NASA Jet Propulsion Laboratory/Caltech (JPL)

- An overview of field operations and testing activities using prototype and proto-flight rovers leading to NASA's Mars Exploration Rovers mission is provided.
- Dual use of field trial configurations to train human operators and to validate onboard autonomy is discussed.
- The distribution of mission intelligence and autonomy across a remote human-robot collaborative operations team is highlighted.
- MER mobility and robotic arm performance spanning several years of surface operations on Mars is discussed.



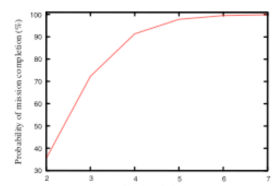


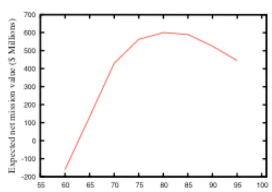
Planning to Fail - Reliability as a Design Parameter for Planetary Rover Missions

S. Stancliff, J. Dolan
The Robotics Institute
Carnegie Mellon University

A. Trebi-Ollennu
Jet Propulsion Laboratory
California Institute of Technology

- The MER rovers have lasted much longer than their intended mission life.
- We hypothesize that significant cost savings can be realized by designing rovers with reliability more closely matched to mission requirements.
- This paper presents our methods for applying reliability engineering to multirobot teams in order to make quantitative estimates of mission success probabilities.
- We then apply these methods to examine the tradeoffs between reliability and overall mission costs for an example rover mission.
- Our results suggest that a better cost-reliability tradeoff can be achieved by designing rovers which have lower subsystem reliabilities than legacy designs.





THU-AM1
Performance Assessment of Algorithms
Chairs: R. Lakaemper & S. Spetka

Analyzing the Performance of Distributed Algorithms

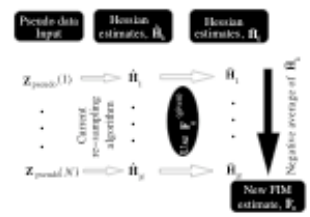
Robert N. Lass, Evan A. Sultanik and William C. Regli
Department of Computer Science, Drexel University

- Distributed Constraint Optimization (DCOP) as an example of distributed algorithms for intelligent systems.
- Some commonly used metrics have no record of being tested against the performance of deployed systems.
- Data is collected from live runs using DCOPolis, a framework for both simulating and deploying systems using DCOP algorithms.
- The data from these experiments is compared to the expected results from the metrics, and the strengths and weaknesses of these metrics are discussed.

Efficient Monte Carlo Computation of Fisher Information Matrix using Prior Information

Sonjoy Das (USC) James C. Spall (JHU/APL) Roger Ghanem (USC)

- The determinant of the Fisher information matrix (FIM) is the most popularly used performance metric for choosing input values in a scientific experiment with the aims of achieving the most accurate resulting model parameter estimates.



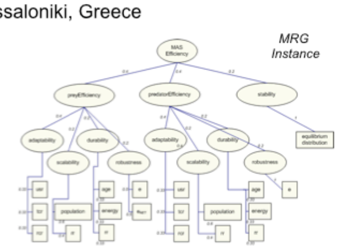
- An extension of the resampling algorithm, that is used to estimate the FIM, is proposed to enhance the statistical characteristics of the estimator of the FIM.
- The proposed algorithm is particularly useful in those cases where the FIM has a structure with some elements being analytically known from prior information and the others being unknown.
- Numerical illustrations show considerable improvement of the new FIM estimator (in the sense of mean-squared error reduction as well as variance reduction) over the current FIM estimator.

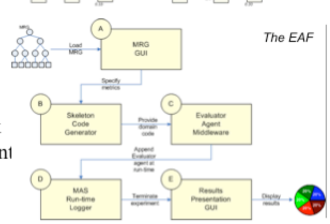
Sonjoy Das James C. Spall Roger Ghanem Digest, PerMIS'07: Improved resampling algorithm

An agent structure for evaluating MAS performance

C. Dimou, A. L. Symeonidis and Pericles A. Mitkas
Dept. of Electrical and Computer Engineering,
Aristotle University of Thessaloniki, Greece

- A generic evaluation methodology for agents and multi-agent systems
- The methodology consists of:
  - Concise guidelines
  - A Metrics Representation Graph (*MRG*)
  - Fuzzy set support for measurement aggregation
- Most of the steps of the methodology have been automated by the Evaluator Agent Framework (*EAF*), an agent structure that evaluates observable behavior
- The proposed methodology and framework have been tested on *Symbiosis*, a multi-agent simulation environment for competing species striving for survival

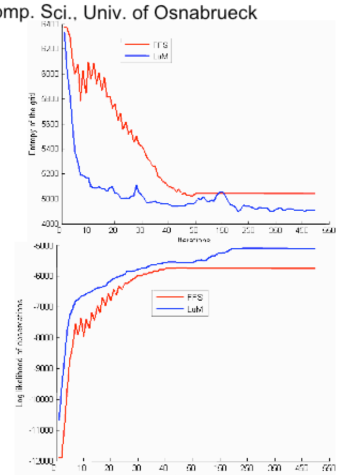




Performance of 6D LuM and FFS SLAM --- An Example for Comparison using Grid and Pose Based Evaluation Methods

R. Lakaemper[1], A. Nüchter[2], N. Adluru[1], and L. J. Latecki[1]
1. Dept. of CIS, Temple Univ. 2. Inst. of Comp. Sci., Univ. of Osnabrueck

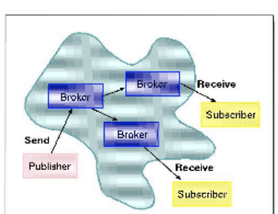
- Two state-of-the-art SLAM algorithms (FFS and LuM) are compared using grid-based and pose-based metrics.
- The comparison experiments are useful for decision making in selecting the SLAM algorithms.
- Entropy and log-likelihood scores are used for grid-based evaluation for both global and regional performance of the algorithms.
- Convergence behavior is also examined both using above metrics and average errors in the **x**,**y**, θ components of poses.
- The experiments are performed on NIST disaster dataset.

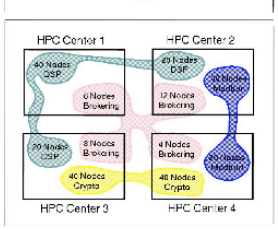


Information Management for High Performance Autonomous Intelligent Systems

S.Spetka[1,2], **S.Tucker**[1], **G.Ramseyer**[3], **R.Linderman**[3]
ITT Corp.[1], SUNYIT[2], Air Force Research Laboratory(AFRL)[3]

- The main advantage of pub/sub information management systems for autonomous intelligent systems is the decoupling of senders and receivers.
- Intelligent autonomous pub/sub systems rely on brokering functions to match publications with subscribers.
- Autonomy for brokers can be measured in terms of local storage, bandwidth and processing costs demanded of participating systems and also the degree to which individual systems can control their own resources.
- Distributed architectures afford the opportunity to assign brokering for incoming subscriptions fairly among participating brokers.





THU-AM2
Special Session IV: Smart Assembly Systems
Organizers: R. Tilove & J. Slotwinski

Smart Assembly: Industry Needs and Challenges

Robert Tilove, Ph.D. (General Motors) and John Slotwinski, Ph.D
National Institute of Standards and Technology

- Globalization has radically changed the nature of manufacturing
- Smart Assembly is about re-inventing assembly processes to succeed in this new environment
- Smart Assembly may be a key aspect of future, thriving manufacturing enterprises
- Efforts are underway to increase awareness of Smart Assembly, through the creation of a Smart Assembly working group, which is hoping to refine the vision, scope, business case scenarios, and roadmaps for a what is hoped to ultimately be a national Smart Assembly activity.

Evaluating Manufacturing Control Language Standards: an Implementer's View

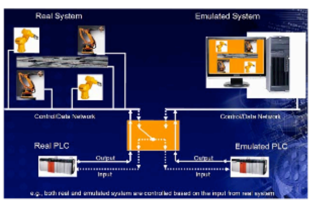
T. Kramer
Intelligent Systems Division, National Institute of Standards and Technology (NIST)

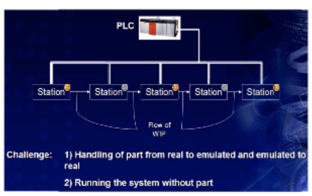
- Thirteen questions to ask in order to evaluate a manufacturing control language standard are suggested.
- Four examples of standard control languages are used, three applicable to machining centers (RS274, BCL and STEP-NC) and one applicable to coordinate measuring machines (DMIS).
- Details are given about what to look for in the answer to each question.
- How the examples stack up against the questions is discussed.

Hybrid Emulation for Manufacturing Automation Controls: Needs and Challenges

Stephan Biller, Fangming Gu and Chengyin Yuan
Manufacturing Systems Research Laboratory, GM R&D Center

- Needs for Hybrid Emulation of Manufacturing Automation System are discussed.
- Previous work in hardware-in-the-loop and emulation-in-the-loop are discussed.
- Difference between hybrid emulations for a product and manufacturing automation system is discussed.
- Challenges for establishing a hybrid emulation for a manufacturing automation system are discussed.
- Approaches for solving those challenges are proposed.





Interoperability Testing for Shop-Floor Inspection

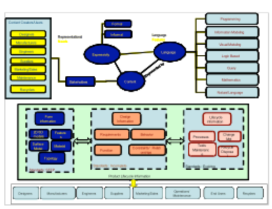
J. Falco, J. Horst, T. Kramer, F. Proctor and W. Rippey
Intelligent Systems Division, National Institute of Standards and Technology (NIST)

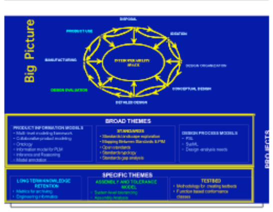
- The I++ Dimensional Measuring Equipment (DME) specification defines information exchange between shop-floor measuring equipment and software that programs them and analyzes their results
- Interoperability is the key metric: how well is data exchanged between these systems?
- An interoperability test suite was developed that mimics either end of the data exchange, and logs and analyzes messages for compliance to hundreds of requirements
- Annual demonstrations help suppliers comply; in 2006 six software packages were tested against four machines for 24 combinations
- Goal: seamless exchange of "smart data" for "smart inspection"

Science based Information Metrology for Engineering Informatics

Sudarsan Rachuri
Manufacturing Systems Integration Division, National Institute of Standards and Technology (NIST)

- Engineering informatics is the discipline of creating, codifying (structure and behavior that is syntax and semantics), exchanging (interactions and sharing), processing (decision making), storing and retrieving (archive and access) the digital objects that characterize the cross-disciplinary domains of engineering discourse.
- A standardized exchange behavior within a specified set of conventions has a form (syntax), function (scope) and the ability to convey as unambiguously as possible an interpretation (semantics) when transferred from one participant to the other.
- The design of a standardized exchange in the context of information metrology is dictated by:
  - ***Language***
  - ***Processible Expressiveness***
  - ***Content***
  - ***Interface***
- Creating the science of information metrology will require a fundamental and formal approach to metrology, measurement methods and testing and validation similar to the physical sciences.





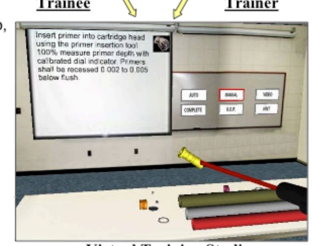
A Virtual Environment-Based Training System for Mechanical Assembly Operations

S.K. Gupta, D.K. Anand, J.E. Brough, R. Kavetsky, and M. Schwartz
Center for Energetic Concepts Development, University of Maryland

- *Motivation*
  - Current training methods are resource intensive
  - Creation of high quality instructional material requires significant time
- *Goals*
  - Provide a virtual learning environment which supports interactive simulation, animation, video, audio, and text
  - Generate/modify tutorials without user programming
  - Generate custom feedback and automatically adapt tutorials
- *Anticipated Benefits*
  - Reduce the cost of generating training instructions
  - Improve learning by utilizing a virtual mentor inside Virtual Training Studio
  - Reduce training cost

Trainee

Trainer



Virtual Training Studio

(Re-)Establishing or Increasing Collaborative Links Between Artificial Intelligence and Intelligent Systems

B.B. Gordon
NASA Goddard Space Flight Center

- This panel discussion will assume, but will also discuss, that AI and IS have some common goals, despite differing histories and world-views.
- The panel will discuss formulating common goals to be motivating from both perspectives.
- The panel will discuss increasing awareness in each community of what the other has to offer.
- The panel will discuss making collaboration easier
  - Conceptually, and
  - Logistically.
- The audience will be invited and expected to ask questions and express opinions.

Restaurants

Red Rock Canyon Grill – American
100 Boardwalk Place
(240) 631-0003

California Pizza Kitchen – American
136 Boardwalk Place
(301) 330-0681

Hamburger Hamlet -- American
9811 Washington Blvd., Rio Center
(301) 417-0773

Joe's Crab Shack - American
221 Rio Blvd
(301) 947-4377

Potbelly's – American
128 Boardwalk Place
(301) 963-4055

Corner Bakery – American
1 Grand Corner Ave
(301) 721-1634

Romano's Macaroni Grill - Italian
211 Rio Blvd
(301) 963-5003

Taco Bar - Mexican
10003 Fields Rd
(301) 987-0376

Guapo's Cantina-- Mexican
9811 Washington Blvd., Rio Center
(301) 977-5655

Rio Grande – Mexican
231 Rio Blvd
(240) 632-2150

Tara Thai – Asian
9811 Washingtonian Blvd, Rio Center
(301) 947-8330

Asian Bistro - Asian
(301) 670-2870

Café Spice - Indian
9811 Washingtonian Blvd, Rio Center
(301) 330-6611

Village Green Grill House of Kabob - Mediterranean
9811 Washingtonian Blvd, Rio Center
(301) 519-4220

Maggie Moo's Ice Cream – Specialty
215 Boardwalk Place
(301) 977-6667

Swensen's Ice Cream – Specialty
Grand Corner Ave
(301) 417-6710

Starbucks Coffee – Specialty
213 Boardwalk Place
(301) 216-9635

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Teresa Vicente

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Angela Ellis

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Betty Mandel (Chair)

Intelligent Systems Division
Manufacturing Engineering Laboratory
National Institute of Standards and Technology
100 Bureau Drive, MS-8230
Gaithersburg, MD 20899
http://www.isd.mel.nist.gov/