
DIGESTS

TUE-AM1
Performance Evaluation
Chairs: James Spall & Craig Schlenoff

Evolution of the SCORE Framework to Enhance Field-Based Performance Evaluations of Emerging Technologies

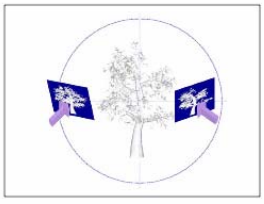
Brian A. Weiss and Craig Schlenoff
National Institute of Standards and Technology

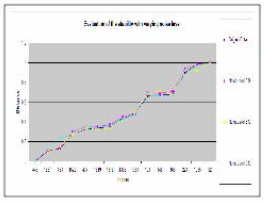
- The System, Component, and Operationally-Relevant Evaluation (SCORE) framework is built around the concept that in order to get a true picture of how a system performs in its intended use-case environment, it must be evaluated both quantitatively and qualitatively at multiple levels.
- SCORE has evolved to include four evaluation levels:
  - Component-Level Testing – Technical Performance
  - System-Level Testing – Technical Performance
  - Capability-Level Testing – Utility Assessment
  - System-Level Testing – Utility Assessment
- Evaluation design elements that SCORE helps one identify include:
  - Identification of the system or component to be assessed
  - Definition of the goal(s), objective(s), & metrics/measures
  - Specification of the testing environment
  - Identification of participants and required training
  - Specification of data collection methods
  - Specification of the evaluation scenarios

Identifying Objects in Range Data Based on Similarity Transformation Invariant Shape Signatures

Xiaolan Li[1,2] Afzal Godil[1] Asim Wagan[1]
[1] National Institute of Standard and Technology, Gaithersburg, MD 20899, U.S.A.
[2] Zhejiang Gongshang University, Hangzhou, Zhejiang 310018, China

- *Identification and recognition of three dimensional (3D) objects in range data is a challenging problem. We propose a novel method to fulfill the task through two steps:*
  - *1) construct the feature signatures for the objects in the scene and the models in a 3D database;*
  - *2) based on the feature signature, find out the most similar model which decides the class of the corresponding object in the scene.*
- *We also evaluate the accuracy, robustness of the recognition method with several configurations.*
- *Our experimental results validate the effectiveness of our method.*





Reliability Estimation and Confidence Regions from Subsystem and Full System Tests via Maximum Likelihood

James C. Spall (james.spall@jhuapl.edu)
The Johns Hopkins University, Applied Physics Laboratory

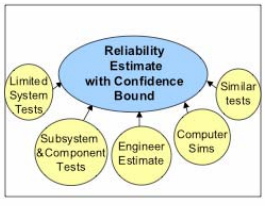
Paper considers problem of estimating reliability of complex systems based on combination of tests on subsystems, components, or other aspects of system, and, if available, tests on full system

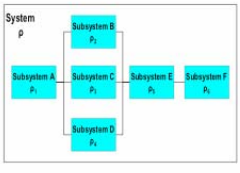
Motivation comes from the difficulty to evaluate reliability of complex systems through large number of full system tests alone

Maximum likelihood estimation (MLE) used to estimate system reliability

For given number of subsystems and/or components, performance metric (likelihood function) does *not* change with system configuration (constraints *do* change)

Paper gives MLE formulation and formal convergence conditions

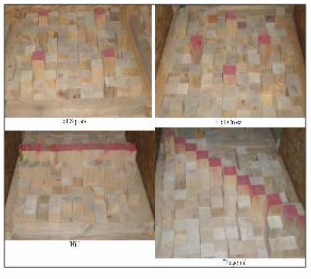




Stepfield Pallets: Repeatable Terrain for Evaluating Robot Mobility

A. Jacoff, A. Downs, A. Virts, E. Messina
Intelligent Systems Division, National Institute of Standards and Technology (NIST)

- The origin of NIST's Stepfield Pallets is discussed.
- The design method is discussed including the rules used to create the stepfield pallet designs.
- The idea of orange stepfield pallets is discussed as well as the differences between the orange & red stepfield pallets.
- The use of stepfield pallets in various NIST Test Methods:
  - Confined Space
  - Grasping Dexterity/Directed Perception
  - Mobility/Endurance Test
- Current work with Symmetric Stepfield pallets is discussed.

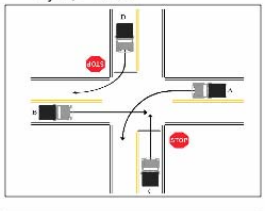


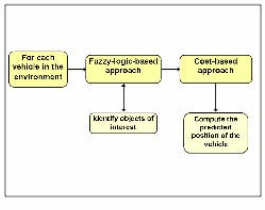
Fuzzy-Logic-Based Approach for Identifying Objects of Interest in the PRIDE Framework

Z. Kootbally, C. Schlenoff, and R. Madhavan
National Institute of Standards and Technology
Gaithersburg, MD, USA

S. Foufou
University of Burgundy
Dijon, France

- PRIDE is a multi–resolutional, hierarchical framework that predicts the future location of moving objects for the purposes of path planning and collision avoidance for an autonomous vehicle.
- Numbers from the National Highway Traffic Safety Administration (NHTSA) for the year 2006 :
  - 42,642 people were killed in motor vehicle crashes.
  - 2,575,000 people were injured.
  - One cause of accidents is misjudgment due to **carelessness.**
- The PRIDE framework uses situation awareness to focus on and identify objects of interest in the environment.
- An object of interest is a moving or stationary object in the environment that has a reasonable probability of intersecting the path of the autonomous vehicle within a predetermined time frame.
- The PRIDE framework utilizes a fuzzy-logic-based approach to identify objects of interest and a cost-based approach to compute the future position of the vehicles in the environment.

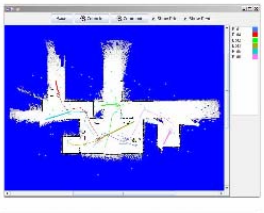


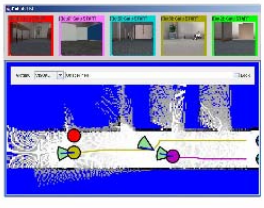


Potential Scaling Effects for Asynchronous Video in Multirobot Search

P. Velagapudi[1], H. Wang[2], P. Scerri[1], M. Lewis[2], K. Sycara[1]
[1]Carnegie Mellon University, USA
[2]University of Pittsburgh, USA

- Users performed a 4 robot search task with either streaming video and a separate map or images asynchronously stored on the map.
- Search performance with 4 robots was better using the streaming video interface.
- Ancillary measures suggest that the asynchronous interface reduced temporal demands for switching between robots.
- Data using streaming video with 8 and 12 robots shows a drop in performance in the 12 robot condition – where the asynchronous interface may have an advantage.



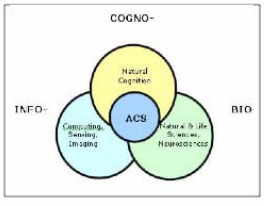


TUE-AM2
Special Session I: Cognitive Systems of EU Cognition Programme
Organizer: Patrick Courtney

Cognitive systems of EU cognition programme

Patrick Courtney

- A significant research programme in cognitive systems is now underway within the European Union with some €400M committed. This programme focuses on developing the technology and the necessary scientific understand to provide significant levels of autonomy and decision making into computer-based systems. Active research approaches in the area range broadly, from traditional rule-based AI, through to connectionist, dynamical and emergent systems and include embodied systems combining computing and robotic systems.
- One major practical motivation for the development of cognitive systems is to overcome the problems faced by traditional computer systems in dealing robustly with the uncertainties and changing demands that characterise the real world. Potential applications cited span a very broad range and have included care-giver robots, and easier-to-use interfaces. One major approach that has emerged has been in the use of open source platforms in order to share experiences and run larger scale experiments.
- This special session is dedicated to the development of the tools and methodologies that are in development within the EU, with an emphasis on the open source approaches with a view to performance analysis and comparison, and to stimulate discussion over cooperative research especially use of open platforms



An Open-Source Simulator for Cognitive Robotics Research: The Prototype of the iCub Humanoid Robot Simulator

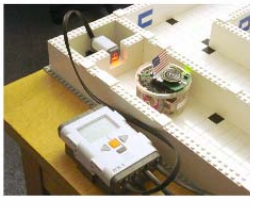
V. Tikhanoff, P. Fitzpatrick, F. Nori, L. Natale, G. Metta, A. Cangelosi

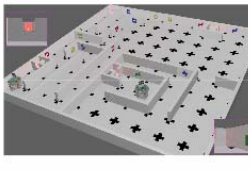
This paper presents the prototype of a new computer simulator for the humanoid robot iCub. The iCub is a new open-source humanoid robot developed as a result of the "RobotCub" project, a collaborative European project aiming at developing a new open-source cognitive robotics platform. The iCub simulator has been developed as part of a joint effort with the European project "ITALK" on the integration and transfer of action and language knowledge in cognitive robots. This is available open-source to all researchers interested in cognitive robotics experiments with the iCub humanoid platform

The Rat's Life Benchmark:Competing Cognitive Robots

Olivier Michel, Fabien Rohrer
Cyberbotics Ltd.

- On-line robot programming competition: www.ratslife.org
- Based on a simulated and/or a real setup
- Cheap and easy to setup: e-puck robots, LEGO bricks, Webots software (free version)
- Focus on visual SLAM, navigation, autonomy
- Participation of 41 teams worldwide
- State-of-the-art results achieved during competition by several teams
- Allow for comparison of different approaches
- Database of simulation and real world movies
- Co-sponsor: IST Cognitive Systems Unit of the European Commission (ICEA project)





Symbiotic Robot Organisms: REPLICATOR and SYMBRION Projects

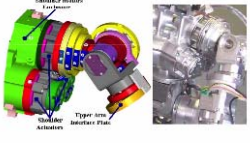
Serge Kernbach, Eugen Meister, Florian Schlachter, Kristof Jebens, Marc Szymanski, Jens Liedke, Davide Laneri, Lutz Winkler, Thomas Schmickl, Ronald Thenius, Paolo Corradi, Leonardo Ricotti

Cooperation and competition among stand - alone swarm agents can increase the collective fitness of the whole system. An interesting form of collective system is demonstrated by some bacteria and fungi, which can build symbiotic organisms. Symbiotic communities can enable new functional capabilities which allow all members to survive better in their environment. In this article we show an overview of two large European projects dealing with new collective robotic systems which utilize principles derived from natural symbiosis. The paper provides also an overview of typical hardware, software and methodological challenges arose along these projects, as well as some prototypes and on-going experiments available on this stage.

The iCub humanoid robot: an open platform for research in embodied cognition

G. Metta, G. Sandini, D. Vernon, L. Natale, F. Nori
Italian Institute of Technology

We report about the iCub, a humanoid robot for research in embodied cognition. At 104 cm tall, the iCub has the size of a three and half year old child. It will be able to crawl on all fours and sit up to manipulate objects. Its hands have been designed to support sophisticate manipulation skills. The iCub is distributed as Open Source following the GPL/FDL licenses. The entire design is available for download from the project homepage and repository (http://www.robotcub.org). In the following, we will concentrate on the description of the hardware and software systems.



Virtual Agent Modeling in the RASCALLI Platform

C. Eis, B. Krenn, Research Studios Austria
M. Skowron, Austrian Research Institute for Artificial Intelligence

- The RASCALLI platform is both a runtime and a development environment for virtual cognitive agents.
- Agents are developed in a modular fashion and can be assembled from implemented components in a Lego-like manner.
- Multiple agents, composed from different sets of components, can be executed in a single platform instance, and thus be compared and evaluated.
- We present the most relevant platform features and the platform architecture, as well as the currently implemented agents, and provide examples of agent evaluation.

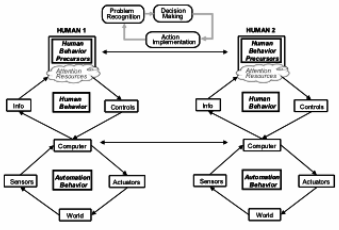
TUE-PM1
Human-System Interaction
Chairs: Michael Lewis & Birsen Donmez

Evaluation Criteria for Human-Automation Performance Metrics

Birsen Donmez, Patricia E. Pina, M. L. Cummings
Massachusetts Institute of Technology

A list of evaluation criteria for determining metric quality is identified.

Future research will develop a cost-benefit approach for metric selection based on these criteria and existing generic metric classes.

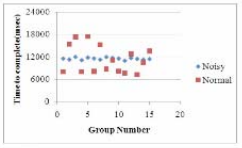


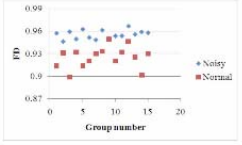
Experimental Constraints (e.g., time required to analyze a metric)
Comprehensive Understanding (e.g., causal relations with other metrics)
Construct Validity (e.g., power to discriminate between similar constructs)
Statistical Efficiency (e.g., effect size)
Measurement Technique Efficiency (e.g., intrusiveness to subjects)

The Gestural Joystick and the Efficacy of the Path Tortuosity Metric for Human/Robot Interaction

Richard Voyles, Jaewook Bae, Roy Godzdanker
University of Denver

- The Gestural Joystick
  - Wearable Pointing Interface for Computers or Robots in Hazardous Environments
  - 2 Degrees of Freedom similar to a Joystick
    - Forward/Reverse
    - Right/Left
  - Glove is completely passive and wire-free
  - Sleeve detects glove motion to control device
- Path Tortuosity Metric
  - Measures "smoothness" of robot motion
  - Smoothness is assumed correlated to quality of control and quality of user interface
  - Metric is used, but has not been verified
  - We show preliminary evidence that Path Tortuosity is independent of Time-to-Complete



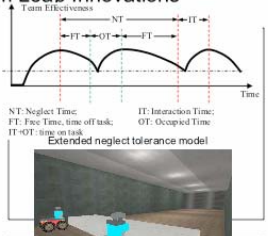


Assessing Measures of Coordination Demand Based on Interaction Durations

Michael Lewis
University of Pittsburgh

Jijun Wang
Quantum Leap Innovations

Controlling multiple robots substantially increases the complexity of the operator's task because attention must constantly be shifted among robots in order to maintain situation awareness (SA) and exert control. In the simplest case an operator controls multiple independent robots interacting with each as needed. Control performance at such tasks can be characterized by the average demand of each robot on human attention. In this paper we present several approaches to measuring, coordination demand, CD, the *added* difficulty posed by having to coordinate as well as operate multiple robots. Our initial experiment compares "equivalent" conditions with and without coordination. Two subsequent experiments attempt to manipulate and measure coordination demand directly using an extension of the Neglect Tolerance model.



Modeling of Thoughtful Behavior with Dynamic Expert System

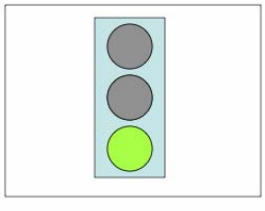
Vadim Stefanuk
Institute for Information Transmission Problems, Russian Academy of Science

The concept of Dynamic Expert System, introduced at the start of 1990th, is a step forward in the modeling of intelligent behavior.

Previously it was shown that the system behaves itself as an *alive creature*.

The present paper demonstrates that Dynamic Expert System resolves the Frame Problems of AI, exhibiting a *thoughtful behavior*.

A simple example of a rule-based traffic light control illustrates this property.

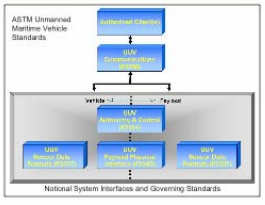


TUE-PM2
Special Session II: Architectures for Unmanned Systems
Organizers: Roger Bostelman & James Albus

UAV Architectures
George Vachtsevanos
Georgia Institute of Technology

Levels-of-Autonomy of the ASTM F41 Unmanned Maritime Vehicles Standard
Mark Rothgeb in conjunction with ASTM F41.01 Committee on Autonomy and Control
Applied Research Laboratory of The Pennsylvania State University

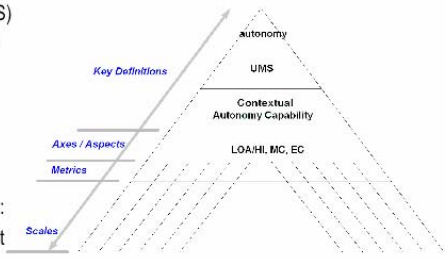
- ASTM International has five committees addressing the scope of Unmanned Maritime Vehicle Systems – one of which is Autonomy and Control (F41.01).
- The F41.01 Autonomy and Control Standard committee has addressed the functional architecture of UMVs and levels of autonomy associated with them.
- Discussion will be held on other sources of level-of-autonomy initiatives and standards.
- We will discuss the case for establishing three dimension related to the levels-of-autonomy and the supporting rationale.
- A brief walk-thru of these levels will be made.
- The role of collaboration among vehicles will be discussed.

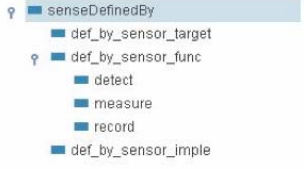


UGV Architectures

Ontological Perspectives for Autonomy Performance
Hui-Min Huang, Elena Messina, Tsai-Hong Hong, Craig Schlenoff
Intelligent Systems Division, National Institute of Standards and Technology (NIST)

- Ontology for unmanned system (UMS) goal facilitates standard performance metrics.
- ALFUS metrics characterize UMS autonomy.
- Develop the ontology by applying ALFUS metrics.
- Further evolution of the ontology with:
  - Urban Search and Rescue Robot requirement sets.
  - Sensory evaluation ontology for a dynamic metrology project.
  - Manufacturing as an extension to the NIST participated DARPA Spoken Language Communication and Translation System for Tactical Use (TRANSTAC) project.





WED-AM1
Metrics & Measures
Chairs: Scott Spetka & Robert Wade

Robotic Systems Technical and Operational Metrics Correlation

Jason R. Schenk, Ph.D. — DeVivo AST
Robert L. Wade — AMRDEC

Problem:

- No DOD or Industry standard metrics to evaluate and articulate robotic specific requirements
- Existing technical and operational characteristics are not standardized or widely accepted
- Correlation to operational performance is not known or understood

Project Description: This project will result in a methodology that provides a more cost effective means to conduct performance evaluation for unmanned systems. The initial focus will be on tele-operated military and law enforcement EOD robotic systems. The results will be embodied in software and documentation that includes both the results of the EOD analysis as well as the methodology for use in other domains.

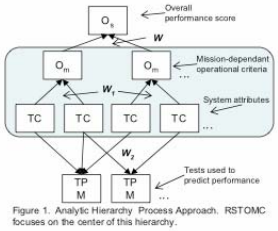


Figure 1. Analytic Hierarchy Process Approach. RSTOMC focuses on the center of this hierarchy.

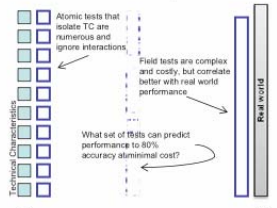


Figure 2. Tests link technical characteristics to performance.

Using Metrics to Optimize a High Performance Intelligent Image Processing Code

Scott Spetka, SUNYIT and ITT Corp.
Susan Emeny, ITT Corp.
George Ramseyer and Richard Linderman, Air Force Research Laboratory

Optimizing the execution of intelligent codes on high performance computer's (HPC's) has become more challenging as the number of processors increases. Single processors in many HPC's have been replaced with dual processors, and more recently multiprocessors. This, combined with the inherent complexities of multi-core processors, made the processing of intelligent codes even more complex on the latest HPC's. The coming availability of thousands of processors in more affordable medium sized HPC's offers the potential for improved performance for codes that can scale sufficiently to take advantage of hundreds of teraflops. Additionally, techniques for harnessing the performance potential of multi-core processors require the appropriate location of data in shared memories, or even shared level-2 caches, which can afford additional orders of magnitude performance increases. The key to designing code that uses the available teraflops wisely is understanding the application's behavior. For intelligent systems, whose behavior may depend on heuristics evaluated at runtime, measurements and profiling runs provide the basis for system design decisions, regarding distribution of data and processing. This paper focuses on the metrics needed to optimize intelligent codes, and how a specific image processing code was instrumented to produce the required metrics.


Jaws at MHPCC.HPC.MIL

Survey of Domain-Specific Performance Measures in Assistive Robotic Technology

Katherine Tsui, Holly Yanco — University of Massachusetts Lowell
David Feil-Seifer, Maja Mataric — University of Southern California

What performance measures have been used in autism, eldercare, intelligent wheelchairs, assistive robotic arms, external limb prostheses, and stroke rehabilitation?

Performance measurements guidelines for gaining clinically validity include:

- Consulting a domain-expert clinician
- Leveraging the "gold standard"
- Capturing emotional state, mental state, and quality of life
- Measuring before and after an experiment
- Data coding
- Definition of Likert scale elements

Measurement Techniques for Multiagent Systems

Robert N. Lass, Evan A. Sultanik, William C. Regli
Drexel University

- Multiagent Systems (MAS) are a software paradigm for building large scale intelligent distributed systems.
- Increasingly, these systems are being deployed on handheld computing devices, or on non-traditional networks such as mobile ad-hoc networks and satellite links.
- These systems present new challenges for computer scientists in describing the performance of a system and analyzing competing systems.
- This paper surveys existing metrics that can be used to describe MASes and related components, and provides a framework for analyzing MASes with a case study using DCOPolis, a distributed constraint reasoning system.

Refining the Cognitive Decathlon

Robert L. Simpson, Jr., Applied Systems Intelligence, Inc.
Charles R. Twardy, OnLine Star, Inc.

Tests of intelligent agents should map cleanly onto cognitive "modules", without gaps. To know those modules, we review modern factor-based intelligence theory, the Cattel-Horn-Carrol (CHC) model.

According to the 10-factor CHC model, WAIS and other standard tests conflate some modules and miss others. Furthermore, they emphasize memory & attention, which computers are very good at.

We reviewed the recently-proposed (2007) BICA Cognitive Decathlon. Admirably broad though it is, we still found 5 modules that should be supplemented.

Finally, we examine cognitive *performance* tests such as those from the NTI Armory. These also have gaps, which could be filled by existing Wechsler-type tests and some special episodic-memory tests.

The BICA Decathlon assumes the agent can understand written or verbal instructions, including "do this". Until such capability is available, we need methods for presenting tests to non-verbal agents. We suggest looking at some animal behavior literature.

The CHC Intelligence Factors

Gf – fluid intelligence
Gc – crystallized; acquired knowledge
Gq – quantitative knowledge, esp. arithmetical
Grw – reading/writing ability
Gsm – short-term memory
Gv – visual & spatial processing
Ga – auditory processing
Glr – long-term storage and retrieval
Gs – processing speed
Gt – decision/reaction time or speed

The BICA Decathlon lacks:

Gf – fluid intelligence
Grw – reading/writing ability
Gt – decision/reaction time
Gs – processing speed
Gq – quantitative knowledge

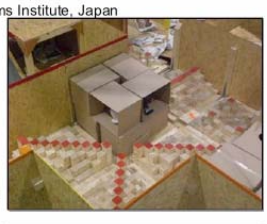
Of these, perhaps the hardest to measure is *Gf*.

RoboCupRescue Robot League: 2008 Overview

Adam Jacoff, National Institute of Standards and Technology, USA
Andreas Birk, International University Bremen, Germany
Johannes Pellenz, University of Koblenz-Landau, Germany
Ehsan Mihankhah, K.N. Toosi University of Technology, Iran
Raymond Sheh, University of New South Wales, Australia
Satoshi Tadokoro, International Rescue Systems Institute, Japan

RoboCupRescue Robot League Competitions

- Increase awareness of the challenges involved in urban search and rescue applications, provide objective performance evaluations of mobile robots in complex yet repeatable environments, and promote collaboration between researchers.
- Robot teams demonstrate capabilities in **mobility, sensory perception, localization and mapping, mobile manipulation, practical operator interfaces,** and **assistive autonomous behaviors** to improve remote operator performance and/or robot survivability.
- As robots meet the challenges, the difficulty of the arenas have been increasing to provide a stepping-stone from the laboratory to the real world.
- This paper provides an overview of the 2008 arenas, rules, and best-in-cass robot capabilities.



WED-AM2

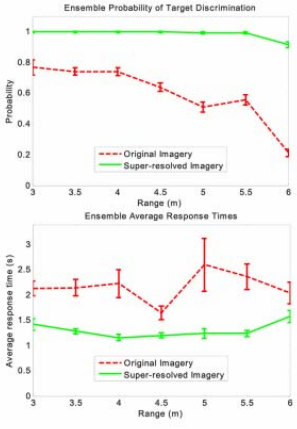
Special Session III: Performance Metrics for Perception in Intelligent Manufacturing

Organizers: Tsai Hong & Roger Eastman

Performance of Super-Resolution Enhancement for Flash LADAR Data

Shuowen Hu, S. Susan Young, Tsai Hong
Army Research Lab, NIST

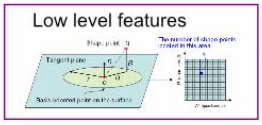
Flash LADAR systems are increasingly used in robotics applications for autonomous navigation and obstacle avoidance. Their compact size and wide field of view are key advantages over traditional scanning LADAR devices, but come at the cost of low spatial resolution. Therefore super-resolution enhancement can be applied to rectify this disadvantage. This study uses the super-resolution algorithm of Young et al. to enhance the resolution of range data acquired from a SwissRanger SR-3000 camera. A preprocessing stage was developed to increase the accuracy of sub-pixel shift estimation for improved image registration. The triangle orientation discrimination perception experiment was performed to assess the improvement in the probability of target discrimination achieved with super-resolution imagery over original imagery at different target ranges. Figures 1 and 2 show that super-resolution increases the probability of target discrimination at all ranges while reducing response times and decreasing inter-subject variability.

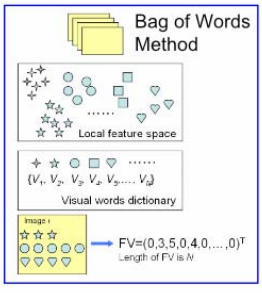


3D Part Identification Based on Local Shape Descriptors

Xiaolan Li[1,2] Afzal Godil[1] Asim Wagan[1]
[1] National Institute of Standard and Technology, Gaithersburg, MD 20899, U.S.A.
[2] Zhejiang Gongshang University, Hangzhou, Zhejiang 310018, China

- This paper explores 3D part recognition based on local shape descriptor. 3D object recognition is becoming an increasingly important task in modern applications such as computer vision, CAD/CAM, multimedia, molecular biology, robotics, and so on. And it is especially challenging when 3D CAD parts should be recognized in a range data in which only partial of the part is captured. We adopt the *Bag of Words* frame to do the *partial-to-global* retrieval.
- In this paper the visual words dictionary is constructed based on two different local feature descriptors: 1) spin images; 2) Scale Invariant Feature Transform descriptor.
- The method is tested on Purdue Engineering Shape Benchmark.





Performance Evaluation of Laser Trackers

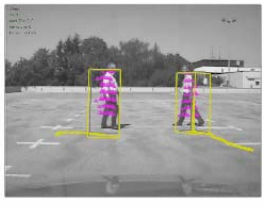
B. Muralikrishnan, D. Sawyer, C. Blackburn, S. Phillips,
B. Borchardt, W. T. Estler
Precision Engineering Division, National Institute of Standards and Technology (NIST)

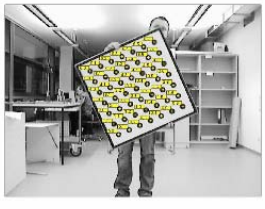
- The performance evaluation tests described in the recently released ASME B89.4.19 Standard are outlined
- The facilities and capabilities of the large-scale coordinate metrology group at NIST are discussed.
- B89.4.19 test results obtained from a number of trackers are presented. Examples include trackers that showed large errors due to geometric misalignments.
- A numerical simulation based method to determine sensitivity of any measurement to geometric misalignment is presented.

Calibration of a System of a Gray-Value Camera and an MDSI Range Camera

Tobias Hanning, Aless Lasaruk
University of Passau, Germany

- Calibration approach for a system of a range camera and a regular gray-value camera
- Flexible calibration target: white plate with a regular grid of black circles
- We expose the target to the camera system in different distances and angles
- Output: Intrinsic camera parameters of both cameras and their relation to each other
- Application: We demonstrate the applicability of our calibration procedure by discussing the calibration results for a system of a 64x8-pixel MDSI range camera developed within the European project MIDIAS and a common gray-value camera.

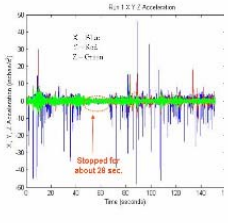




Preliminary Analysis of Conveyor Dynamic Motion for Automation Applications

Jane Shi
Manufacturing Systems Research Lab, GM R&D Center

- Raw conveyor motion data have been collected using a 6DOF accelerometer from a total of five different types of conveyor at four different GM assembly plants.
- Simple statistical analysis has been conducted to quantify the conveyor stability in the main direction of travel.
- Fast Fourier Transformation (FFT) frequency analysis has been performed to identify any frequency pattern of the conveyor dynamic motion data.
- Dynamic motion profile library has been built for each type of conveyor that can be used in laboratory experiments for developing and validating new automation solutions on a continuous moving assembly line.



Dynamic 6DOF Metrology for evaluating a visual servoing algorithm

Tommy Chang, Tsai Hong, Michael Shneier, German Holgin,
Johnny Park, Roger Eastman
National Institute of Standards and Technology, Purdue University, Loyola College

Goal:
Develop methods and metrics for measuring the performance of sensors for **dynamic** position and **orientation** determination

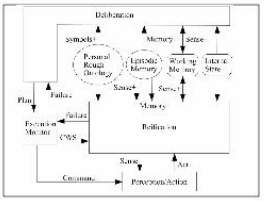
Dynamic 6DOF Measurement Challenges:
- Synchronization issues: Logs laser tracker and vision sensor data simultaneously
- Calibration issues for common coordinate systems
- Data representations issues: quaternion, Euler, matrix, axis angle, etc.
- Experimental design, data analysis

WED-PM1
Autonomous Systems
Chairs: James Gunderson & Edward Tunstel

Integrating Reification and Ontologies for Mobile Autonomous Robots

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

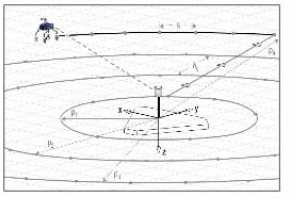
- Autonomous robots need to reason about the world using both:
  - semantic knowledge and sensor based knowledge
- Reification is a
  - Biologically principled, bi-directional mapping between symbolic and sensor domains
- When integrated with an ontology the robot can
  - reason about the world, and successfully execute its intentions.
- We present the design, and results of implementation

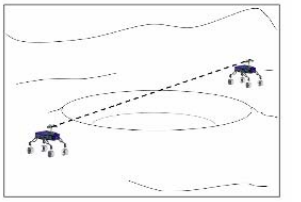


Mobile Robotic Surveying Performance for Planetary Surface Site Characterization

Edward Tunstel
Space Department, Johns Hopkins University Applied Physics Laboratory, Laurel, MD

- Mobile surveying approaches that enable instrumented rovers to perform science and engineering land surveys are described.
- Several survey traverse patterns involving local and remote in-situ sensing using one- and two-rover configurations are considered.
- A simple area coverage performance metric is applied to characterize expected relative performance trends for survey approaches.
- The importance of enriching solely geometric measures with attributes germane to planetary surface surveying is highlighted.
- The motivation is to improve utility of metrics as decision aids to mission operators.

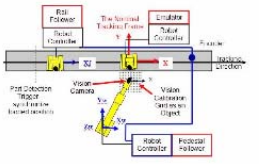


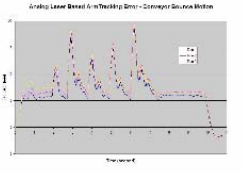


Quantification of Line Tracking Solutions for Automotive Applications

Jane Shi, Rick F. Rourke, Dave Groll, Peter W. Tavora
GM R&D Center, GM Manufacturing Engineering

- Unlike line tracking in automotive painting applications, line tracking for automotive general assembly applications requires position tracking in order to perform assembly operations to a required assembly tolerance.
- Quantification experiments have been conducted for a total of 16 test cases under two line tracking scenarios with three types of line tracking solutions: encoder based tracking, encoder plus static vision based tracking, and the analog laser sensor based tracking.
- Two key drivers have been identified that impacts the line position tracking performance.
- By understanding current capabilities of line tracking solutions, appropriate robotic automation systems can be developed that is capable enough for the specified assembly tolerance plus the environment uncertainty with adequate dynamic response at the appropriate location for the general assembly applications.

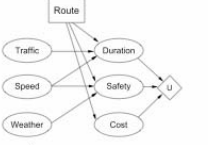




Evaluating Situation Awareness of Autonomous Systems

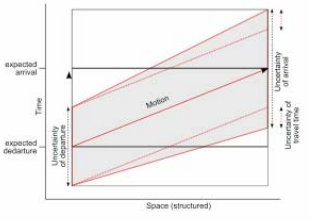
Jan D. Gehrke
University of Bremen, Germany

- Situation awareness is the perception of the environment within a volume of time and space, the comprehension of these perceptions, and projections in the near future (Endsley 1988)
- Situation-aware systems differ from usual agent architectures by featuring relevance-driven information acquisition.
- The paper proposes criteria for autonomous systems to achieve situation awareness, namely
  - Reasoning about ignorance
  - Model of perception abilities
  - Assessment of information relevance
  - Model of information dynamics and spatio-temporal reasoning
  - Social ability for information exchange
- Sensor ontologies, dynamic decision networks, information value theory, and regions of relevance provide possible approaches for implementation.
- The advantage of situation-aware agents is demonstrated in a transport scenario with weather and traffic as influence factors and learned driving time predictions.



$$Vr_j = \left(\sum_i P(K_j = e_{ji}|K) \cdot \right.$$

$$\left. P(l(e_{ji}|K, V_j = e_{ji})) - EU(a|K) \right)$$



WED-PM2

Special Session IV: Results from a Virtual Manufacturing Automation Competition

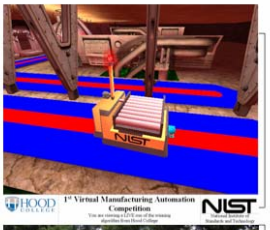
Organizers: Stephen Balakirsky, Raj Madhavan & Chris Scrapper

NIST/IEEE Virtual Manufacturing Automation Competition: From Earliest Beginnings to Future Directions

S. Balakirsky[1], R. Madhavan[2], C. Scrapper[1]
[1]NIST, [2]ORNL/NIST

This paper provides an overview of the NIST/IEEE VMAC Competition. Detailed information will be provided on the competitions:

- History
- Operation
- Research objectives
- Supporting infrastructure
- Future



Partitioning Algorithm for Path Determination of Automated Robotic Part Delivery System in Manufacturing Environments

Payam Matin, Ali Eydgahi, Ranjith Chowdary
Department of Engineering and Aviation Sciences, University of Maryland Eastern Shore

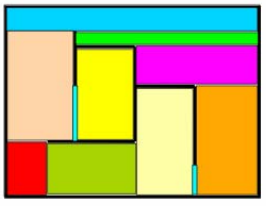
A mathematical model of a plant layout containing static obstacles is constructed.

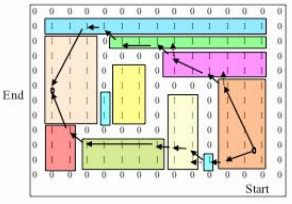
A partitioning algorithm is then introduced that partitions the layout into obstacle-free regions.

A searching algorithm is utilized to yield all possible combinations of regions that can connect a starting point to a destination throughout the plant layout.

Physical paths are constructed by drawing line segments within the obstacle-free regions and through the intersections between the regions.

A program in C language has been developed that accommodates the algorithm introduced with acceptable level of success.



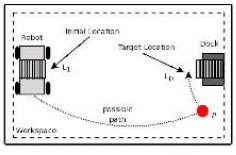


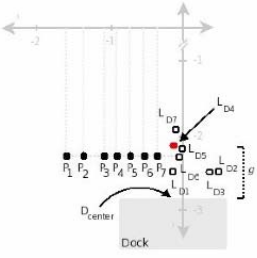
Analysis of a Novel Docking Technique for Autonomous Robots

Henson, G., Maynard, M., Liu, X., Dimitoglou, G.
Department of Computer Science
Hood College, Frederick, MD 21701

Environment: Manufacturing floor
Objective: AGV Docking
Platform: Ackerman steering
Challenges: Docking Accuracy
Steering Coarseness

Solution: Technique for precise docking based on human parallel parking (reversing and aligning to target location)
Simulated using USARsim



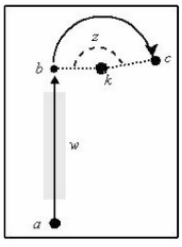


Algorithms and Performance Analysis for Path Navigation of Ackerman-Steered Autonomous Robots

Henson, G., Maynard, M., Dimitoglou, G., Liu, X.
Department of Computer Science
Hood College, Frederick, MD 21701

Environment: Manufacturing floor
Objective: Path Navigation
Platform: Ackerman steering
Challenges: Accuracy and Speed of Navigation
Steering Coarseness

Solution: Algorithms for accurate navigation
Techniques for dynamic path correction
Simulated using USARsim



THU-AM1
Model-based Performance Assessment
Chairs: Kate Remley & Kam Saidi

Wireless Communications in Tunnels for Urban Search and Rescue Robots

Kate A. Remley[1], George Hough[2], Galen Koepke[1], Robert T. Johnk[3], Dennis G. Camell[1], and Chriss Grosvenor[1]
1. NIST Electromagnetics Division, Boulder, CO
2. New York City Fire Department, New York, NY
3. Institute for Telecommunications Sciences, Boulder, CO

We report on propagation tests carried out in a subterranean tunnel to support improved wireless communications for urban search and rescue robots. We describe single-frequency and ultrawideband channel-characterization tests that we conducted, as well as tests of telemetry and control of a robot. We utilize propagation models of both single-frequency path loss and channel capacity to predict robot performance. These models can also be used for optimizing wireless communications in tunnels of various sizes, materials, and surface roughness.

Towards Information Networks to Support Composable Manufacturing

Mahesh Mani [DPG], Albert T. Jones [ESG], Junho Shin [ESG], Ram D. Sriram [DPG]
[DPG] Design and Process Group,
[ESG] Enterprise Systems Group,
Manufacturing System Integration Division,
National Institute of Standards and Technology

Rigid, supply-chain organizational structures are giving way to highly dynamic collaborative partnerships.

- Here partnerships will develop rapidly by composing global manufacturing resources in response to open market opportunities; and, they will disband just as rapidly when those opportunities disappear.
- Cooperation, coordination, and distributed decision-making will be critical to the success of these dynamically composable systems.
- Necessitates the creation of a manufacturing information network (MIN) that automates, as much as possible, the identification, formalization, encoding, and sharing of appropriate manufacturing- and business-related knowledge.

We present some of the issues and requirements associated with the creation of such MINs.

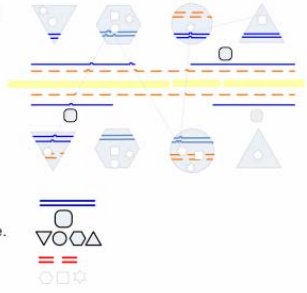


Figure: Composable-On-Demand MINs

A Performance Assessment of Calibrated Camera Networks for Construction Site Monitoring

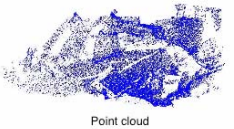
I. Katz, N. Scott, K. Saidi
Materials and Construction Research Division, National Institute of Standards and Technology (NIST)

- Calibrated camera networks (CCNs) are introduced as a tool for maintaining situation awareness on a capital construction site.
- Potential applications and benefits of CCNs over existing tracking methodologies are discussed.
- Empirical results are presented on the calibration and 3D localization capabilities of a prototype network consisting of four cameras.
- 3D points can be localized to within 7 cm of ground truth, on average.

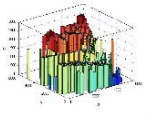
3D Reconstruction of Rough Terrain for USARSim Using a Height-map Method

G. Roberts, S. Balakirsky, and S. Foufou
Intelligent Systems Division, National Institute of Standards and Technology (NIST)

• Simplified reconstruction of rough terrains are built from point clouds acquired using laser scanners. These reconstructions are created using a Height-map method.
  – A Height-map is a gray scale picture which represents the height information of the studied terrain.
•We use a Step-field representation to generate a Height-map.
  – A step-field can be represented by a set of side by side pillars.
• Point clouds can contain surfaces above other surfaces. One Height-map cannot represent different elevations for a given location.
• We present a methodology for the creation of several Height-maps for the same point cloud.



Point cloud



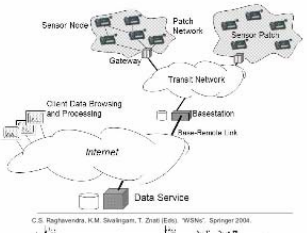
Step-field

Height-map

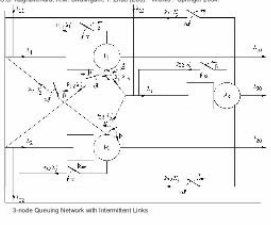
A Queuing-Theoretic Framework for Modeling and Analysis of Mobility in WSNs

Harsh Bhatia[1], R.B. Lenin[2], Aarti Munjal[3], S. Ramaswamy[2], Sanjay Srivastava[1]
[1]Dhirubhai Ambani Institute of ICT, INDIA
[2]Department of Computer Science, University of Arkansas at Little Rock, U.S.A.
[3]Department of Mathematical and Computer Science, Colorado School of Mines, U.S.A.

- This work analyzes the performance measures of wireless systems using Open Queuing Networks (OQNs)
  - OQNs are collection of queuing nodes with finite/infinite buffer whereby arrival and service of packets are modeled using suitable probability distributions
- To capture the mobility natures of the wireless system, we introduce:
  - Intermittent gated nodes
  - Intermittent links
  - Intermittent servers
- The intermittent durations are governed by suitable probability distributions depending on the underlying mobility models
- Analytical formula derived for end-to-end delay.
  - Analytical results are validated through simulation using discrete event simulator OMNeT++
- These measures would serve as benchmark case to verify existing and new routing protocols' efficiencies.



C.S. Raghavendra, K.M. Sivalingam, T. Znati (Eds): "WSNs" Springer 2004.



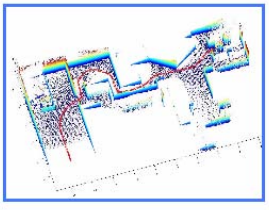
3-node Queuing Network with Intermittent Links

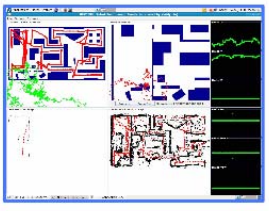
THU-AM2
Special Session V: Quantitative Assessment of Robot-generated Maps
Organizers: Chris Scrapper, Raj Madhavan & Stephen Balakirsky

Characterizing Robot-Generated Maps: The Importance of Representations and Objective Metrics

Chris Scrapper, Raj Madhavan, and Stephen Balakirsky
National Institute of Standards and Technology (NIST)

- Stable navigation solutions are critical for mobile robots intended to operate in dynamic, unstructured environments.
- Currently, there is no way to quantitatively measure the performance of these systems against user–defined requirements.
- Lack of standardized test methods and unified evaluation framework precludes researchers from working towards a common goal.
- With a multitude of representations and approaches to generating maps, how do we define objective evaluation methodologies?
- How can evaluation and visualization tools provide researchers with insight into failures?

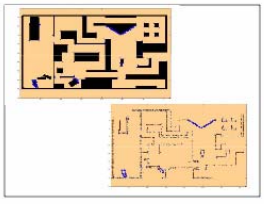


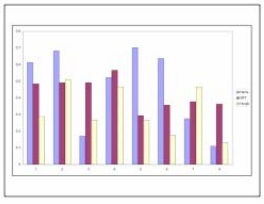


Map Quality Assessment

Asim Imdad Wagan, Afzal Godil, Xiaolan Li
NIST

- *Localized features are calculated on the pre-evaluated map*
- *Nearest neighbor of each valid local feature is searched between the map and the ground truth map*
- *The quality of the map is defined according to the number of the features having the correspondence in the ground truth map*
- *Three feature detectors are used, which are the Harris corner detector, Hough Transform and Scale Invariant Feature Transform*





Using Virtual Scans to Improve Alignment Performance in Robot Mapping

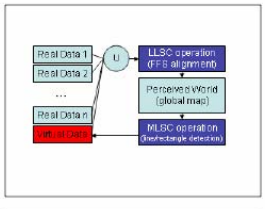
Rolf Lakaemper, Nagesh Adluru
Temple University

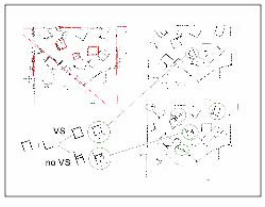
• General Framework and Implementation of a System to Increase Performance of Iterative Alignment Processes

• Augmentation of Low Level Data (Sparse Laser Scans) with Mid Level Hypotheses ('Virtual Scans') about Expected Objects

• Seamless Integration of Physical Scan Data and Virtual Scans Mutually Assisting Each Other in Feedback

• Experimental Evaluation Proves Increase in Performance



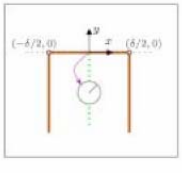


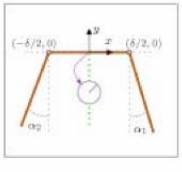
Discussion: Roadmap for Map Evaluation Frameworks

The role of Bayesian bounds in comparing SLAM algorithms performance

Andrea Censi
California Institute of Technology

- SLAM algorithms are hard to analyze formally because of the many out-of-model approximations.
- The study of Bayesian bounds might be helpful: sometimes it's better to analyze the problem than the solution.
- Two problems are considered in particular:
  - How to compare algorithms using a different representation for the map.
  - How to compare algorithms using different prior information on the world.



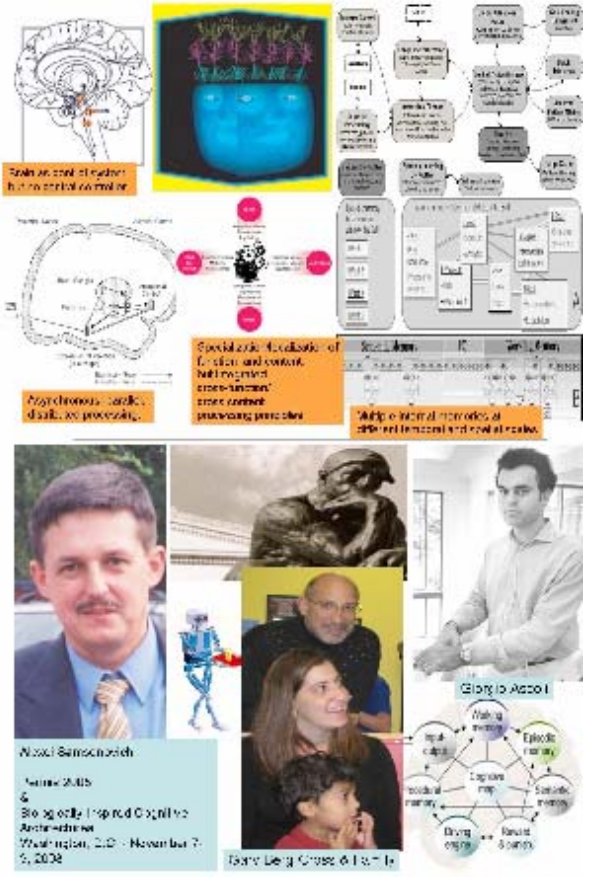


THU-PM1
Special Session VI: Biologically Inspired Models of Intelligent Systems
Organizer: Gary Berg-Cross

Biologically Inspired Models for Intelligent Systems

Gary Berg-Cross (EM&I), Alexei Samsonovich (GMU), Giorgio Ascoli (GMU)

- Cognitive architectures (CA) provide important approaches for intelligent systems through structures that are specifically designed to act like certain cognitive systems.
- Most often, the idea is to act like a person, or act intelligent under some definition of that concept. At last year's special PerMIS session developmental robotics was a newly emerging field relevant to CA that studies how autonomous robots can learn to acquire behavior and knowledge on their own, strictly through their interactions with the surrounding environment.
- A goal is gradual acquisition of knowledge and skills (using previously acquired knowledge and skills), up to a human level of intelligence in various domains.
- This approach takes its biological inspiration from developmental psychology/neuroscience, and asks such question as: how can we make robots "want" to learn, and how are biological/ functional constraints (e.g. limited attention span) leveraged ?
- This session continues the discussion focusing on the biological inspiration and computational theories of biological information processing describing some of its emerging valuable outcomes.
- The primary objective of this session is to showcase recent modeling and rapid prototyping experience aimed at building cognitive agent architectures inspired by the human brain in hopes of operating at the human level.
- At the same time, the focus will be on mind, new interdisciplinary sets of methods for analysing the interaction of language, action and cognition in humans and artificial cognitive agents and theoretical discussion of the underlying mechanisms and related to them metrics and a roadmap to achieving this goal in a "near" future. These include relatively sophisticated ideas like the concept "self".

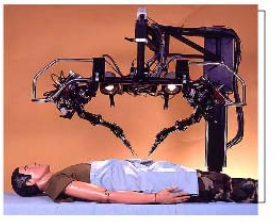


THU-PM2
Special Session VII: Medical Robotics
Organizer: Ram Sriram

Overcoming Barriers to Wider Adoption of Mobile Telerobotic Surgery: Engineering, Clinical and Business Challenges

Gerald R. Moses, PhD University of Maryland
Charles Doarn, MBA, University of Cincinnati
Blake Hannaford, PhD, University of Washington
Jacob Rosen, PhD, University of Washington

- This presentation will describe a collaborative effort to design and develop one or more portable robotic systems for telesurgery and develop those systems through successful animal trials. Recent advances in engineering, computer science and clinical technologies have enabled prototypes of portable robotic surgical platforms. Specific challenges remain before a working platform is suitable for animal trials, such as the inclusion of image-guidance and automated tasks
- Other barriers to the development of mobile robotic surgical platform will be described. These include technical challenges of refinement of robotic surgical platforms, reduction of weight, cube, complexity and cost, and expansion of applications of technology to several procedures. Clinical challenges involve the protection of patient rights and safety, selection of surgical procedures appropriate for the system, the application of surgical skill to evaluate hardware and the application of surgical lore to software programs. Finally, business challenges include resolution of intellectual property considerations, legal liability aspects of telesurgery, patient safety and HIPPA, reimbursement and insurance issues, FDA approval of the final product and development of a commercialization plan.



HLPR Chair – A Novel Patient Transfer Device

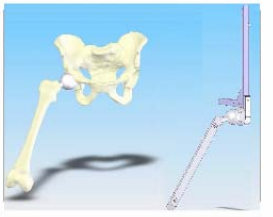
Roger Bostelman, James Albus
NIST

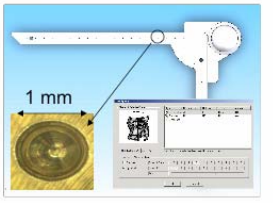
- **H**ome **L**ift, **P**osition and **R**ehab **Chair** invented and prototyped at NIST
- Recently evaluated for static and dynamic stability
- Unique shape compared to conventional wheel/ powered chairs requiring tests to ensure rider safety.
- Controls have been transitioned towards an autonomous patient mobility device for less cognizant drivers
- Plan to use the tested NIST defacto standard, 4D/RCS control system architecture
- Plan to transfer HLPR to manufacturing

Calibration of a Computer Assisted Orthopedic Hip Surgery Phantom

Daniel Sawyer, Nick Dagalakis, Craig Shakarji, Yong Sik Kim
Precision Engineering Division, National Institute of Standards and Technology

- NIST Phantoms are artifacts that test the measurement performance of Computer Assisted Orthopedic Surgery (CAOS) Systems
- CAOS measure the location and position of a patient's hip joint before surgical reconstruction or hip replacement.
- Cartesian Coordinate Measuring Machines are used to calibrate the critical dimensions of the phantoms.
- Variation in the surface quality of the phantom target holes requires the use of simulation tools to determine the optimum calibration strategy and estimate the measurement uncertainty.
- This presentation describes the calibration process and measurement simulation tools used





Robotic Navigation in Crowded Environments: Key Challenges for Autonomous Navigation Systems

James Ballantyne, Salman Valibeik, Ara Darzi, Guang-Zhong Yang
Imperial College London
London, United Kingdom

- Crowded environments, such as hospitals and public buildings provide significant challenges for autonomous navigation system. The robot must be fully aware of its surroundings and incorporate this knowledge into its decision-making and planning process. The purpose of this paper is to outline major challenges that an autonomous navigation system must overcome to enable effective emersion into crowded environments such as hospitals.
- Challenges were found by investigating current implementations in crowded environments. The chosen methods have shown great results in static environments and environments with limited moving objects. However, these same methods struggle when entering crowded environments.
- Key Challenges in:
  - Human-Robot Interaction
  - Dynamic Object Detection
  - Localization and Mapping
  - Motion Planning