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April 26, 2000

Wednesday, April 26th

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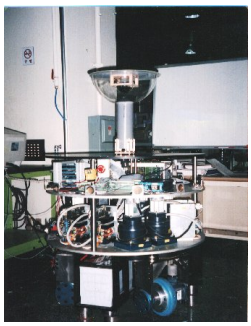
Mobile Robots 1
Chairs: Alberto Elfes, Xiaoping Yun

Geometric Kinematics Modeling of Omni-directional Autonomous Mobile Robot and Its Applications
D. S. Kim, H. C. Lee and W. H. Kwon
Seoul National University

- Necessity of Practical and Simple Kinematics Modeling for the Developed Omni-directional Mobile Robot
- Geomertic Kinematics Model, Basic Trajectory Analysis using Proposed Kinematics
- Path Error Control using Basic Trajectory, Navigation Test using Proposed Kinematics Model
- Design of Kinematics and Inverse Kinematics, Proving Proposed Algorithm through Applications and Implementations

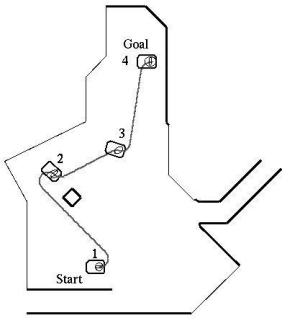


Topological Characterization of Safe Coordinated Vehicle Motions
R. J. Milgram[1] and S. G. Kaufman[2]
[1]Stanford University and [2]Sandia National Laboratories

- Problem: Motion Planning of vehicles on a network
- Method: Calculate configuration space
- The resulting space is much simpler than expected
- Algorithms based on this space implemented

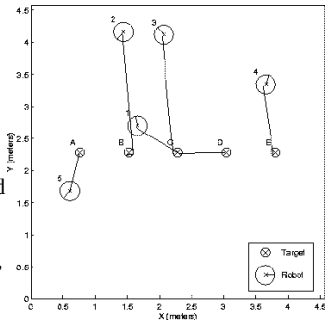
Landmark-Based Safe Path Planning for Car-Like Robots
A. Lambert and Th. Fraichard
INRIA

- Nonholonomic path planning integrating cumulative drift error
- Define & use localization regions based on world features
- Safe paths planned for indoor, car-like vehicle
- Uncertainty & nonholonomy dealt with in path planning



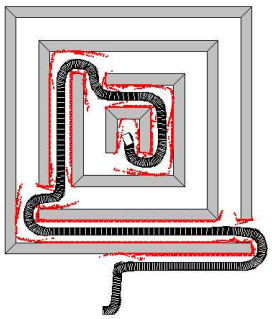
A Utility Approach to Multi-Agent Coordination
T. B. Gold, J. K. Archibald and R. L. Frost
Brigham Young University

- Devise distributed algorithm for robots to create formation
- Satisficing approach used, similar to cost-benefit analysis
- Distance, convergence measured as number of robots varies
- Praxeic utility approach flexible, effective



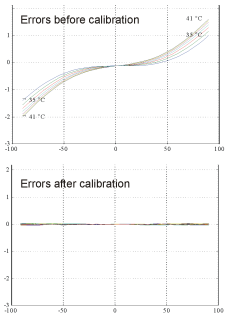
A New Local Path Planner for Nonholonomic Mobile Robot Navigation in Cluttered Environments
G. Ramirez and S. Zeghloul
Universite de Poitiers

- Feasible Velocities Polygon - a new obstacle description
- A two-module planner inspired by the Bug algorithm
- Optimization-based approach with global convergence
- Well adapted for use with embarked sensors



Precision-calibration of Fiber-optics Gyroscopes for Mobile Robot Navigation
L. Ojeda, H. Chung and J. Borenstein
University of Michigan

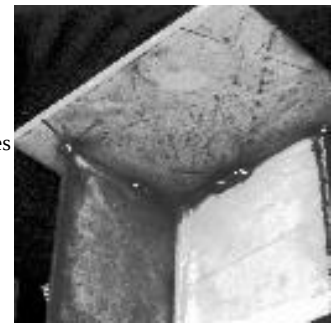
- Bias drift is small, non-linearity and temperature dependency become significant.
- Calibration method described here aims at reducing the resulting errors.
- Reduction of errors of one order of magnitude were obtained.
- Gyro calibration shown to improve the performance dramatically.



Visual Servoing 1
Chairs: Peter Allen, Minoru Asada

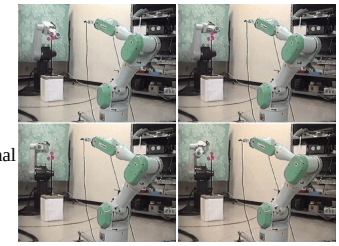
Visual Servoing from Lines
Nicolas Andreff, Bernard Espiau and Radu Horaud
INRIA Rhone-Alpes

- Positioning a camera with respect to a set of lines
- Explicit control law using binormalized Plucker coordinates of a line
- Global convergence theorem
- Application to the orthogonal trihedron case



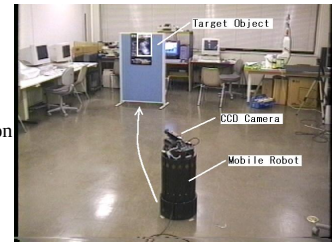
Adaptive Binocular Visual Servoing for Independently Moving Target Tracking
M. Asada, T. Tanaka and K. Hosoda
Osaka University

- Unknown Moving Object Tracking based on Adaptive Visual Servoing
- Stereo Epi-polar Constraint and Virtually Stationary Target
- Better Performance Than Conventional Adaptive Visual Servoing
- A Proposal of One Extension of AVS and Success of Application



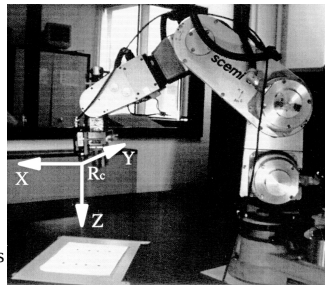
Visual Tracking using Dynamic Transition in Groups of Affine Transformed Templates
Ken Ito and Shigeyuki Sakane
Chuo University

- View-based visual tracking of an object in 3D environment
- Affine transformed templates generated from geodesic domes
- Visual tracking tasks in manipulation and robot navigation
- The system can cope with the changes of the template's appearance in the 3D environment.



Robust Vision Based 3D Trajectory Tracking Using Sliding Mode Control
P. Zanne, G. Morel and F. Plestan
Universite of Strasbourg 1

- Conventional 3D visual servoing suffers from a lack of robustness
- Study of the effect of camera calibration errors on the 6 DOF pose reconstruction
- Robustness to bounded parametric errors using sliding mode control
- Accurate 6DOF tracking experiments under weak calibration

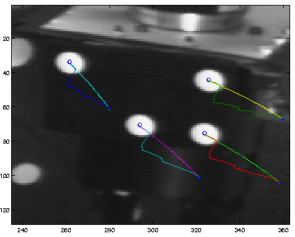


Joint Coupled Compensation Effects in Visually Servoed Tracking
P. Oh and P. Allen
Columbia University

- Problem: Robotically monitor a large assembly workcell with a hybrid 5-DOF robot
- Approach: Partition degrees-of-freedom; visually servo pan-tilt unit and kinematically servo cartesian gantry
- Results: Joint-coupling improves tracking performance by reducing lag
- Conclusions: Fast bandwidth DOF, when visually servoed, physically act as lead compensators for slower joints

Controlling Robots With Two Cameras: How to Do it Properly
B. Lamiroy, B. Espiau, N. Andreff and R. Horaud
INRIA Rhone-Alpes

- Develop sound framework for stereo visual servoing
- Constraint minimization handling epipolar geometry
- Higher convergence precision and smoother movements
- Stereo is more robust and more flexible than mono

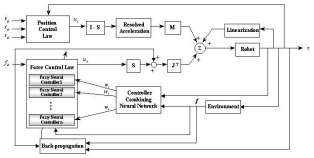


Fuzzy Logic Systems
Chairs: Toshio Fukuda, Ren C. Luo

Application of Multiple Fuzzy-Neuro Force Controllers in an Unknown Environment Using Genetic Algorithms

K. Kiguchi[1], K. Watanabe[1], K. Izumi[1] and T. Fukuda[2]
[1]Saga University and [2]Nagoya University

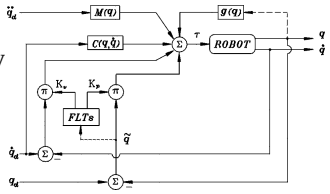
- Realize precise force control in an unknown environment
- Multiple fuzzy neuro force controllers are combined with a proper ratio using GA
- Desired force response has been generated in several kinds of environments
- An effective force control method has been proposed using soft computing



Fuzzy PD+ Control for Robot Manipulators

[1]V. Santibanez, [2]R. Kelly and [1]M. Llama
[1]Instituto Tecnologico de la Laguna and [2]CICESE

- Introduction
- Fuzzy PD+ Control: Stability Analysis
- Experimental Evaluation
- Conclusions



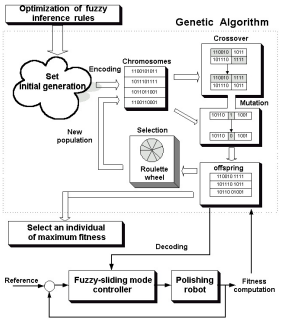
Mobile Target Tracking Using Hierarchical Grey-Fuzzy Motion Decision-Making Method

T. M. Chen and R. C. Luo
National Chung Cheng University

Fuzzy-Sliding Mode Control with the Self Tuning Fuzzy Inference Based on Genetic Algorithm

S. J. Go and M. C. Lee
Pusan National University

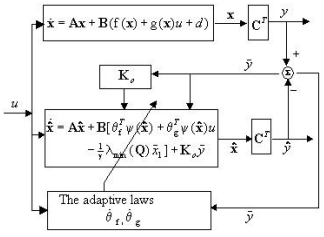
- The fuzzy inference rules should be determined only by an expert.
- A self tuning fuzzy inference method by the genetic algorithm.
- The optimal fuzzy inference rules by the genetic algorithm are automatically selected.
- Although designer is a non-expert, the fuzzy-sliding mode controller can be designed by the self tuning fuzzy inference method.



Adaptive Fuzzy-Neural Observer for A class of Nonlinear Systems

Yih-Guang Leu[1] and Tsu-Tian Lee[2]
[1]Lee-Ming Institute of Technology and [2]National Taiwan University of Science and Technology

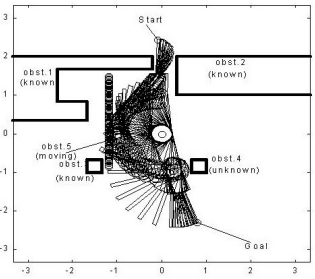
- Designing an adaptive fuzzy-neural observer for a class of uncertain nonlinear systems
- Obtained by H-infinity control technique and the strictly positive real Lyapunov design approach
- Simulating the observer for a single-link robot plant and showing satisfactory performance
- Providing the modeling error and the external bounded disturbance attenuation with H-infinity performance



Fuzzy and Recurrent Neural Network Motion Control among Dynamic Obstacles for Robot Manipulators

J. B. Mbede, X. Huang and M. Wang
Huazhong University of Science and Technology

- In the potential field approach to path planning, the development of the APF is computationally intensive operation.
- The proposed fuzzy obstacle avoidance entails attractive and repelling forces provided by two inputs.
- the robot using the proposed robust neuro-fuzzy motion control, succesfully avoids the moving, unknown and static obstacles.
- The use of the proposed neuro-fuzzy motion controller is very attractive for real time applications where manipulator dynamics can experience parameter variations, load changes and any possible external disturbances.

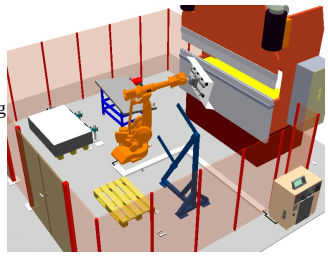


Motion Planning
Organizers & Chairs: Lydia Kavraki, Steven M. LaValle

Current Approaches to Motion Planning
Lydia Kavraki
Rice University

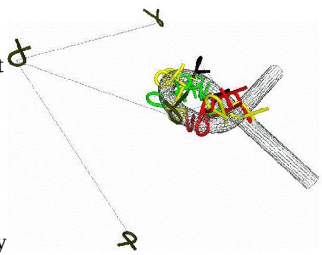
Path Planning Using Lazy PRM
R. Bohlin[1] and L. Kavraki[2]
[1]Chalmers University of Technology and [2]Rice University

- Addresses single query path planning in high-dimensional configuration spaces
- Presents a variation of the Probabilistic Roadmap Method designed to minimize collision-checking and hence running time
- Provides experimental results from an industrial environment
- Concludes that the new planner, called Lazy PRM, is efficient in practice



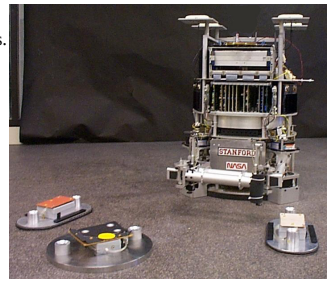
Enhancing Randomized Motion Planners Exploring with Haptic Hints
O. B. Bayazit, G. Song and N. M. Amato
Texas A&M University

- Cooperative motion planning by user and automatic planner.
- User's haptically collected input guides planner's exploration.
- Large improvements achieved by pushing approximate paths to freespace.
- Visual/force feedback extremely useful.



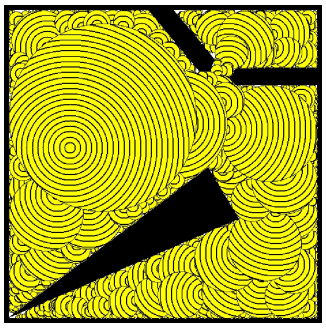
Kinodynamic Motion Planning Amidst Moving Obstacles
R. Kindel, D. Hsu, J. C. Latombe and S. Rock
Stanford University

- Many robots requries fast, kinodynamic motion planning in dynamic workspaces.
- A single-query, random-control based motion planner was developed.
- Hardware experiments and simulations were done for a space robot among moving obstacles.
- The planner efficiently generates kinodynamically constrained paths usable by real robots.



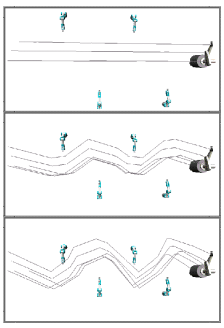
A Framework for Planning Feedback Motion Strategies Based on a Random Neighborhood Graph
L. Yang and S. M. LaValle
Iowa State University

- Build a volumetric approximation to high-DOF free space using a network of randomly-chosen neighborhoods.
- Exploit existing algorithms for efficient distance computation, point location, and neighborhood intersections.
- Ensure representation quality by using probabilistic termination condition.
- Guide the robot using quickly-reconfigurable, global navigation functions that allow feedback.



Real-Time Replanning in High-Dimensional Configuration Spaces Using Sets of Homotopic Paths
Oliver Brock and Oussama Khatib
Stanford University

- Motion execution in dynamic environments must be reactive
- Elastic strips as approach to real-time replanning
- Workspace volume used to represent set of homotopic paths
- Real-time path modification for high-DOF robots in dynamic envorinments



Human Augmentation and Assist Devices

Organizers & Chairs: Harry Asada, Hami Kazerooni

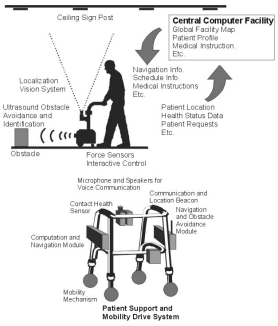
Surface Waves for Active Transport of Bedridden Patients
Joseph Spano and H. H. Asada
Massachusetts Institute of Technology

Design and Control of Human Assisted Walking Robot
Peter D. Neuhaus and H. Kazerooni
University of California, Berkeley

- Maneuvers Heavy Loads for Extended Periods of Time
- Speed Proportional with Human Force
- Stabilized by Human, Practical
- Powered by an IC Engine

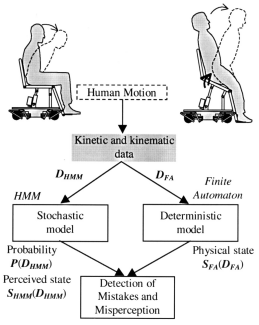
PAMM - A Robotic Aid to the Elderly for Mobility Assistance and Monitoring: A "Helping-Hand" for the Elderly
S. Dubowsky, F. Genot, S. Godding, H. Kozono, A. Skwersky, L. S. Yu and H. Yu
Massachusetts Institute of Technology

- To identify and develop the enabling technologies for a mobility aid and health monitoring system for the elderly.
- Key technologies developed include: Planning and Control, Environmental Mapping, Human-machine Interface, Health Monitoring
- Lab and field tests have shown the feasibility of the concept and demonstrated good performance of the system
- The PAMM system has been well recieved by the users



Detection of Human Mistakes and Misrepresentation for Human Perceptive Augmentation: Behavior Monitoring Using Hybrid Hidden Markov Models
M. Hiratsuka[1], [2] and H. H. Asada[2]
[1]Kawasaki Heavy Industries Co., Ltd. and [2]Massachusetts Institute of Technology

- Mistakes and misperception in operating complex systems, such as assist devices for elderly and handicapped people, might lead to a serious accident.
- Standing-up failures are assumed to be caused by mistakes and misperception in a human motion.
- Hidden Markov Models and Finite Automata of a human motion evaluate the appropriateness and the consistency of a human motion.
- Our approach is applied to a standing-up assist device for elderly and handicapped people.

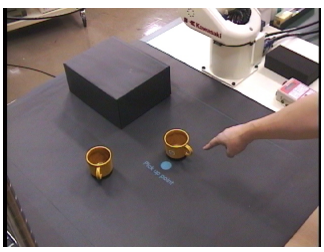


Mobile Robot Helper
K. Kosuge, M. Sato and N. Kazamura
Tohoku University

- Human-Robot Cooperation
- Control Algorithm Specifies the Apparent Dynamics of the Object
- Load Sharing is Realized by Introducing Lifting-up/down System
- Human and Robot Execute the Task in Cooperation with Each Other

A Human-Robot Interface Using an Interactive Hand Pointer that Projects a Mark in the Real Work Space
Shin Sato and Shigeyuki Sakane
Chuo University

- Projector-based Augmented Reality for human-robot interface
- Tracking an operator's pointing hand and projecting a mark
- Pick-and-place tasks using CCD cameras and infrared cameras
- The IHP is a useful tool for human-robot interaction.



Medical Robotics
Organizers & Chairs: Russell Taylor, Nicholas Ayache

An Overview of Medical Robotics
R. H. Taylor
Johns Hopkins University

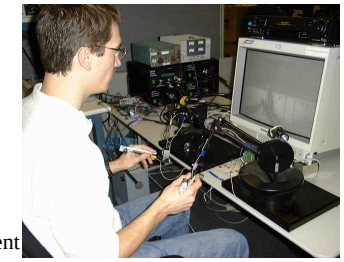
- Computer-Integrated Surgery as CIM of the 21'st Century
- Human-machine cooperation in information-intensive tasks
- Robot systems to enable novel treatments
- Research combines robots, computing, and HMI

Anisotropic Elasticity and Force Extrapolation to Improve Realism of Surgery Simulation
G. Picinbono, J. C. Lombardo, H. Delingette and N. Ayache
INRIA, Sophia-Antipolis

- Real time surgery simulation with force feedback
- Anisotropic elasticity, finite elements and force extrapolation
- Applications to laparoscopic liver surgery and vessels modelling
- Simulation of surgical gesture with good visual and haptic rendering

Evaluating Control Modes for Constrained Robotic Surgery
F. Lai and R. D. Howe
Harvard University

- Incision constrains minimally invasive robotic surgery
- Compare control: screen vs. instrument mapping, 4 vs. 6 DOF
- Best performance: 4 DOF with instrument mapping
- Control should reflect instrument constraints

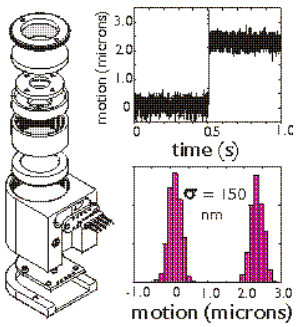


Preliminary Experiments in Cooperative Human/Robot Force Control for Robot Assisted Microsurgical Manipulation
R. Kumar, P. Gupta, A. Barnes, P. Jensen, L. L. Whitcomb and R. H. Taylor
Johns Hopkins University

- Force sensing on user handle and instrument tip
- Robot holds instrument and complies to user forces for 'steady-hand' cooperative manipulation
- Stable contact and 1/25 scaled-down force trajectory tracking shown with compliant spring and animal eye tissue
- System enhances user dexterity, reduces tremor, and extends user's haptic sensitivity

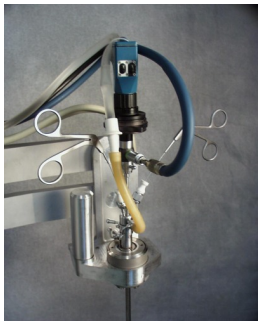
The Intuitive Tele-Surgery System: Overview and Application
Gary S. Guthart[1] and J. Kenneth Salisbury Jr.[2]
[1]Intuitive Surgical Inc. and [2]Stanford University

- Enhancement of minimally invasive surgical dexterity
- Development master-slave surgical telerobot
- System used in hundreds of human cases including beating heart bypass
- Telerobotics can radically enhance surgical performance



Neurobot: a special-purpose robot for Neurosurgery
B. Davies[1], S. Starkie[1], S. J. Harris[1], E. Agterhuis[2], V. Paul[3] and L. M. Auer[4]
[1]Imperial College, [2]Fokker Control Systems, [3]IBMT, Fraunhofer Institut fur Biomed Technik, A G Medizin Telematik, St Ingbert and [4]ISM, Institute of Applied Sciences in Medicine, Salzburg, Austria

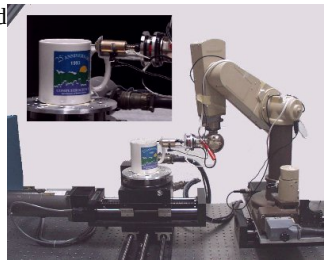
- Robot provides precise control of endoscopic tools
- Force control puts the surgeon in charge, guiding the robot
- Active constraints prevent injury to healthy tissue
- Evaluation by neurosurgeons using brain phantoms



Static and Dynamic Contact
Chairs: Imin Kao, Dinesh Pai

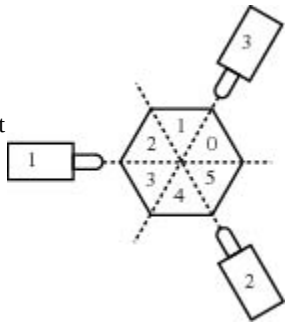
Active Measurement of Contact Sounds
Joshua L. Richmond and Dinesh K. Pai
University of British Columbia

- Automatic acquisition of sound measurements.
- Uses a special
- Measurements used to create a sound model of an object.
- Produced good models of a brass vase.



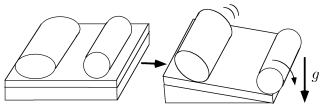
A Tapping Microprositioning Cell
W. H. Huang
Rensselaer Polytechnic Institute

- Positions parts precisely within the cell by tapping the part.
- Tapping actuators are placed about the perimeter of the cell.
- The system is controllable.
- We give a positioning algorithm and show simulated results.



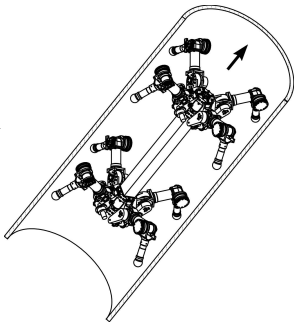
Neighborhood Equilibrium Grasp for Multiple Objects
K. Harada and M. Kaneko
Hiroshima University

- We discuss the neighborhood equilibrium where the system can be shifted to another equilibrium state even when the current equilibrium is broken.
- We discuss the equilibrium grasp for multiple objects.
- We evaluate the robustness of the equilibrium state by utilizing the rotating angle of the system.
- We show several numerical examples to verify our idea.



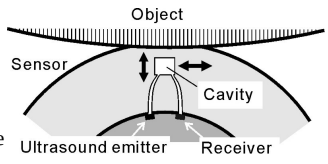
About Friction in Walking Machines
F. Pfeiffer and Th. Rossmann
Technische Universitaet Muenchen

- Gears in Walking Machines and Robots, Harmonic Drives
- Multibody theory with unilateral contacts
- Efficiency of Harmonic Drives
- Powerful tool for design and friction observer layout



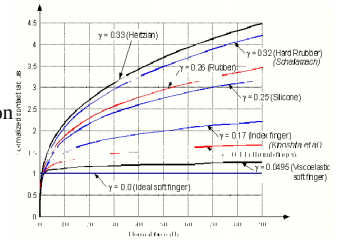
Instantaneous Evaluation of Friction Based on ARTC Tactile Sensor
H. Shinoda, S. Sasaki and K. Nakamura
Tokyo University of Agriculture & Technology

- Detecting a friction coefficient at the moment of touch, with no preliminary motions.
- An ARTC measures two skin stress components parallel and vertical to the surface.
- Stress parallel to the sensor surface depended on the friction.
- ARTC tactile sensor senses friction coefficient at the moment of touch.



Study of Soft Finger Contact Mechanics Using Finite Elements Analysis and Experiments
Nicholas Xydas, Milind Bhagavat and Imin Kao
SUNY Stony Brook

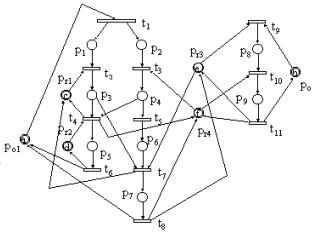
- Nonlinear FEM modeling and simulation of soft finger contact
- Experiments and model verification
- Normal force vs. radius of contact, pressure distribution
- Limit surface



Discrete Event Dynamic Systems 1
Chairs: MuDer Jeng, Meng Chu Zhou

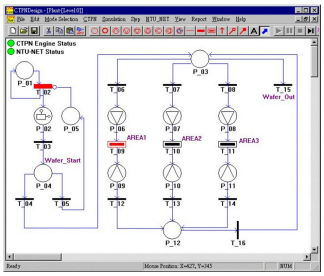
Manufacturing Modeling Using Process Nets with Resources
MuDer Jeng[1], Xiaolan Xie[2] and YiSheng Huang[3]
[1]National Taiwan Ocean University, [2]INRIA/ENIM - Ile du Saulcy and [3]Fu-Shin Institute of Technology and Commerce

- Introduction
- The Proposed Nets and their Conditions
- Qualitative Properties of PNRs
- Conclusions



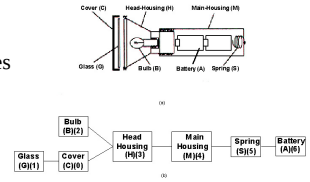
Modeling and Performance Evaluation of a Controlled IC Fab Using Distributed Colored Timed Petri Net
C. H. Kuo and H. P. Huang
National Taiwan University

- For highly model-mixed and flexible routing manufacturing system
- Integrate with MES system
- Provide conflict resolution and token competition rules
- Consider throughput, stage move, WIP(wafer in process) distribution, lot cycle time, utilization of IC Fab



Disassembly Modeling, Planning, and Application: A Review
Y. Tang[1], M. C. Zhou[1], E. Zussman[2] and R. Caudill[3]
[1]New Jersey Institute of Technology, [2]Technion Israel Institute of Technology and [3]MERC

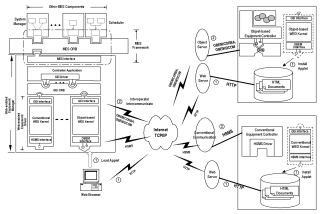
- Motivation
- Modeling Disassembly Processes
- Disassembly Process Planning
- Conclusion



Adaptive Supervisory Control under Sensor Unavailability
H. Darabi and M. A. Jafari
Rutgers University

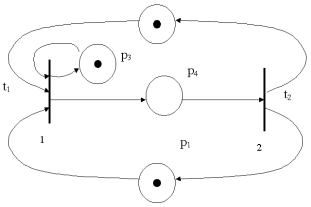
Developing a Web-enabled Equipment Driver for Semiconductor Equipment Communications
F. T. Cheng, M. T. Lin and R. S. Lee
National Cheng Kung University

- Connecting a different machine to an Eq manager usually needs to modify the associated Eq driver, which is diffcult.
- To solve this problem, we propose a Web-enabled Eq Driver (WED) that uses the mobile object technology & a web browser.
- It has been built at NCKU and will be demoed.
- The proposed WED establishes a novel, efficient, and versatile scheme for semiconductor Eq communications.



Incremental Optimization of Timed Cyclic Event Graphs
A. Giua, A. Piccaluga and C. Seatzu
University of Cagliari

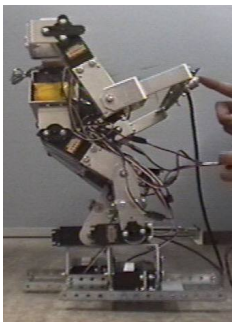
- Problem: allocate a given number of tokens tokens so as to maximize the firing rate of a cyclic event graph
- Solution: incremental optimization algorithm
- The algorithm is very efficient both in terms of computational time and memory requirements
- Necessary and sufficient conditions for the convergence to the optimum have been provided



Humanoids
Chairs: Ruediger Dillmann, Shigeki Sugano

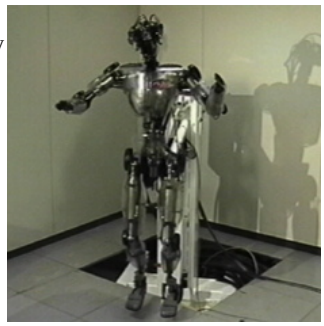
Mobile Manipulation of Humanoids: Real-Time Control Based on Manipulability and Stability
K. Inoue, H. Yoshida, T. Arai and Y. Mae
Osaka University

- Integrated manipulation and locomotion of humanoids
- Arm control for carrying out objective tasks
- Autonomous locomotion coordinating with arm motion
- Experimental robot with external force applied to



Planning of Joint Trajectories for Humanoid Robots Using B-Spline Wavelets
Ales Ude[1], Christopher Atkeson[2] and Marcia Riley[2]
[1]Japan Science and Technology Corporation and [2]Georgia Tech

- Generation of humanlike full-body motions
- Multiresolution B-spline wavelet representation
- Large-scale optimization with a trust region method
- Application to the generation of Okinawan dance movements



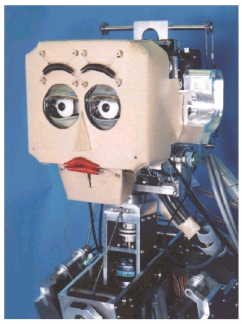
Human Symbiotic Robot Design based on Division and Unification of Functional Requirements
T. Morita, H. Iwata and S. Sugano
Waseda University

- A Target of this study is development of human symbiotic robots, which can support daily work in humanfs living space.
- For ensuring impact safety, a simulation model and several mechanisms are proposed. As regards to dexterity, hand mechanisms are developed with focusing on pressure control ability.
- Effectiveness of the design method is confirmed from several evaluation experiments, such as cooking tasks.
- A design method of human symbiotic robots, which have the possibilities for ensuring safety and dexterity, is proposed.

Complex Continuous Meaningful Humanoid Interaction: A Multi Sensory-Cue Based Approach
G. Cheng and Y. Kuniyoshi
ElectroTechnical Laboratory, ETL

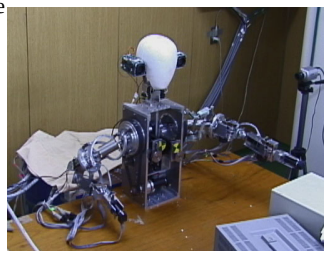
An Anthropomorphic Head-Eye Robot expressingEmotions based on Equations of Emotion
Atsuo Takanishi, Kensuke Sato, Kunio Segawa, Hideaki Takanobu and Hiroyasu Miwa
Waseda Univeristy

- Our motivation is developing function for a humanoid robot having the ability to communicate naturally with a human.
- The sub-system as the tactile sensation recognizing 'push', 'stroke' and 'hit'.
- Equations of Emotion for the 3D artificial psychological model.
- The robot can express Emotions based on Equations of Emotion changing by external stimulation.



Design of Active/Passive Hybrid Compliance in the Frequency Domain - Shaping Dynamic Compliance of Humanoid Shoulder Mechanism
M. Okada[1], Y. Nakamura[2] and S. I. Hoshino[1]
[1]University of Tokyo and [2]Japan Science and Technology Corporation

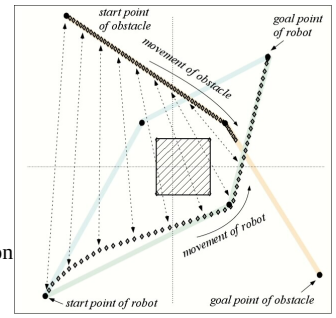
- Technical design of active/passive hybrid compliance
- Dynamic compliance in the frequency domain
- H_∞ control theory and systems identification method
- Humanoid torso robot with the cybernetic shoulder



Sensing and Motion Planning
Chairs: Vladimir Lumelsky, Shin'ichi Yuta

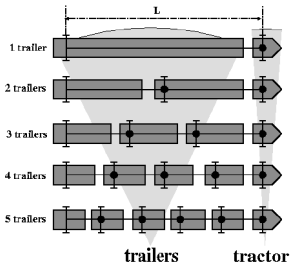
Modeling Motion Uncertainty of Moving Obstacles for Robot Motion Planning
J. Miura and Y. Shirai
Osaka University

- Probabilistic Model of Obstacle Motion
- Velocity Uncertainty and Path Ambiguity of Obstacle
- Observation Uncertainty of Robot
- Decision-Theoretic Robot Motion Planning



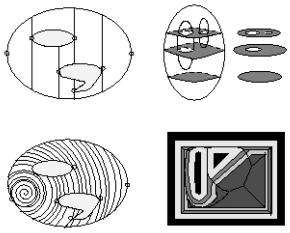
Manipulative Difficulty Index of a Mobile Robot with Multiple Trailers in Pushing and Towing with Imperfect Measurement
W. Li, T. Tsubouchi and S. Yuta
University of Tsukuba

- Manipulative Difficulty Index(MDI)
- MDI Evaluation Examples
- Stochastic Linear Feedback Controller
- Line Following for Tractor-trailer System



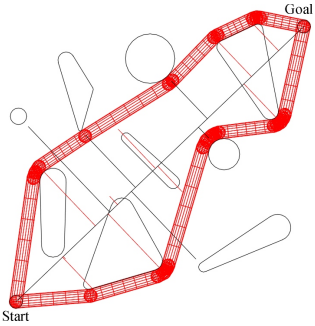
Exact Cellular Decompositions in Terms of Critical Points of Morse Functions
H. Choset, E. Acar, A. A. Rizzi and J. E. Luntz
Carnegie Mellon University

- Exact Cellular Decomposition in Terms of Critical Points
- Morse Functions and Critical Points
- Different Decomposition Patterns for Different Functions
- A Frame Work for Motion Planning Algorithms



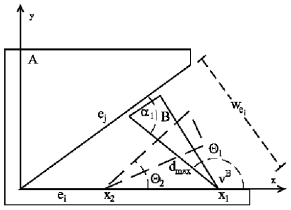
Real-Time Generation of Collision-Free Paths for a Mobile Sphere
E. J. Bernabeu and J. Tornero
Universidad Politecnica de Valencia

- Path Planning of a Mobile Sphere
- Hough Transform Application. Minimum Volume Locus
- Generation of 3D and Several 2D Paths in Real Time
- Linear Complexity for Generating Several 2D Paths



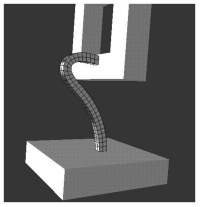
On Relating the Disconnectedness of a Contact Formation to the Geometric Properties of its Constituent Objects
D. Johnston and J. Xiao
University of North Carolina - Charlotte

- Configurations of the same contact formation may be disconnected.
- Disconnectedness depends on the geometry of contacting objects.
- For polygons, some necessary geometrical conditions are presented for disconnectedness.
- The results are useful for quickly checking if a CF has disjoint configurations.



Deformable Volumes in Path Planning Applications
E. Anshelevich, S. Owens, F. Lamiraux and L. Kavraki
Rice University

- PRM extended to a class of three-dimentional deformable volumes (with full 3D bending)
- Paths consisting of minimal-energy deformations
- Mass-Spring Representation of the deformable volumes
- Path planning for an elastic pipe/wire: an extended example



Navigation and Mapping
Chairs: Gregory Dudek, Gaurav Sukhatme

Rover Maneuvering for Autonomous Vision-Based Dexterous Manipulation
I. A. D. Nesnas, M. W. Maimone and H. Das
Jet Propulsion Laboratory

- Problem: Autonomous rock sample acquisition and instrument placement
- Approach: Used vehicle's mobility system to compensate for limited dexterity of manipulators and used stereo vision for feedback and target tracking.
- Results: Successfully performed multiple rock sample acquisitions of selected targets from a distance of more than one meter away and instrument placement from a distance of more than five meters away.
- Conclusions: Further refinements to algorithms are needed to increase robustness and handle more challenging terrain.

Fault Detection and Identification in a Mobile Robot Using Multiple Model Estimation and Neural Network
P. Goel, G. Dedeoglu, S. I. Roumeliotis and G. Sukhatme
University of Southern California

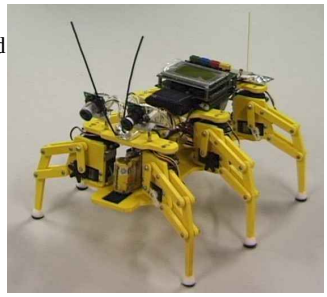
- Automated Detection and Identification of faults in a mobile robot.
- Fault models are embedded in parallel Kalman Filter estimators. The set of residuals is processed by a backpropagation Neural Network.
- Faults are simulated on a real robot. Data collected for 8 different kinds of faults.
- Proposed scheme is able to detect and identify both sensor and mechanical failures.

On-line Construction of Iconic Maps
E. Bourque and G. Dudek
McGill University

- When creating image-based virtual reality, how do we decide which images to retain?
- Alpha-backtracking is introduced to decide when to keep images based on partial statistical knowledge.
- With minimal backtracking, the results are close to the ideal off-line case.
- Alpha-backtracking can provide favorable results when data storage must be minimized.

Obstacle Avoidance on a Legged Robot without 3D Reconstruction of the Surroundings
Y. H. Chow and Ronald Chung
The Chinese University of Hong Kong

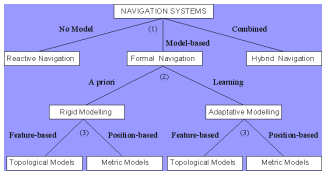
- Legged locomotion on a ground plane
- Obstacle detection
- Obstacle avoidance
- Real-time implementation of complete system



Multiple-Goals Path Planning for Coordinate Measuring Machines
S. N. Spitz and A. A. G. Requicha
University of Southern California

Combination of Model-based and Reactive Methods in Autonomous Navigation
D. Maravall, J. de Lope and F. Serradilla
Technical University of Madrid

- Autonomous Navigation of Mobile Robots: from Map Building to Route Planning and Execution
- Combination of Model-based Navigation and Reactive Navigation Enlarges Mobile Robot's Autonomy
- Map Building Using the
- Hybrid Navigation Systems Fully Tested in Office-like Environments



Control and Applications 1
Chairs: Erwin Prassler, Alberto Rovetta

Proposition and Basic Experiments of Shape Feedback Master-Slave Arm - On the Application for the Demining Robots -

Shigeo Hirose and Keisuke Kato
Tokyo Institute of Technology

Single Rigid Body Representation, Control and Stability for Robotic Applications

H. Hemami[1] and B. Dariush[2]
[1]The Ohio State University and [2]Honda R&D Americas, Inc.

- Develop a convenient, robust, and stable algorithm to represent rigid body systems.
- Lyapunov's method is used to prove stability.
- The theory is verified using a single segment rigid body model.
- A simple, modular, and stable feedback structure has been developed.

Dynamic modeling and identification of earthmoving engines without kinematic constraints: application to the compactor

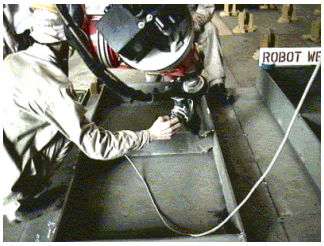
E. Guillo and M. Gautier
Institut de Recherche en Cybernetique de Nantes(IRCyN)

- A better knowledge of earthmoving engines behavior is needed
- Their diversity requires an extended classical robot description
- Dynamic modelling without kinematic constraints is proposed
- Dynamic identification is performed on an instrumented engine

An Industrial Application of Control of Dynamic Behavior of Robots - A Walk-Through Programmed Welding Robot

M. H. Ang Jr.[1], L. Wei[2] and L. S. Yong[2]
[1]National University of Singapore and [2]Gintic Institute of Manufacturing

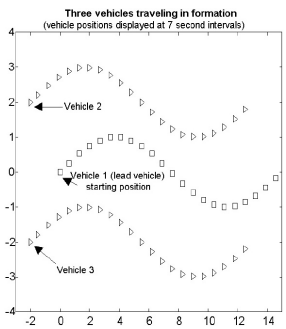
- A humanly-intuituve way to command motion of a robot
- Using
- Walk-through achieved with force sensor and motion response regulated according to desired dynamics
- Improved welding in shipyards due to better quality and ease in teaching



A framework for decentralized control of autonomous vehicles

Daniel J. Stilwell and Bradley E. Bishop
U.S. Naval Academy

- Goal: minimize communication among cooperating vehicles
- Environmental interactions are modeled as feedback paths
- Solution based on systems theory and observer design
- Design example with autonomous underwater vehicles



A Robotic Road Sweeper

E. Prassler[1], D. Schwammkrug[1], B. Rohrmoser[2] and G. Schmidl[3]
[1]University of Ulm, [2]University of Stuttgart and [3]Alfred Kaercher GmbH

- Hardware and Software Design
- Motion Planning for an Outdoor Cleaning Robot
- Experimental Results
- Conclusions

National and International Research and Development Programs and Projects

Chair: Georges Giralt, LAAS-CNRS, France

Speakers:

R. Bajcsy, NSF
G. Bekey, University of Southern California
S. Bensasson, Future Emerging Technologies Unit, IST, European Union
H. Inoue, University of Tokyo
D.E. Okhotsimsky, V. Gradetsky, Russian Academy of Sciences
S. Sastry, M. Swinson, DARPA/ITO
M. Uhran, S. Lide, NASA

The support of key enabling technologies such as IT, micro and emergent nano technologies fosters the shift of robotics and advanced automation out of the shopfloor and the well engineered environments towards a host of novel applications ranging from field robotics to everyday's life human-centered robotics. The shift in paradigm, which strongly emphasizes human machine interaction, calls more than ever for cooperative programs and projects both at the national and international level.

This symposium attempts to discuss this shift, starting with introductory outline on the efforts being carried within the International Advanced Robotics Program (IARP), and continuing with two series of in-depth presentations.

Five large scale programs:

- *Challenges and Opportunities for Robotics Research in the Information Technology Research Initiative*
  R. Bajcsy, NSF
- *Basic and Applied Research in IT - Bridging the gap in the programs of the European Union*
  S. Bensasson, IST, EU
- *HRP: Humanoid Robotics Project*
  H. Inoue, Tokyo University
- *Robotics at ITO, DARPA*
  S. Sastry, M. Swinson, ITO, DARPA
- *Robotics and the Commercial Development of Space at NASA*
  M. Uhran, S. Lide, NASA

And two special presentations :

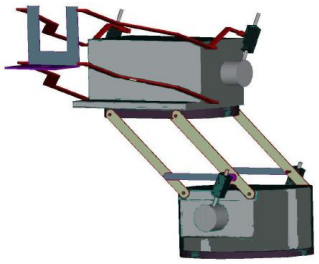
- *Current Robotics Activities in Russia, Pursuing the Tradition of Pioneering Past Achievements*
  D.E. Okotsimsky and V. Gradetsky, Russian Academy of Sciences
- *Robotic Assembly of Satellite Power Systems*
  G. Bekey, University of Southern California

Parallel Mechanisms
Chairs: J. Angeles, Manfred Husty

A Novel Manipulator Architecture for the Production of SCARA Motions

J. Angeles, A. Morozov and O. Navarro
McGill University

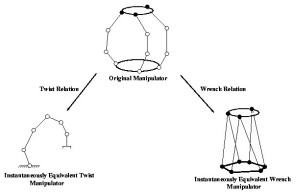
- The need to move moderately heavy loads keeping them horizontally
- Two serial arrays of tilt-pan motion generators are used
- None of these. A preliminary design is reported
- SCARA motions for moderately heavy loads can be produced with a structure stiffer than current SCARA systems



Analytic Jacobian of In-Parallel Manipulators

D. Kim, W. K. Chung and Y. Youm
Pohang University of Science & Technology (POSTECH)

- A consistent formulation of (inverse) Jacobian matrix.
- Reciprocal screw relation is used.
- Analytic expression of reciprocal screw is developed.
- Any (6-DOF) manipulator can be analyzed consistently.



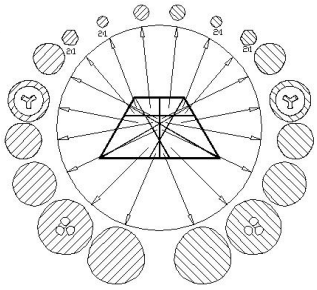
Determination of the Carriage Stroke of 6-PSS Parallel Manipulators having the Specific Orientation Capability in a Prescribed Workspace

T. Huang[1], B. Jiang[1] and D. J. Whitehouse[2]
[1]Tianjin University and [2]University of Warwick

On the Optimum Design of Planar 3-DOF Parallel Manipulators with Respect to the Workspace

Xinjun Liu, Zhenlin Jin and Feng Gao
Yanshan University

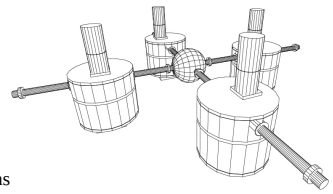
- In the field of optimal design of parallel manipulators, two problems are distinguished: performance evaluation and synthesis. The second problem is to determine the geometry of the manipulator. The classical methods of optimal design, like the cost-function approach, have difficulties to deal with this problem. Many factors, such as workspace, dexterity, singularity, stiffness, are involved in the process of optimal design of manipulators. The major obscure in this process is how to illustrate the relationships, from which we can determine the link lengths of manipulators, between the performance criteria and the link lengths of manipulators.
- The paper presents a useful design tool, the physical model of the solution space, which can be used to express the relationships between the performance criteria and the link lengths of manipulators. Then the performance atlases, which are useful for the designer to design robots, can be obtained.
- The workspace for planar 3-DOF parallel manipulators is investigated in the design tool, and the performance atlases for workspace volume and workspace shape are obtained. The results are useful for the design of the parallel manipulators
- The results show when the workspace volume and workspace shape for planar 3-DOF parallel manipulators can reach optimal result. The technique used in this paper can also used to study other performance criteria and the optimal design of other serial or parallel manipulators.



On the Stability Conditions for a Class of Parallel Manipulators

M. M. Svinin[1], K. Ueda[1] and M. Uchiyama[2]
[1]Kobe University and [2]Tohoku University

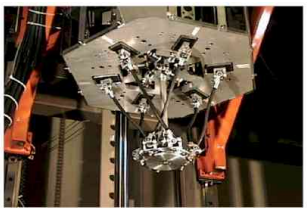
- Stiffness and stability of force distributions
- Conditions for symmetry of the stiffness matrix
- Center of stiffness and conditions for stability
- Stabilizability of unstable distributions in singular configurations



Workspace Analysis of the ParaDex Robot– a novel, Closed-Chain Kinematically-Redundant Manipulator

Y. Wang[1], W. S. Newman[1] and R. S. Stoughton[2]
[1]Case Western Reserve University and [2]MicroDexterity Systems, Inc.

- Motivation: new parallel-mechanism design has complex workspace
- Approach: develop fast collision-detection algorithms for this robot
- Results: can evaluate poses within 0.5ms on PC
- Conclusions: the C-space is complex, but manageable



Manufacturing Scheduling
Chairs: Angela Di Febbraro, Li-chen Fu

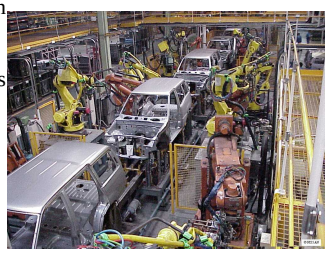
Advanced Scheduling Methodologies for Flexible Manufacturing Systems using Petri Nets and Heuristic Search

A. Moro[1], H. Yu[2] and G. Kelleher[1]
[1]Liverpool John Moores University and [2]Exeter University

Local Search Heuristics For the Assembly Line Balancing Problem With Incompatibilities Between Tasks

J. Bautista, R. Suarez, M. Mateo and R. Companys
Institut d'Organitzacio i Control de Sistemes Industrials (UPC)

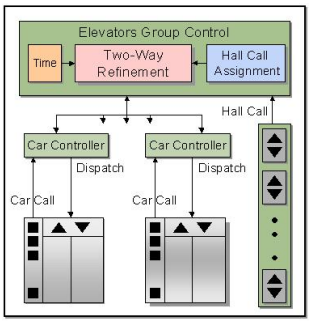
- Greedy heuristics and exploration of search space.
- Proposal: GRWASP for decisions plus GA for local search.
- Neighborhoods in algorithm: problem space, heuristic space.
- Results: GA and GRWASP generally better than others.



Dynamic Scheduling Approach to Group Control of Elevator Systems with Learning Ability

Y. W. Ho and L. C. Fu
National Taiwan University

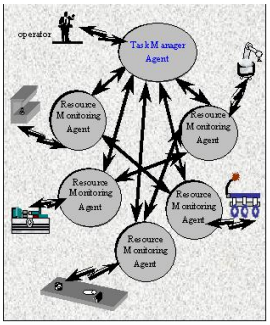
- Dispatch and schedule elevators to serve hall calls and car calls.
- Use Petri-Net for modeling tools & back-propagation network for learning ability.
- Develope a simulation environment to demonstrate the superiority of this method.
- Proposed a dynamic scheduling strategy to schedule an elevator system in real time.



Multi-Agent Architecture for Distributed Monitoring in Flexible Manufacturing Systems (FMS)

D. Ouelhadj[1], C. Hanachi[2] and B. Bouzouia[3]
[1]Worcester, UK, [2]Universite de Toulouse and [3]Centre de Developpement des Technologies Avancees, Algeria

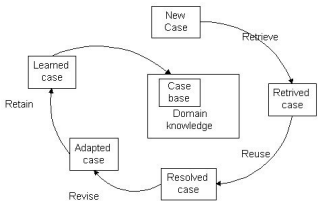
- Decentralization of monitoring systems in FMS
- Multi-agent approach
- Simulation results demonstrated feasibility & potentiality of the approach
- Main advantages: Flexilbility, heterogeneity, autonomy, robustness, adaptability



Maintenance of Robotic Systems using Hypermedia and Case-Based Reasoning

R. M. Crowder[1], R. McKendrick[2], R. Rowe[3], E. Auriol[4] and M. Tellefsen[5]
[1]University of Southampton, [2]IT Innovations, [3]Mulitcosm, [4]Acknosoft, and [5]Odense Steel Shipyard Ltd.

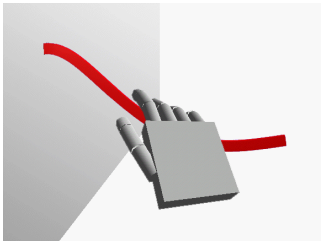
- Supporting the world's largest robot welding cell
- Combining CBR with hypermedia
- Integration of information across the factory
- Measurable reduction in locating information



Haptic Interface 1
Chairs: John Canny, Tim Salcudean

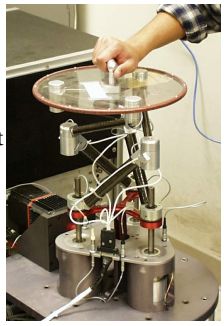
Haptic Interaction with Global Deformations
Y. Zhuang and J. Canny
University of California, Berkeley

- Global deformations
- Nonlinear FEM
- Efficient collision
- Haptic interpolation



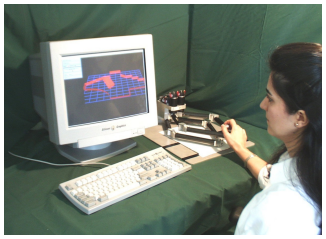
Environment Delay in Haptic Systems
B. Miller, E. Colgate and R. Freeman
Northwestern University

- Stable Haptic Systems with Environment Delay
- Admittance versus Impedance Environment Design
- Passive Display of Delayed Virtual Wall
- Optimal Virtual Coupling Design



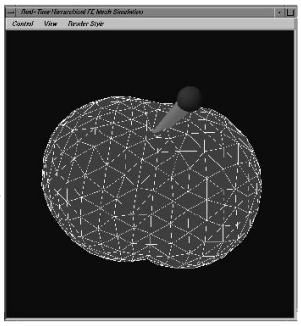
Haptic Rendering of Planar Rigid-Body Motion using a Redundant Parallel Mechanism
D. Constantinescu, I. Chau, S. P. DiMaio, L. Filipozzi, S. E. Salcudean and F. Ghassemi
University of British Columbia

- Haptic rendering of planar rigid body motion is considered.
- Two level collision detection with passive penalty methods are used.
- Various virtual walls and dry friction models were compared.
- Reset-integrator friction model successful at rendering dry friction.



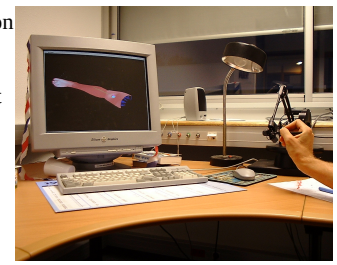
Design Constraints for haptic Surgery Simulation
O. Astley and V. Hayward
McGill University

- A fundamental challenge for haptic surgery simulation is to achieve update rates for the simulation of deformable objects that are acceptable to the human haptic system.
- Nine observations are made to motivate a hierarchical finite element mesh structure that relies on the notion of equivalent meshes.
- In essence, the update rate is a tradeoff problem. As an example, updates rates up to 100Hz were obtained for a 430 nodes mesh on a R10000.
- Future papers will describe these results in more detail.



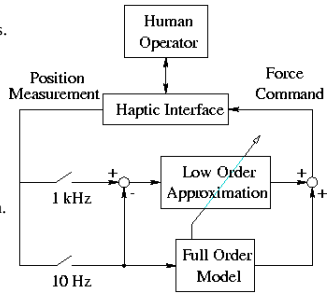
A Haptic Interface for a Virtual Exam of the Human Thigh
D. d'Aulignac, R. Balaniuk and C. Laugier
INRIA, Rhone-Alpes

- Discordance between simulation and haptic frequency.
- Local approximation of contact through buffer model.
- Physical simulation can run at lower frequency.
- More realistic haptic sensation.



Multirate simulation for high fidelity haptic interaction with deformable objects in virtual environments
Murat Cenk Cavusoglu[1] and Frank Tendick[2]
[1]University of California at Berkeley and [2]University of California at San Francisco

- Application: Haptic interaction with deformable objects in virtual environments.
- Problem: Difference between the sampling rate requirements of the haptic interfaces (1kHz) and the update rates of the physical models being manipulated (10Hz).
- Method: Proposed a multirate simulation approach with a local linear approximation. Performed a detailed analysis and experimental verification of the approach.
- Results: Improved fidelity and stability.

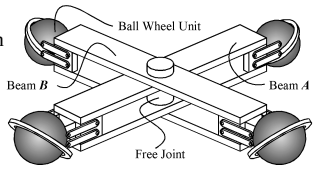


Mobile Vehicle Mechanics
Chairs: Matt Mason, Karim A. Tahboub

Dynamics Analysis and Control of Holonomic Vehicle with a Continuously Variable Transmission

K. A. Tahboub[2] and H. H. Asada
[1]Massachusetts Institute of Technology and [2]Palestine Polytechnic Institute

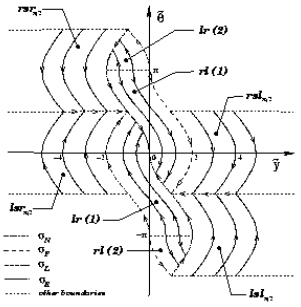
- Ball Wheel Mechanism
- Continuously Variable Transmission
- Stability Augmentation... Optimum Power Consumption
- Adaptive Friction-Compensation Control



Optimal feedback control for route tracking with a bounded-curvature vehicle

P. Soueres[1], A. Balluchi[2] and A. Bicchi[3]
[1]LAAS-CNRS, [2]PARADES E.E.I.G. and [3]University di Pisa

- We propose an optimal feedback control for Dubins' model of a car to follow straight routes.
- The control design is based on Pontryagin's Maximum Principle completed by global geometric arguments. The controller is then expressed within the hybrid control framework.
- Experimental results are reported, showing the real-time feasibility of the proposed approach.



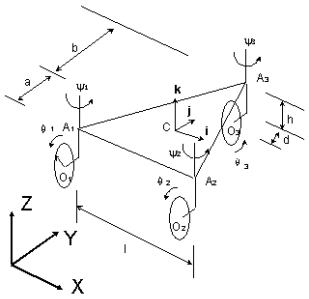
Extremal Trajectories for Bounded Velocity Differential Drive Robots

D. J. Balkcom and M. T. Mason
Carnegie Mellon University

The Kinematics for Redundantly Actuated Omni-directional Mobile Robots

B. J. Yi[1] and W. K. Kim[2]
[1]Hanyang University and [2]Korea University

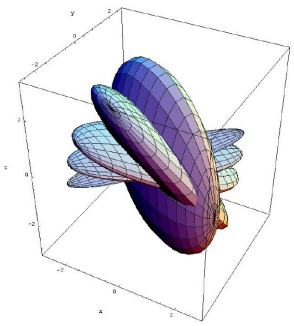
- Motivation and Problem Statement: Lack of exact kinematic modeling of omni-directional mobile robots, no analysis on employment of redundant actuation
- Techniques and Proposed Approach: Apply kinematic modeling approaches employed in Parallel Robot, load distribution method to minimize singularity, lessen actuation effort, and employ several subtasks
- Simulation Results: Load Distribution (Minimum versus Redundant Actuation), subtasks employing internal load distribution
- Conclusions: Provides the exact kinematic model, singularity analysis, its associated load distribution for redundantly actuated omni-directional mobile robot



Instantaneous Kinematics and Dexterity of Mobile Manipulators

Krzysztof Tchon and Robert Muszynski
Wroclaw University of Technology

- Kinematic dexterity evaluation of mobile manipulators patterned on the existing theory for robotic manipulators and mobile robots.
- Control system representation of the kinematics and a control-theoretic approach.
- Computation of dexterity ellipsoids for exemplary mobile manipulators.
- New tools for analysis of mobile manipulators applicable in motion planning and control.



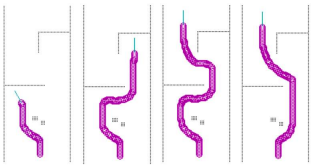
Time Optimal Trajectories for Bounded Velocity Differential Drive Robots

D. J. Balkcom and M. T. Mason
Carnegie Mellon University

Mapping and Localization 2
Chairs: Hugh Durrant-Whyte, Bijoy K. Ghosh

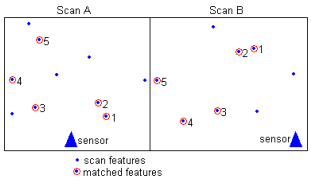
VFH*: Local obstacle Avoidance with look-ahead verification
Iwan Ulrich and Johann Borenstein
The University of Michigan

- Real-Time Obstacle Avoidance for Mobile Robots
- Improvement to VFH (Vector Field Histogram)
- Look-Ahead Verification with A* Search
- Better Performance Even with Short Search Depth



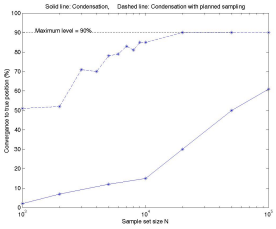
Data Association for Mobile Robot Navigation: A Graph Theoretic Approach
T. Bailey, E. Nebot, J. Rosenblatt and H. F. Durrant-Whyte
University of Sydney

- Want feature mapping robust to vehicle pose errors.
- Use the invariant relative geometry between features.
- Experiment using range laser with indoor & outdoor vehicles.
- Obtained reliable association, reject false and dynamic features, using no vehicle model.



Experiments on Augmenting Condensation for Mobile Robot Localization
P. Jensfelt, O. Wijk, D. Austin and M. Andersson
Royal Institute of Technology

- Feature based mobile robot localization
- Augmenting condensation with planned sampling
- A substantial reduction in sample set size
- Localization in large scale environments can be handled with a small sample set size

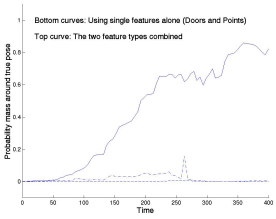


Improving the accuracy of dynamic localization systems using RTK GPS by identifying the GPS latency
D. Bouvet and G. Garcia
Institut de Recherche en Cybernetique de Nantes (IRCyN)

- Motivation: using RTK GPS for precise localization of outdoor vehicles
- The unknown GPS latency depends on the number of visible satellites
- Observability analysis helps define the protocol to identify the latency
- Validation on a mobile robot

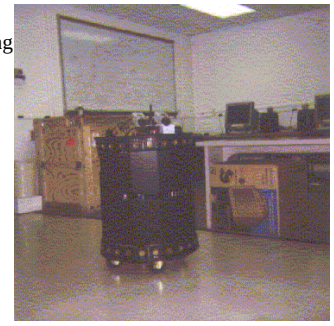
Feature Based Condensation for Mobile Robot Localization
P. Jensfelt, D. Austin, O. Wijk and M. Andersson
Royal Institute of Technology

- Feature based mobile robot localization
- A comparance between different features for localization
- Use features extracted from different sensors
- More than one feature type is needed



Line Segment Based Map Building and Localization Using 2D Laser rangefinder
L. Zhang and B. K. Ghosh
Washington University, St. Louis

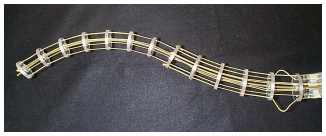
- Systematical and efficient mapping and localization with laser
- Line segment based closed map and localization
- Accurate map, fast local and global localization (4ms, 20ms)
- Proposed techniques are good for real applications



Redundancy
Chairs: Greg Chirikjian, Ian D. Walker

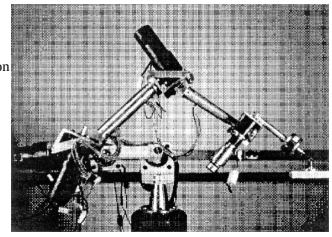
On the kinematics of remotely-actuated continuum robots
Ian A. Gravagne and Ian D. Walker
Clemson University

- Investigate the Kinematics of Trunk and Tentacle-like Robots
- Concentrate on Manipulators with Continuous Backbones
- Discuss Intricacies of Remote Actuation
- Images of Prototype Robots in the Laboratory



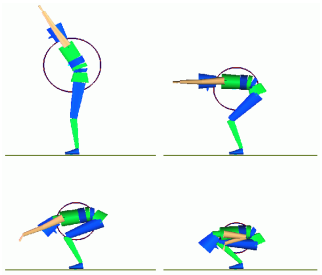
A Numerical Evaluation of the Workspace of Rediestro, A Redundant Manipulators
Marco Ceccarelli[1] and Jorge Angeles[2]
[1]Universit degli Studi di Cassino and [2]McGill University

- What is the effect of kinematic isotropy conditions on the workspace capability of a manipulator
- The workspace of Rediestro, a redundant manipulator, has been analyzed using transformation matrices and a binary representation of the scanning mobility.
- The workspace of Rediestro has been determined and the effect of design parameters has been evaluated
- The paper focuses on Rediestro, but gives insight on the relations between workspace and kinematic isotropy of a much broader scope.



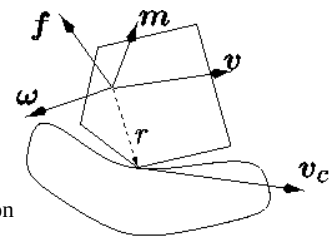
Kinematic Control of the Mass Properties of Redundant Articulated Bodies
P. Baerlocher and R. Boulic
EPFL

- Control of the center of mass and moments of inertia.
- Inverse kinematics is applied to these mass properties.
- Simulation examples with 2D chains and a human figure.
- Useful for static balance and mass distribution control.



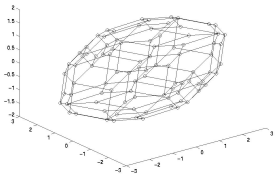
Gauss' Principle and the Dynamics of Redundant and Constrained Manipulators
Herman Bruyninckx[1] and Oussama Khatib[2]
[1]Katholieke Universiteit Leuven and [2]Stanford University

- More efficient algorithm for constrained robots
- Based on Gauss' Principle of Least Constraint
- Allows linear-time algorithms
- Applicable to compliant motion and redundant robots



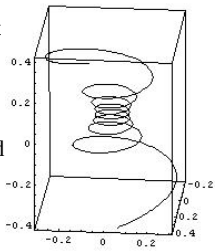
A Recursive Dimension-Growing Method for Computing Robotic Manipulability Polytope
Y. S. Hwang[1], J. Lee[2] and T. C. Hsia[1]
[1]University of California, Davis and [2]Chung-nam University, Korea

- Efficient computing of robotic manipulability polytope
- A recursive algorithm based on Dimension-Growing
- Substantial computation time reduction for higher DOF robot
- Can extend the method to compute robot dynamics for real time control



Instability of pseudoinverse acceleration control of redundant mechanisms
Y. C. Chen and Kevin O'Neil
University of Tulsa

- Min. norm acceleration control of redundant mechanisms:
- unstable near kinematic singularities
- Characteristics of the instability are analyzed
- Stabilization by nullspace accelerations possible

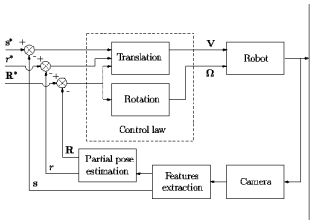


Real-Time Visual Servoing and Tracking
Organizers & Chairs: Peter Corke, Seth Hutchinson

Real-Time Vision, Tracking and Control
P. I. Corke[1] and S. A. Hutchinson[2]
[1]CSIRO, Australia and [2]University of Illinois at Urbana-Champaign

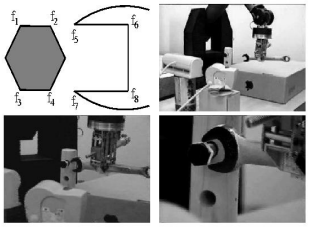
2 1/2 D visual servoing: a possible solution to improve image-based and position-based visual servoings
F. Chaumette[1] and E. Malis[2]
[1]IRISA / INRIA Rennes and [2]Cambridge University

- Description of potential problems in visual servoing
- 2 1/2 D visual servoing: a promising approach
- Presentation of 2 control schemes
- Advantages/drawbacks



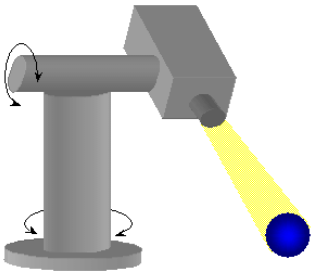
On Specifying and Performing Visual Tasks with Qualitative Object Models
G. D. Hager[1] and Z. Dodds[2]
[1]Johns Hopkins University and [2]Harvey Mudd College

- Object and camera uncertainty limit hand/eye abilities.
- We present limitation-respecting task languages.
- Several tasks are shown using weak object models.
- Guarantees are possible even without full knowledge.



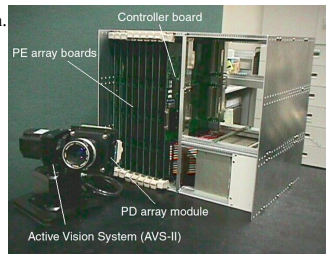
Real-Time Vision, Tracking and Control - Dynamics of Visual Servoing
Markus Vincze
Vienna University of Technology

- What is the
- Best performance is expressed as maximum image pixel error (=prop. to max. velocity of target)
- Result 1: use architecture for parallel image acquisition and processing
- Result 2: use high-speed camera and small image windows



1 ms column parallel vision system and its application of high speed target tracking
Y. Nakabo[1], M. Ishikawa[1], H. Toyoda[2] and S. Mizuno[2]
[1]University of Tokyo and [2]Hamamatsu Photonics K. K.

- We realized a high speed visual feedback system with 128x128 resolution.
- Column parallel data transfer and all parallel image processing enable the system to work at 1ms cycle time.
- We present a high speed target tracking and some results of image processing.
- Advantages of our system design for robot control applications are discussed.



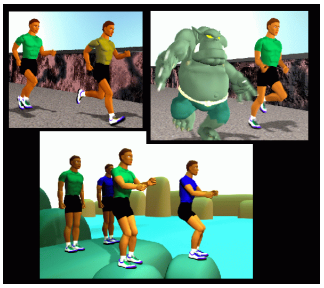
Dynamic Simulation of Humanoid Motion
Organizers & Chairs: Jessica Hodgins, Nancy Pollard

Simulating Leaping, Tumbling, Landing, and Balancing Humans
W. L. Wooten[1] and J. K. Hodgins[2]
[1]Pixar Animation Studios and [2]Georgia Institute of Technology

- Describe methods for automatically generating animated behaviors using dynamic simulation
- Behaviors are generated with transitions between parameterized basis controllers
- Four basis controllers created broad jumps, standing jumps, somersaults, and platform dives
- Parameterized basis controllers are useful in creating complex, dynamically simulated behaviors

Interactive, Force-Based Motion Editing for Locomotion Tasks
N. S. Pollard and F. Behmaram-Mosavat
Brown University

- Goal: realistically alter motion sequences
- Approach: analytic scaling of ground forces
- New runs and jumps, new characters
- Basic physical constraints are maintained

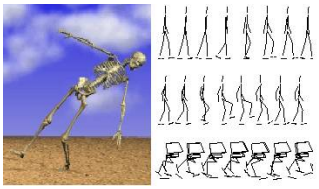


Editing Dynamic Properties of Captured Human Motion
Z. Popovic
University of Washington

Dynamic Simulation of Human Movement Using Large-Scale Models of the Body
M. G. Pandy and F. C. Anderson
University of Texas, Austin

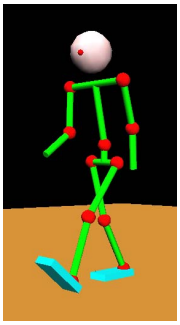
Towards Agile Animated Characters
M. Van de Panne, J. Lazlo, P. Huang and P. Faloutsos
University of Toronto

- Skills for dynamically simulated smart characters
- Methods: limit cycle control, finite horizon planning
- Results: walking, falling, hopping, flipping
- Animation and robotics share many goals



Dynamic Filter - Concept and Implementation of On-Line Generator for Human Figures
K. Yamane and Y. Nakamura
University of Tokyo

- Dynamics filter: a motion generator that converts a physically inconsistent motion into a consistent one to minimize the size of database required to generate human-like motions for human figures.
- Apply stabilizing feedback control and local optimization based on the equation of motion
- Various motions including those in different environment were created from motion capture data
- Dynamics filter proved to be effective in generating a variety of motions from a small set of motions



Industrial Robots
Organizers & Chairs: Hadi Akeel, Steve Holland

Product and Technology Trends for Industrial Robotics
Hadi A. Akeel[1] and Steven W. Holland[2]
[1]FANUC Berkeley Laboratory and [2]General Motors Corporation

Robot Mechanisms
Brian Carlisle
Adept Technology Inc.

- Classes of robot mechanisms are reviewed.
- Examples of various robot mechanisms are provided.
- Technology constraints on robot mechanism design are discussed.
- Areas for technology development are presented.

Robotics: The Future is so Bright
Craig Jennings
Motoman Robotics

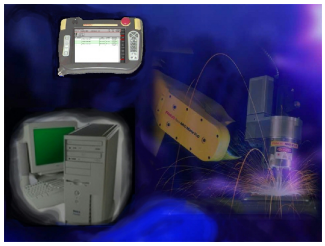
- Robot Industry is Soaring
- Robot Technology Advancements
- Movement Toward Total Robot Solutions
- New Robot Markets Expanding

Underwater Robotics: Out of the Research Laboratory and Into the Field
Louis L. Whitcomb
Johns Hopkins University

- Survey of commercial underwater robotics.
- Industry demands two new classes of underwater vehicles:
- - Deep-diving work-class remotely operated vehicles.
- - Survey-class autonomous vehicles.

The PC and its Influence on Robot Controllers
Gary Rutledge
FANUC Robotics

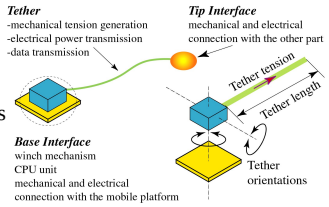
- What has been the impact of PC's on robot controller design?
- Compare the architectures of several controllers.
- Most robot controllers follow a similar architecture.
- The PC augmented controller architecture is most common.



Legged Locomotion 1
Chairs: H. Kimura, Dan Koditschek

A New Flexible Component for Field Robotic System
E. F. Fukushima, N. Kitamura and S. Hirose
Tokyo Institute of Technology

- Tethers have been used for a long time.
- Basic hardware device shown in Figure is introduced.
- A tether/winch basic experiments were conducted.
- A multi-purpose hyper-tether basic device is to be available soon.

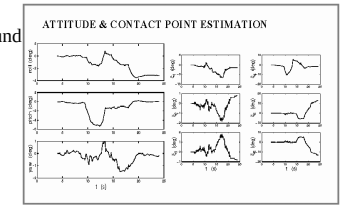


Design, Modeling and Preliminary Control of a Compliant Hexapod Robot
U. Saranli[1], M. Buehler[2] and D. E. Koditschek[1]
[1]University of Michigan and [2]McGill University

- Biomimetic control of a hexapod robot under dynamically dextrous operation
- Open-loop control strategies implement an alternating tripod gait
- Stable running and turning both in simulation and experiments at speeds up to 0.5 m/s
- Autonomous and fast locomotion over rough terrain achieved even without feedback

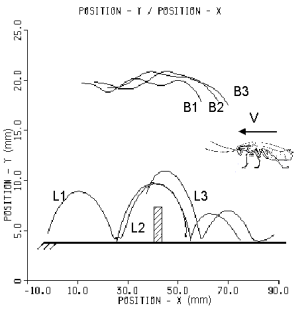
Kinematic Observers for Articulated Rovers
J. Balaram
California Institute of Technology

- Improved State Estimation
- Nonlinear Kinematics; Wheel-Ground Contact Point Estimation; Complementary Filtering
- Results from Simulation & Mars Yard Experiments
- Refined State Estimation Using Nonlinear Kinematics



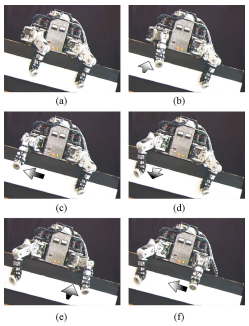
Kinematographic Experiments on Leg Movements and Body Trajectories of Cockroach Walking on Different Terrain
S. Bai, K. H. Low and W. Guo
Nanyang Technological University

- Moving patterns of cockroaches walking on un-even terrains
- Filming the movement of cockroaches by two sets of high speed cameras
- Identification of the changes in body and leg position.
- Potential application in gait planning and motion control of walking machines.



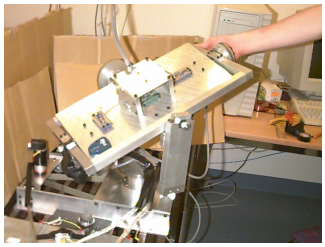
Hugging Walk
M. Kaneko, T. Shirai and T. Tsuji
Hiroshima University

- Motivation: Proposing hugging style walk with multiple contacts
- Problem: For a given set of joint torque, obtain resultant force sets.
- Result: Two indecies for evaluating robustness against disturbance.
- Conclusion: Hagging walk contributes to increasing robustness.



Nonlinear Pitch and Roll Estimation for Walking Robots
H. Rehbinder and X. Hu
Royal Institute of Technology

- The problem of drift free pitch and roll estimation for a walking robot is studied.
- An exponentially convergent high-gain observer is used to fuse sensor data from a two-axis inclinometer and three rate gyros.
- The observer is evaluated with a tailormade rotating test platform capable of 3DOF rotations.
- The drift of integrated gyros and the low bandwidth of inclinometers can be compensated for by a theoretically sound algorithm.

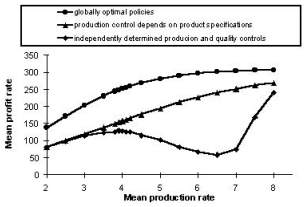


Production Control
Chairs: Fabio Balduzzi, T. Kesavadas

Optimal control law for lot-sizing in a single production facility
A. Di Febbraro[2], R. Minciardi[1] and S. Sacone[1]
[1]University of Genova and [2]Politecnico de Torino

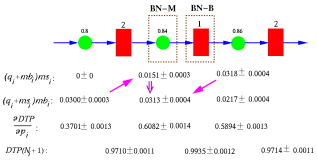
Design of Product Specifications and Control Policies in a Single-Stage Production System
Vassilis Kouikoglou and Yannis Phillis
Technical University of Crete

- Coordinated production/quality control for profit maximization
- Use of queueing and Taguchi methods for cost/revenue estimation
- Coordinated policies yield higher profits than independent ones
- Future work: application to more complex systems



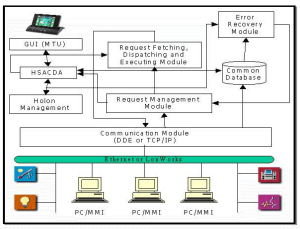
Bottlenecks with respect to Due-Time Performance in Pull Serial Production Lines
J. Li and S. M. Meerkov
The University of Michigan

- Due-Time Performance (DTP) is the probability to ship to the customer a desired number of parts during a fixed time interval.
- Bottleneck (BN) is the machine that impedes DTP in the strongest manner.
- A method for DTP-BN identification is developed using the data on machine blockages and starvations.
- The results can be used for supply chain management.



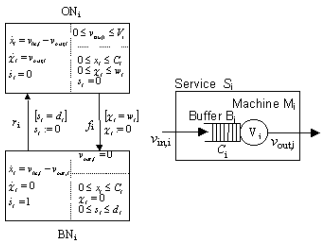
Holonic Supervisory Control and Data Acquisition Kernel for 21st Century Intelligent Building System
T. J. Shih and L. C. Fu
National Taiwan University

- Develop a control kernel for rapidly constructing message exchange architecture for modern building
- Provide an agile SCADA mechanism (Holonic SCADA)
- System commands and messages exchange under DDE and Ethernet channels
- A prototype of HSCADA mechanism has the features: Flexible, scalable, re-configurable, and easy integration by SROCK



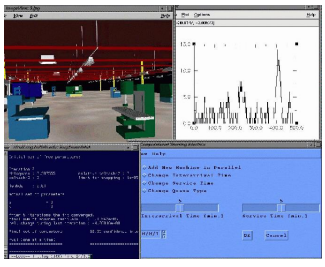
Fluid Models and Hybrid Automata in Manufacturing
F. Balduzzi
Politecnico di Torino

- Modeling and control of automated manufacturing systems with hybrid automata
- Modular composition of elementary services
- Verification of the system requirements via reachability analysis
- Solutions obtained in terms of the timing information associated with the verification problem



Interactive Simulation of Manufacturing Systems using Computational Steering
T. Kesavadas and A. Sudhir
State University of New York, Buffalo

- To develop a more efficient methodology for carrying out manufacturing simulation
- An interactive approach to simulation using computational steering and visualization
- Results show that using this technique, we can reduce queue overflow and identify possible bottleneck machines
- This approach is useful in running large simulations and lends itself to parallel processing



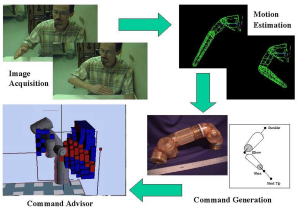
Teleoperation 2
Chairs: Claudio Melchiorri, Yasuyoshi Yokokohji

Modeling, Control and Optimization of a New Tele Robot
A. Schlotter and F. Pfeiffer
Technische Universitaet Muenchen

- Elastic multibody model of a tele robot with new kinematic concept
- Development and implementation of a model-based feedback linearization control
- Optimization of control parameters and of free and geometric prescribed trajectories
- Verification by experimental results

An Intelligent Vision-only Operator Interface for Dextrous Robots
P. Fiorini[1], G. Chalfant[1], Y. Tsumaki[2], E. Di Bernardo[1] and P. Perona[1]
[1]California Institute of Technology and [2]Tohuku University

- Provide non-contact command and feedback in dexterous teleoperation
- Visual tracking of operator's arm and kinematics visualization
- Developed an off-line demonstrator of tracking and visual feedback
- Next step: real-time vision-only operator interface.

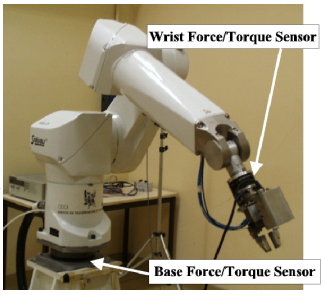


A Method for Simultaneously Increasing Transparency and Stability Robustness in Bilateral Telemanipulation
J. E. Speich, K. Fite and M. Goldfarb
Vanderbilt University

- An Introduction to Bilateral Telemanipulation Control Architectures
- Transparency and Stability in a Two-Channel Position-Force Architecture
- A Dynamic Compensator which Simultaneously Increases Transparency Bandwidth and Stability Robustness
- A Single DOF Numerical Example

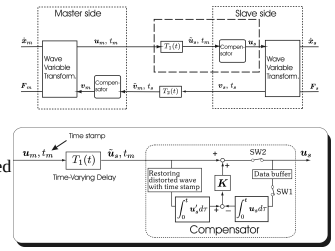
On the Use of a Base Force/Torque Sensor in Teleoperation
F. Geffard, C. Andriot, A. Micaelli[1] and G. Morel[2]
[1]CEA and [2]ENSPS- LSIIT

- Improving transparency and safety of bilateral teleoperation
- Passivity based comparison of a wrist and a base force/torque sensor solution
- Experimental tests on an industrial manipulator
- Base force/torque sensor solution better improves friction rejection



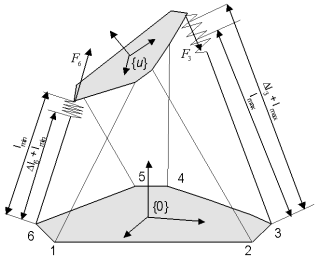
Bilateral Control with Energy Balance Monitoring under Time-Varying Communication Delay
Y. Yokokohji, T. Imaida and T. Yoshikawa
Kyoto University

- Time-varying delay degrades the performance of wave-variable-based teleoperator.
- Compensation of position drift by modifying the waveforms within the limit of energy margin.
- Compromised behavior between performance and safety was demonstrated by the simulation.
- The method is simple and easy to implement. Passivity was guaranteed even under the time-varying delay.



On the Use of Virtual Springs to Avoid Singularities and Workspace Boundaries in Force-Feedback Teleoperation
A. Rubio[1], A. Avello[1] and J. Florez[2]
[1]CEIT and [2]Universidad de Navarra

- Reaching the end of the workspace of the master or the slave robots makes teleoperation difficult for operator
- Several virtual springs exert a force to avoid the master robot to get into the proximity of a singularity or out of its workspace. The proximity to a singularity is measured by the condition number of a modified Jacobian.
- The behavior of the virtual force feedback is quite intuitive for the operator and does not have to care about the particular position of the manipulator.
- Virtual springs has proven to be very useful and can be easily implemented in any robot.

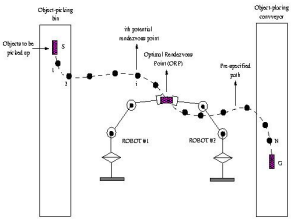


Robotics Cooperation 1
Chairs: Rachid Alami, Tucker Balch

Multi-Robot Target Acquisition using Multiple Objective Behavior Coordination
P. Pirjanian and M. Mataric
University of Southern California

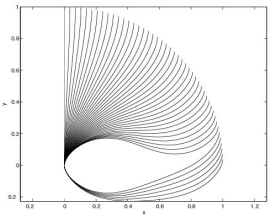
Time-Optimal Rendezvous Planning for Pick-an-Place Task Sharing
M. Mehrandezh and K. Gupta
Simon Fraser University

- Novel concept of sequential task sharing (STS) – like passing a baton in a relay race – for two co-operating robots in assembly
- Finding the time-optimal rendezvous point between two robots in STS mode
- Sample results for two 2-dof robotic manipulators
- STS results in an over 100



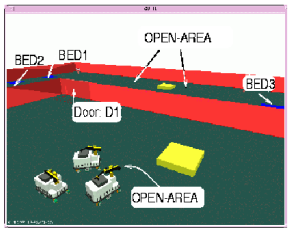
Designing Motion Guides for Ergonomic Collaborative Manipulation
K. Lynch and C. Liu
Northwestern University

- Design of passive guide constraints for ergonomic material handling.
- Optimal control theory and sequential quadratic programming.
- The objective function defines iso-cost force ellipses in the human frame.
- There are two distinct types of motion guides for an infinite weight ratio.


The two kinds of optimal guides to points on a unit circle for an infinite weight ratio

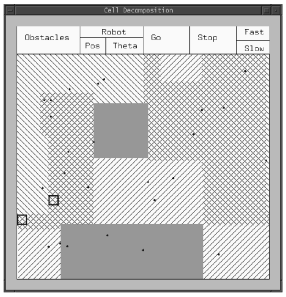
A multi-robot cooperative task achievement system
S. C. Botelho and R. Alami
LAAS/CNRS

- A general architecture for multi-robot cooperation
- Combination of individual planning and coordinated decision
- Illustrated by a simulated system
- Robots that cooperatively enhance their plans



Cooperative Coverage of Rectilinear Environments
Zack J. Butler, Alfred A. Rizzi and Ralph L. Hollis
Carnegie Mellon University

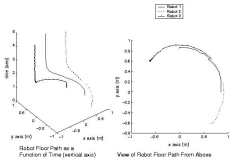
- Sensor-based coverage algorithm
- Cooperation methodolgy
- Completeness proof outline
- Implementation



Covered by robot 0 robot 1 both

A Decentralized Approach to Elementary Formation Maneuvers
J. Lawton, B. Young and R. Beard
Brigham Young University

- Hilare Robot Testbed
- Formation Control
- Passivity-Based Extension
- Hardware Results

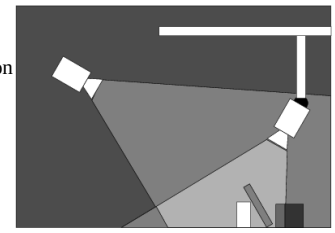


Visual Servoing 2
Chairs: Francois Chaumette, Henrik Christensen

Robust Vision-Based Pose Control
C. Taylor and J. Ostrowski
University of Pennsylvania

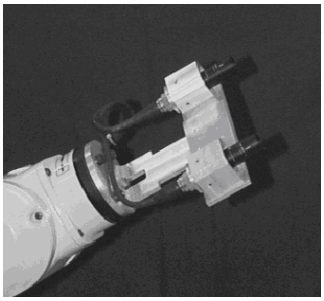
Eye-in-hand/Eye-to-hand Cooperation for Visual Servoing
Gregory Flandin, Francois Chaumette and Eric Marchand
IRISA - Campus Universitaire de Beaulieu

- Cooperation of Global and Local Cameras
- Solutions are based on perturbation estimation and task redundancy
- They are compared thanks to experimental results
- The stability was proved and confirmed with experimentations



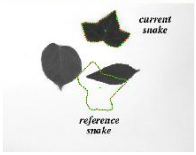
A Novel Visual Servoing with Stereo Cameras using QR Decomposition and Disturbance Observer
J. S. Lee[1], I. H. Suh[2], B. J. You[1] and S. R. Oh[1]
[1]Korea Insitute of Science and Technology and [2]Hanyang University

- A novel visual servoing approach is proposed by adopting disturbance observer and QR decomposition.
- QR decomposition factors any image Jacobian into a unitary matrix and an upper triangular matrix.
- Disturbance observer compensates errors induced in block diagonalization of the upper triangular matrix.
- Block diagonalized triangular matrix improves performance indices such as measurement sensitivity of image features, control sensitivity and controllability.



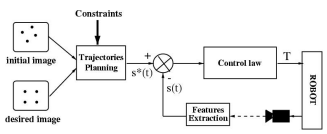
Automatic Segmentation and Matching of Planar Contours for Visual Servoing
G. Chesi[1], E. Malis[2] and R. Cipolla[2]
[1]Universita di Siena and [2]University of Cambridge

- This work concerns visual servoing with respect to planar contours without any a priori knowledge of them shape.
- Matching is done together with the estimation of the homography matrix between a target and current view of the contour. Then, a 2 1/2 D visual servoing technique is used to reposition the end-effector of the robot at the target position.
- The system has been successfully tested on several contours with very complex shapes such as leaves, keys and the coastal outlines of islands. The experiments show that the system can position the robot end-effector with a great precision even for large camera displacements.
- In order to simplify the matching problem, the only hypotheses made here are that the contour is planar and that occlusions can occur only during the tracking stage. Future work will be devoted to matching planar objects with occlusion.



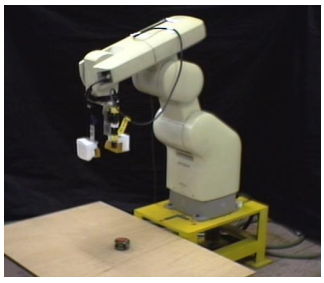
Path Planning in Image Space for Robust Visual Servoing
Youcef Mezouar and Francois Chaumette
IRISA - Campus Universitaire de Beaulieu

- Path planning in image space coupled to Image-based Servoing
- Robust wrt calibration errors for any initial position
- We obtain a satisfactory 3D camera trajectory
- and all the object remains in the camera field of view



Potential Switching Control in Visual Servo
K. Hashimoto and T. Noritsugu
Okayama University

- Stable region of visual servo – Local
- Potential switching – Enlarge stable region
- Potential plots for 1 DOF and 2 DOF cases
- Visual servoing with 6 DOF robot

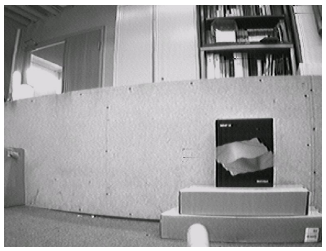


Trajectory Control
Chairs: Alessandro DeLuca, Jadran Lenarcic

Vision-Based Dynamic Estimation and Set-Point Stabilization of Nonholonomic Vehicles

F. Conticelli[1], D. Prattichizzo[2], F. Guidi[3] and A. Bicchi[3]
[1]Scuola Superiore Sant' Anna, [2]University of Siena and [3]University of Pisa

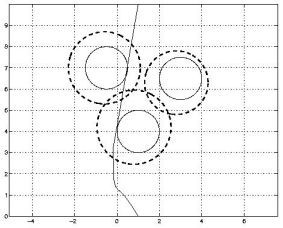
- In this paper, a nonholonomic vehicle is stabilized to a desired pose through a visual servoing technique. The control task consists in regulating the robot pose by using real-time visual data.
- The visual servoing of the nonholonomic vehicle is built through discontinuous change of coordinates and Lyapunov-based design.
- Simulations on an autonomous mobile robot are reported, that show the practicality of the proposed approach.
- Vision-based stabilization may be required in autonomous parking or docking of mobile robots.



Closed loop motion plans for mobile robots

J. M. Esposito and V. Kumar
University of Pennsylvania

- We approach sensor-based planning using a game-theoretic framework
- Rather than synthesize control laws from the space of all functions, we limit our search to specific classes of functions; namely, piecewise linear feedback and a certain type of one parameter feedback laws.
- While our min-max control laws prove optimal under the worst case scenario, the problem does not possess a saddle point solution due to the underlying topology of the problem.
- These feedback laws enable the robot to actively exploit the dynamics of the given sensor model.



Impedance Fields for Trajectory Enhancement in the Intelligent Assist Device

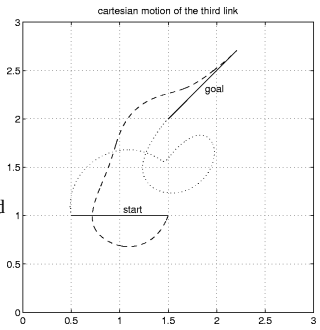
G. R. Luecke, K. L. Tan and N. Zafer
Iowa State University

- Motion Augmentation In Heavy Lift Assist Devices
- Human Force Input Controls General Motion
- Impedance Fields Guide To Target, Protect Against Collisions
- Intelligent Assist Improves Ergonomics and Safety

Motion Planning and Trajectory Control of an Underactuated Three-Link Robot via Dynamic Feedback Linearization

Alessandro De Luca and Giuseppe Oriolo
Universit di Roma "La Sapienza"

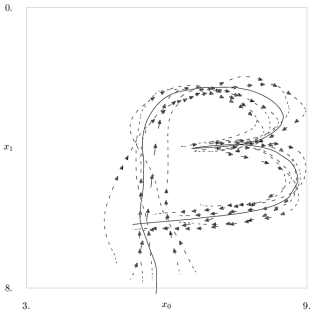
- Motion planning becomes an interpolation problem
- Exponential stabilization of the planned trajectory is straightforward



Trajectory fitting with smoothing splines using velocity information

C. Lee[1] and Y. Xu[2]
[1]Carnegie Mellon University and [2]The Chinese University of Hong Kong

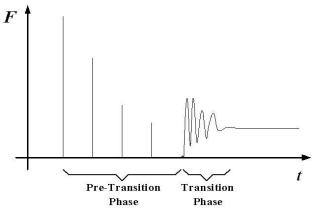
- Problem: find a smooth best-fit trajectory from multiple examples
- Solution: We derive a spline smoother in phase space
- Example: trajectory fit using smoother with principal curves
- Uses: action learning, animation, and recognition



Pre-Transition Phase Control: Three Different Approaches

N. Doh, G. Jeon, W. K. Chung and Y. Youm
Pohang University of Science & Technology (POSTECH)

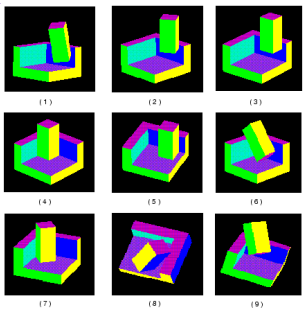
- Hard contact transition control
- Defining Pre-Transition Phase.
- Three different methods for pre-transition phase control.
- Increased performance, stability and robustness.



Constrained Motion Planning and Control
Organizers & Chairs: Jing Xiao, Brendan McCarragher

Constrained Motion Planning and Control: An Overview
Jing Xiao
University of North Carolina - Charlotte

- Motivation and Problems
- Survey of Existing Work
- Challenges Ahead
- Conclusions

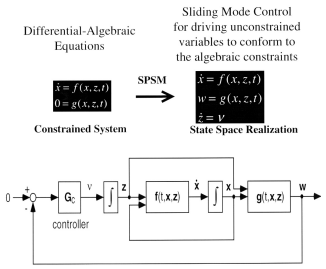


Motion Planning of Objects in Contact by the Silhouette Algorithm
H. Hirukawa[1] and Y. Papegay[2]
[1]Agency of Industrial Science and Technology, Japan and [2]INRIA, Sophia-Antipolis France

Hybrid Dynamic Control and Adaptation of Constrained Manipulation Systems
B. McCarragher
Australian National University

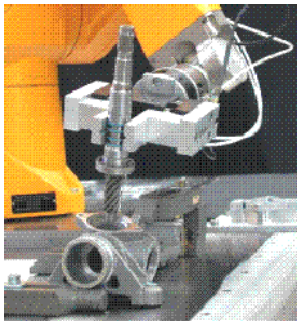
A Unified Approach to Modeling and Realization of Constraint Robot Motion Using Singularity Perturbed Sliding Manifolds
H. H. Asada, B. Gu and B. W. Gordon
Massachusetts Institute of Technology

- A new formalism for dynamic constrained motion
- High-index and highly nonlinear DAE is solved by using the Singularly Perturbed Sliding Manifolds (SPSM) method
- Numerical example of a four-bar linkage formed by a robot arm and a crank is given
- The DAE formalism provides a general, powerful methodology for treating complex, nonlinear behavior of highly coupled robotic systems



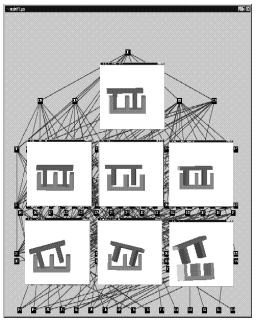
Generating Polyhedral Convex Cones from Contact Graphs for the Identification of Assembly Process States
H. Mosemann[1], T. Bierwirth[1], F. Wahl[1] and S. A. Stoeter[2]
[1]Technical University of Braunschweig and [2]University of Minnesota

- Measured forces and torques provide information about contact geometry of subassemblies
- Automatically generate polyhedral convex cones from contact graphs
- Contacts graphs are calculated for several subassemblies using a rapid interference detection algorithm
- Identification of contacts takes about 0.006 seconds



A Divide-and-merge Approach to Automatic Generation of Contact States and Planning of Contact Motion
J. Xiao and X. Ji
University of North Carolina - Charlotte

- Automatically generate contact state graphs between two arbitrary polyhedra.
- A divide-and-merge approach: divide the graph into subgraphs, automatically generate subgraphs, and merge them together.
- Results: contact state graphs for two arbitrary polyhedra in a contact state of up to three principal contacts (PC).
- Conclusions: the approach is efficient and contact state graphs can simplify contact motion planning by stratification.



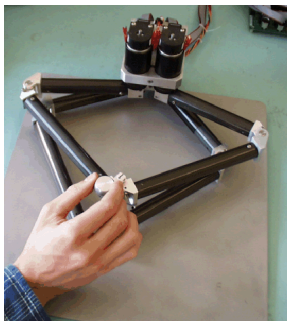
Haptics
Organizers & Chairs: John Hollerbach, Vincent Hayward

Some current Issues in Haptics Research
John Hollerbach
University of Utah

- Mechanical, computational, and application issues that challenge haptics
- Description of the current state of the art
- Explicit examples from virtual prototyping and Treadport locomotion interface projects
- A demonstrated utility of haptics is the most important next step

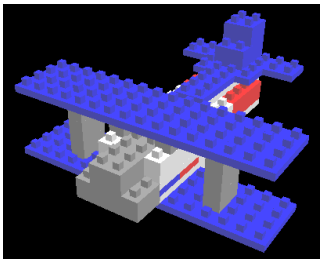
Isotropy and Actuator Optimization in Haptic Interface Design
S. E. Salcudean and L. Stocco
University of British Columbia

- High Performance Needed for a Realistic Haptic Interface
- Design Method for Workspace-Inclusive Isotropy
- Conventional & Maglev Robot Design Examples
- High Stiffness & Acceleration are Obtained



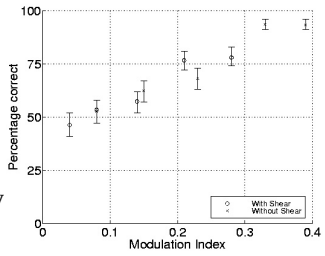
Stable Haptic Interaction Using the Excalibur Force Display
Richard Adams and Blake Hannaford
University of Washington

- Haptic system design often generates trade between stiffness and stability
- Analytic design method based on Llewelyn's stability criterion
- Stability guaranteed for passive virtual environments
- 51,000 N/M coupling stiffness without small or large oscillation in a virtual building blocks environment.



Human Tactile Spatial Sensitivity for Tactile Feedback
G. Moy, U. Singh, E. Tan and R. S. Fearing
University of California, Berkeley

- Test spatial, shear stress, and viscoelastic perception
- Shear stress in tactile display reduces spatial resolution
- Afterimage effects correlate with fingerpad viscoelasticity
- 10



Designing with haptic feedback
Karon MacLean
Interval Research Corp.

- We share insights in what and how haptic feedback is useful in UI design:
- observations on physical interaction and how and why we do it;
- analysis of situations where active touching helps; and
- a model for designing haptic feedback into specific applications.

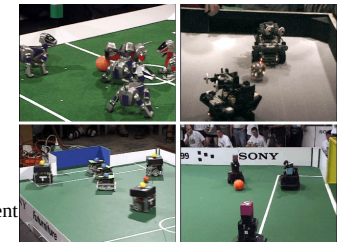
Haptic Interface Control - Design Issues and Experiments with a Planar Device
M. R. Sirouspour, S. P. DiMaio, S. E. Salcudean, P. Abolmaesumi and C. Jones
The University of British Columbia

- The haptic rendering of a virtual environment has been addressed.
- A four-channel teleoperation architecture was proposed for this purpose.
- This method was implemented using a new parallel haptic mechanism and an explicitly modelled virtual environment.
- Good force and position tracking were achieved.

Entertainment
Organizers & Chairs: Minoru Asada, M. Fujita

Robotics in Edutainment
M. Asada[1], R. D'Andrea[2], A. Birk[3], H. Kitano[4] and M. Veloso[5]
[1]Osaka University, [2]Cornell University, [3]Vrije Universiteit Brussel, [4]JST Japan and [5]Carnegie Mellon University

- Issues in Robotics from a viewpoint of Edutainment
- RoboCup, RoboFesta, RoboCup Jr. and so on.
- Robot Competition as System Engineering Course
- A series of robot competitions, education courses, and entertainment applications as a new area of robotics in edutainment.



Digital Creatures for Future Entertainment Robotics
M. Fujita
Sony Corporation

- Motivations for Robot Entertainment
- Descriptions of AIBO
- Some other experiments
- Conclusions

RoboCup Jr.: RoboCup for Edutainment
H. Kitano[1], S. Suzuki[2] and J. Akita[3]
[1]ERATO Kitano Symbiotic Systems Project, JST, Sony Computer Science Laboratories, [2]Osaka University and [3]Kanazawa University

RoboCup Jr. with LEGO Mindstorms
H. H. Lund and L. Pagliarini
University of Aarhus

- Non-expert users to develop complex robot behaviors, e.g. robot soccer players.
- User-guided behavior-based robotics. Developed field & smart, electronic ball, which allowed easy navigation & detection w. LEGO MINDSTORMS robots.
- Avoid the problems with users having to learn a complex syntax and semantics of a traditional programming language.
- Children (age 7-14) able to develop their robot soccer players within 60 minutes.

The Outline of the International Robot Games Festival
E. Nakano[1], M. Asada[2], S. Tadokoro[3], K. Osuka[4], K. Nagai[5], Y. Masutani[2] and H. Kitano[6]
[1]Tohuku University, [2]Osaka University, [3]Kobe University, [4]Kyoto University, [5]Ritsumeikan University, and [6]JST, Japan

- International Robot Games are a good way to develop related technologies and to enhance understanding of science and technology among people.
- RoboFesta 2001 will be held in Japan during the summer and autumn of 2001 in Osaka and Kanagawa, Japan.
- An international forum will be also held

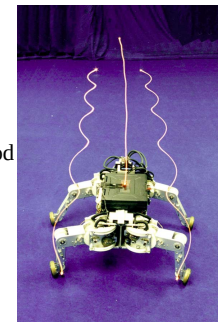
Robot Improv: Using Drama to Create Believable Agents
Allison Bruce, Jonathan Knight and Illah R. Nourbakhsh
Carnegie Mellon University

- Believable Agents and Robotics
- Using Lessons from Drama
- An Architecture for Improvised Performance
- Robot Improv - The Plays

Novel Locomotion Techniques
Chairs: Arthur Sanderson, M. Uchiyama

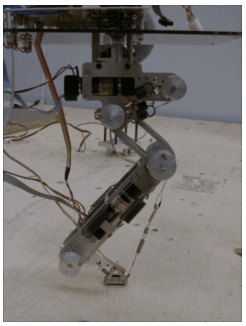
Study on Roller-Walker (Multi-mode Steering Control and Self-contained Locomotion)
Gen Endo and Shigeo Hirose
Tokyo Institute of Technology

- Leg-Wheel Hybrid Vehicle with Passive Wheels
- Proposition of Basic Motion Control Method
- Velocity Simulations and Experiments
- Wireless Maneuvering Experiments



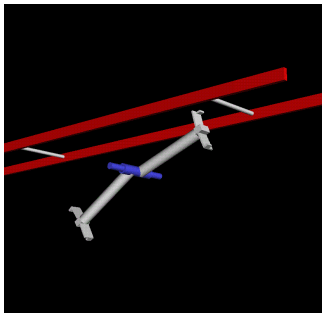
Low-Energy Control of a One-Legged Hopping Robot with 2 Degrees of Freedom
R. Dummer and M. Berkemeier
Utah State University

- Biologically Inspired Model
- Forward Hopping Analysis
- Poincare Return Map
- Experimental Results



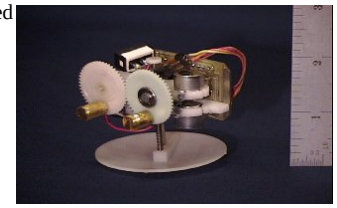
A Leaping Maneuver for a Brachiating Robot
J. Nakanishi and T. Fukuda
Nagoya University

- Investigation of the leap problem.
- The task of transferring from a branch to the next which is far out of reach involving a component of free flight.
- Formulation of swing and flight control strategies for a two-link robot to achieve such a leaping maneuver.
- Numerical simulations suggest the effectiveness of the proposed strategy.



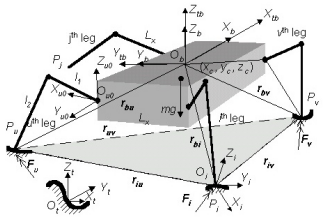
Design of a 5cm Monopod Hopping Robot
T. E. Wei, G. M. Nelson, R. D. Quinn, H. Verma and S. L. Garverick
Case Western Reserve University

- Fully Autonomous Single-Legged Hopping Robot
- Fits Entirely Into a Cube 2
- Able to Climb Steps
- Statically and Dynamically Stable



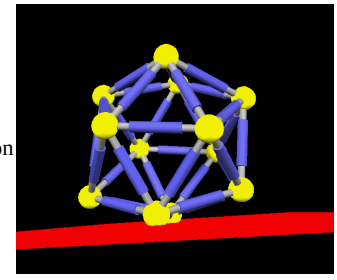
Stability Analysis of Walking Robots via Leg-end Supporting Moments
D. Zhou[1], K. H. Low[1] and T. Zielinska[2]
[1]Nanyang Technological University and [2]Warsaw Univsersity of Technology

- To measure the stability margin of walking robots
- Leg-end Supporting Moment (LSM) method
- With and without external body forces on various terrain
- Capable for drilling, dragging and manipulating



Dynamic Rolling of Modular Robots
W. H. Lee and A. C. Sanderson
Rensselaer Polytechnic Institute

- Active shape-induced rolling
- Dynamic models of tipping, rolling, and impact
- Active rolling control simulation of rolling Tetrobots
- Execution of the continuous rolling locomotion

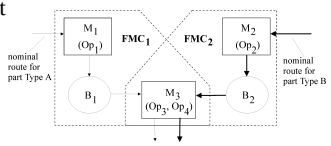


Supervisory Control of DEDS
Chairs: Beno Benhabib, Elsbieta Roszkowska

Supervisory Control of Multi-Workcell Manufacturing Systems with Shared Resources

A. Ramirez-Serrano and B. Benhabib
University of Toronto

- Purpose and Problem Statement
- Methodology
- New Aspects of Work
- Results and Conclusions



Some Improvements to the Banker's Algorithm Based on the Process Structure

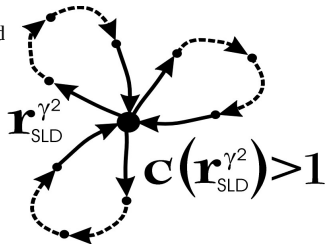
F. Tricas, J. M. Colom and J. Ezpeleta
Universidad de Zaragoza

- Deadlock problems in concurrent systems are difficult to manage
- Petri nets are used to model the system
- Based on the model, a deadlock avoidance approach is adopted
- The control is based on two improvements of the Banker's algorithm

Preventing Second Level and Avoiding First Level Deadlocks in FMS

E. Roszkowska
Wroclaw University of Technology

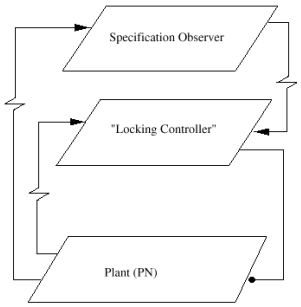
- Optimal DAP for a less constrained system
- Second-level-deadlock significant resources
- One-step-ahead safety test
- Application area



Modeling Admissible Behavior with Net Condition/Event Systems

L. E. Pinzon[1], M. A. Jafari[1] and H. Hanisch[2]
[1]Rutgers University and [2]Magdeburg University

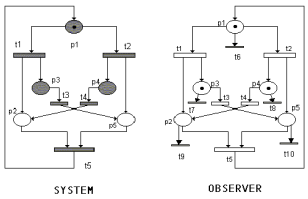
- Given a safe Petri Net model of a DES and a sequential specification, how to obtain a model for the admissible behavior of the system?
- Combine plant and specification models using the event signals of Net Condition/Event Systems (NCES). Use structure of combined model to determine all pre-bad states.
- Introduce a
- We present an efficient and minimally-restrictive procedure to obtain the admissible behavior of the system.



Observer Design for Discrete Event Systems modeled by Interpreted Petri Nets

A. Ramirez-Tevino, I. Rivera-Rangel and E. Lopez-Mellado
CINVESTAN-IPN Unidad Guadalajara

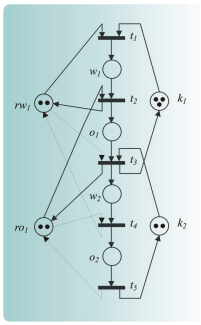
- Observability deals with determining the initial state of a system.
- Observability is usefull to estimate states that cannot be measured.
- Interpreted Petri Net are used to model Discrete Events Systems.
- An observer for IPN models is defined in IPN terms.



A Petri Net Approach to Deadlock Analysis for Classes of Kanban Systems

P. Valigi and F. Magnino
Universit di Perugia

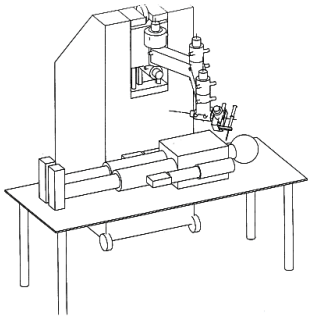
- Petri net models of Kanban Flow Lines and Reentrant Kanban Flow Lines
- Deadlock analysis and siphons
- Deadlock free property of KFL
- Some results about



Robotics in Medicine
Chairs: Alicia Casals, J. Troccaz

PADyC : a Synergistic Robot for Cardiac Puncturing
O. Schneider[1], J. Troccaz[1], O. Chavanon[2] and D. Blin[2]
[1]Institut A. Bonniot and [2]Faculte de Medecine de Grenoble, France

- PADyC : Technical Overview
- Surgical Application : Pericardial Puncture
- Current Status of the Project
- Conclusion



A Robotic Stepper for Retraining Locomotion in Spinal-Injured Rodents
D. J. Reinkensmeyer[1], W. K. Timoszyk[1], R. D. de Leon[2], R. Joynes[2], E. Kwak[1], K. Minakata[1] and V. R. Edgerton[2]
[1]University of California, Irvine and [2] University of California, Los Angeles

- Motivation: Develop a robotic system that controls and quantifies bipedal stepping by spinal-transected rats.
- Techniques: Attach rat's hind limbs to PHANToM robots and generate a virtual treadmill through haptic simulation.
- Results: Spinal-transected rats could step on the virtual treadmill.
- Conclusions: The virtual treadmill is a new tool for understanding spinal control of stepping and could provide useful data for development of robotic gait-training devices for humans.

Telerobotic Surgery Control and Safety
A. Rovetta
Politecnico di Milano

- Execution of telesurgery robotic operation, by Internet, ISDN
- Telerobotic system for a prostate biopsy
- Prostate biopsy on a human patient
- Surgical robotics according to the European Normative

A Medical Robotic Assistant for Minimally Invasive Surgery
V. F. Munoz, C. V. Thorbeck, J. G. DeGabriel, J. F. Lozano, E. S. Badajoz, A. G. Cerezo, R. Tozcano and A. J. Garrido
Universidad de Malaga

Robot Assisted Standing Up
Roman Kamnik and Tadej Bajd
University of Ljubljana

- A robot assistive device is proposed aimed as a support for the impaired individuals when rising from the sitting to the standing position.
- As a prototype, the 1 DOF instrumented hydraulically driven robot mechanism was built.
- Initial testing and evaluations were accomplished with paraplegic person, who was during standing-up using the arm support and functional electrical stimulation of the paralysed muscles.
- Results confirm the functionality in three possible utilization areas: the device can serve as an functional rehabilitative aid, as a training device or as an assessment tool when studying the standing-up manoeuver.

Experimental Evaluation of a Robotic Image-Directed Radiation Therapy System
K. Sharma[1], W. S. Newman[1], M. Weinhous[2], G. Glosser[2] and R. Macklis[2]
[1]Case Western Reserve University and [2]The Cleveland Clinic

- Motivation: localization of radiation treatment to moving targets
- Approach: human/machine cooperation for interactive exposure gating
- Results: significant reduction in exposure of healthy tissue
- Conclusions: motivates R&D of real-time imaging for cancer treatment