t u e s d a y

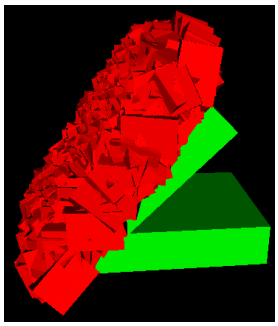
April 25, 2000

Tuesday, April 25th

Assembly and Motion Planning
Chairs: Y. B. Jia, Yuan F. Zheng

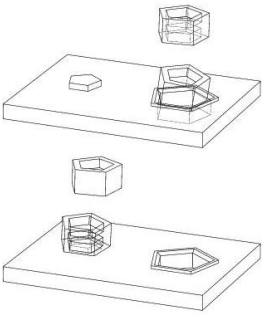
Towards Random Sampling with Contact Constraints
X. Ji and J. Xiao
University of North Carolina, Charlotte

- Randomly sample configurations of polyhedra satisfying contact constraints.
- Directly sample in contact space by exactly calculating the value range for each independent variable.
- Implementation results are reported for contact states consisting of a single principal contact (PC).
- The approach is efficient, and the results can be applied to contact motion planning.



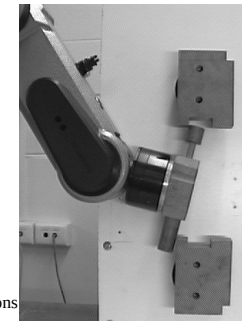
Determining Feasible Contact States of Pairs of Spatial Polyhedra
Barry Goeree, Ernest Fasse and Michael Marefat
University of Arizona

- Qualitative contact models are useful for assembly planning.
- Hypothesis testing methods can be used for model generation.
- An optimization-based testing method is presented.
- The method has been applied to non-convex polyhedral pairs.



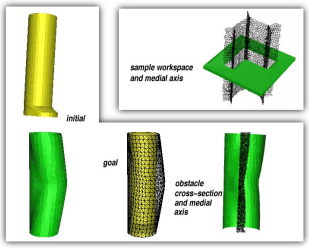
Programming by Demonstration - Constructing Task Level Plans in a Hybrid Dynamic Framework
J. Chen and B. McCarragher
Australian National University

- Most existing Programming by Demonstration approaches allow the robot to repeat suboptimal actions used by the human demonstrator
- We construct an execution plan for the robot from the best 'task-level' strategies used by the human
- We demonstrate the common household task of changing the roll on a paper roll holder. Using the constructed plan the robot performed better than when directly copying the demonstrator
- The approach allows the robot to avoid suboptimal actions that are typically found in human demonstrations



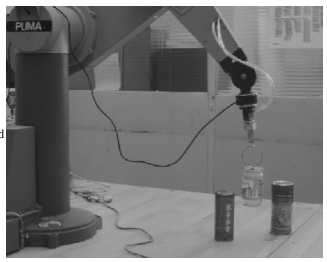
A Framework for Using the Workspace Medial Axis in PRM Planners
C. Holleman and L. Kavraki
Rice University

- PRM planners often fail due to narrow passages.
- Sample configurations based on the workspace medial axis.
- We show positive results for two difficult scenarios.
- PRM can be strengthened by incorporating workspace geometry.



Real-Time Motion Planning for Personal Robots Using Primitive Motions
L. Xu[1] and Y. F. Zheng[2]
[1]Zhejiang University and [2]The Ohio State University

- This paper is to develop a motion planning mechanism for personal robots to move in unstructured environments. The idea is to reduce the burden to the users in planning low level motions. As a result, the personal robot becomes a convenient tool to elderly and ill people.
- We use prmitive motions as basic components for planning the robot motion. The basic components resemble the motion patterns of human hands. The combination of basic motions thus generate motions of the personal robot natural to human beings. Modification to the primitive motions is also developed for the personal robots to cope with obstacles.
- Experiments were conducted on a robotic arm. The results show that the developed mechanism is effective.
- The primitive motion scheme is an important contribution to the development of personal robots. By using this scheme, the robot can generate complex trajectories without being steered all the time. This makes the operation of personal robots easy.

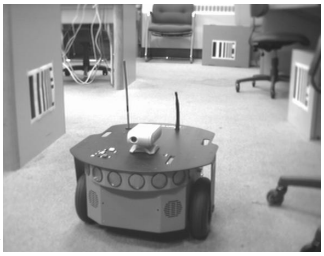


Attractive Regions in the Environment
H. Qiao
City University of Hong Kong

Landmarks and Environmental Modeling
Chairs: Peter Allen, Julio Rosenblatt

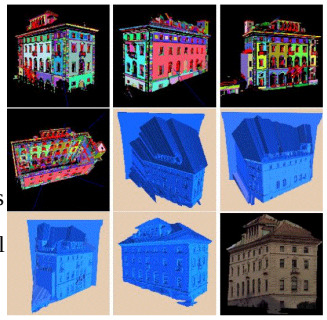
Mobile robot navigation using self-similar landmarks
Amy J. Briggs, Daniel Scharstein, Darius Braziunas, Cristian Dima and Peter Wall
Middlebury College

- Reliable vision-based navigation using artificial landmarks
- Self-similar patterns detectable under wide range of views
- Detection at 36 frames per second without specialized hardware
- First practical real-time navigation system using visual landmarks



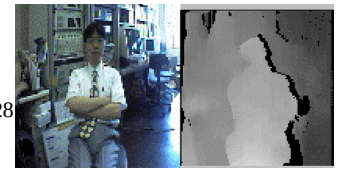
Integration of Range and Image Sensing for Photorealistic 3D Modeling
I. Stamos and P. Allen
Columbia University

- Geometric and photometric correct 3-D modeling
- Segmentation of range data, fusion of range w/ image data
- Experiments with real buildings
- Complete system for 3-D model acquisition



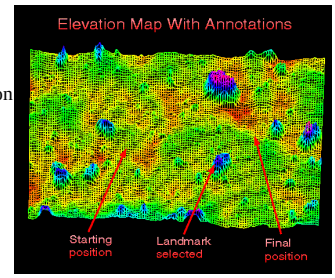
Design and implementation of Onbody Real Time Depth Map Generation System
S. Kagami, K. Okada, M. Inaba and H. Inoue
The University of Tokyo

- Realtime Depthmap Generation Using onbody PC only
- Recursive Correlation and Online Consistency Checking
- Realtime Calculation on 128x128 with 32 Search Length
- Real-World Experiments using Several Robots



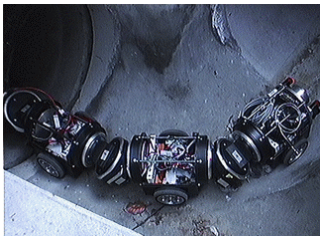
Landmark Selection for Terrain Matching
C. F. Olson
California Institute of Technology

- Problem: Landmark selection for accurate localization
- Motivation: Autonomous localization for Mars rovers
- Technique: Estimate uncertainties using error model
- Result: Improvement in both correctness and precision



3-D Interpretation of Sewer Circular Structures
M. Kolesnik[1] and G. Baratoff[2]
[1]Schloss Birlinghoven, Augustin Germany and [2]University of Ulm, Germany

- Vision-based distance computation is important for orientation of an autonomous robot.
- Algorithm for distance computation in the sewer utilizing one calibrated camera is presented.
- Two types of sewer circular structures are extracted and interpreted.
- 3D interpretation method gives information about the location and orientation of the sewer inspecting robot.



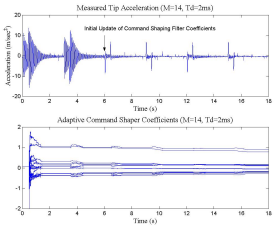
Object Recognition by Subscene Graph Matching
Wen-Jing Li and Tong Lee
The Chinese University of Hong Kong

- Recognition of occluded articulated objects
- Matching Graphs of partitioned scenes by Hopfield Network
- Matched scissors with different angles of opening
- Locating objects with similar local structures

Flexible Robots
Chairs: Andrew Goldenberg, Gregory P. Starr

Adaptation of Generalized Time-Delay Command Shaper for Flexible Manipulator Control
S. Rhim and W. J. Book
Georgia Institute of Technology

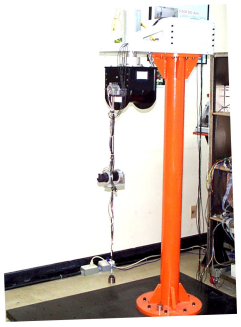
- Time-delay Command Shaping with Uncertain System Parameters
- Direct Adaptive Command Shaping using Generalized Time-delay Command Shaper
- Experimental Results are Shown
- Direct Adaptive Command Shaping Effectively Suppresses Vibration of Flexible Machines with Uncertain System Parameters



Stability of A Flexible Link with an Arbitrarily Oriented Tip Rotor and a Conservative Tip Load
L. Li, G. R. Heppler and K. Huseyin
University of Waterloo

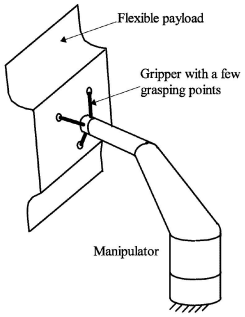
Bandwidth Modulation of Rigid Subsystem for the Class of Flexible Robots
J. Cheong, W. K. Chung and Y. Youm
Pohang University of Science & Technology (POSTECH)

- Reshaping the Bandwidth of Rigid Sub-system
- Passivity-based SPR filter and DOB-based Q filter Design
- Joint Tracking Experiments for Various Bandwidth Parameters
- Rigid Bandwidth Must Be Far Below the Fundamental Mode



Vibration Controllability of Flexible Robot-Payload Systems
T. Zhou, J. W. Zu and A. A. Goldenberg
University of Toronto

- Problem: payload vibration due to its flexibility
- Can the interested vibration modes be controllable?
- Dynamic modeling and local controllability theory
- Locations of grasping points play an important role



PDS Cooperative Control of Two One-Link Flexible Arms
F. Matsuno and A. Hayashi
Tokyo Institute of Technology

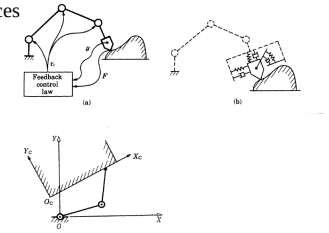
Robust Control Design for Flexible-Link/Flexible-Joint Robots
D. G. Wilson[1], G. P. Starr[1], G. G. Parker[2] and R. D. Robinett[3]
[1]The University of New Mexico, [2]Michigan Technological Univsersity and [3]Sandia National Labratories

Robot Control
Organizers & Chairs: Joris Deschutter, Tsuneo Yoshikawa

Overview of Robot Control
J. DeSchutter
Katholieke Universiteit Leuven

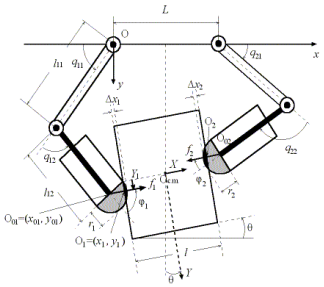
Force Control of Robot Manipulators
T. Yoshikawa
Kyoto University

- Survey of State of the Art of Force Control with 86 References
- Basic Approaches to Force Control
- New Formulation of Premises for Various Approaches
- Brief Survey of Related Research Topics



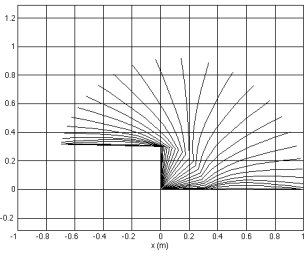
Passivity - Based Control
S. Arimoto
Ritsumeikan University

- Robot dynamics naturally satisfy passivity, which follows directly from a variational form. This leads to design of effective robot controllers.
- Dual two-DOF fingers with soft-tips grasping an object satisfies passivity too, form which separate feedback control signals for 1)stable grasping and 2) regulating rotational angle of the object can be found.
- The overall control signal can be designed by the principle of superposition of such feedback signals.
- These theoretical findings and simulation results show that multi-fingered hands with soft-tips can be used in versatile everyday tasks.



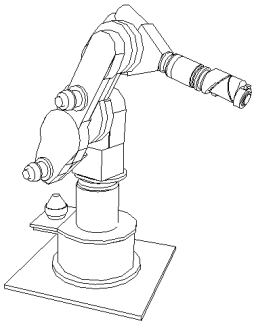
Feedforward/Feedback Laws for the Control of Flexible Robots
Alessandro De Luca
Universit degli Studi di Roma "La Sapienza"

- Model-based feedforward and feedback solution using motor PD law
- New algorithm for rest-to-rest slew in given time for a one-link flexible arm
- Iterative algorithm for end-effector trajectory execution of the two-link FLEXARM



Experimental identification of robot dynamics for control
J. Swevers[1], C. Ganseman[1], X. Chenut[2] and J. C. Samin[2]
[1]Katholieke Universiteit Leuven and [2]Univ. catholique de Louvain

- Design of robot identification experiments for model based robot control.
- Selection of appropriate experiment design and optimization criteria, sensors and model.
- Maximum likelihood estimation, periodic excitation.
- Experimental results illustrate the appropriate choices.

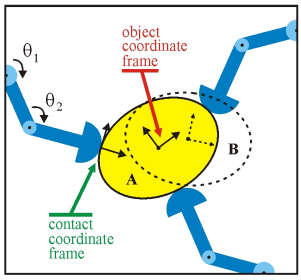


Design of Steering Mechanism and Control of Nonholonomic Trailer Systems
Y. Nakamura[1], H. Ezaki[1], Y. Tan[1] and W. Chung[2]
[1]University of Tokyo and [2]Korea Institute of Science and Technology

Dexterous Manipulation
Organizers & Chairs: Mark Cutkosky, Martin Buss

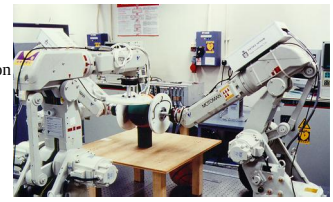
An Overview of Dextrous Manipulation
A. M. Okamura, N. Smaby and M. R. Cutkosky
Stanford University

- Definition of dexterous manipulation
- Formulation of the dexterous manipulation problem using kinematics, contact types, and forces
- Grasp planning/quality measures and mid- and low-level control frameworks
- List of accomplishments and areas for future work



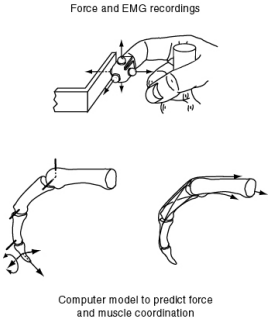
The Planning and Control of Robot Dextrous Manipultation
Li Han[1], Zexiang Li[2], Jeff Trinkle[3], Zhiqiang Qin[2] and Shilong Jiang[2]
[1]Texas A&M University, [2]Hong Kong University of Science and Technology and [3]Sandia National Laboratory

- Problem Statement for Robot Dextrous Manipulation
- Force and Motion Feasibility/Optimization Issues
- Modular Manipulation Planning and Control Strategy
- Experimental Results



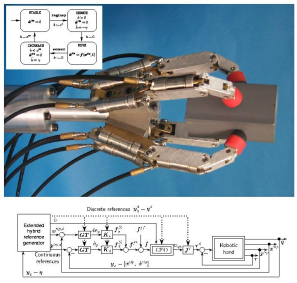
Applying principles of robotics to understand the biomechanics, neuromuscular control and clinical rehabilitation of human digits
F. J. Valero-Cuevas
Cornell University

- The function and control of the hand are not well understood
- Principles of robotics reveal the mechanics of the hand
- Computer models help design surgical procedures
- Experiments and models reveal the neural control of dexterity



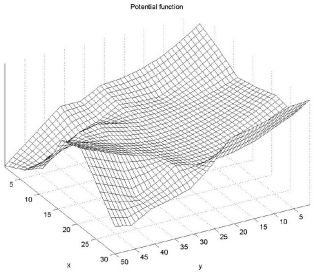
A Discrete-Continuous Control Approach to Dextrous Manipulation
Martin Buss and Thomas Schlegl
Technische Universitat Muenchen

- Introduction & Motivation
- Hybrid Modeling & Control Architecture
- Regrasping Experimental Results
- Conclusions & Future Work



Rolling Contacts and Dextrous Manipulation
A. Bicchi and A. Marigo
University of Pisa

- Nonholonomy on purpose: manipulation by rolling
- Theoretical foundations: classification of admissible contacts
- Proof of the long-standing conjecture on generic controllability of rolling
- Conclusions and open problems



Robot Learning
Organizers & Chairs: Chris Atkeson, Stefan Schaal

Real-Time Robot Learning With Locally Weighted Learning

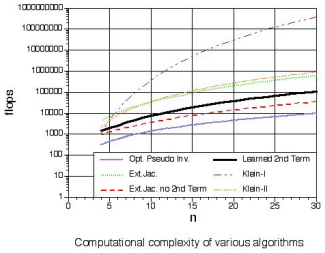
S. Schaal[1], C. G. Atkeson[2] and S. Vijayakumar[3]
[1]University of Southern California, [2]Kwato Dynamic Brain Project (ERATO/JST) and [3]Riken Brain Research Institute

- How can we achieve real-time learning for high-dimensional robot systems?
- Spatially localized nonparametric neural networks offer a powerful approach to robot learning based on sound statistical principles, either as memory-based or non-memory-based algorithms
- Real-time learning was demonstrated for the task of devil-sticking, pole-balancing, and inverse dynamics learning with an anthropomorphic 7DOF robot arm
- Locally weighted learning offers one of the most powerful approaches to real-time robot learning

Inverse Kinematics for Humanoid Robots

G. Tevatia and S. Schaal
University of Southern California

- Existing Extended Jacobian Methods (EJM) computationally too expensive
- Most efficient version of EJM with comparable performance developed
- Compared with various algorithms for computational complexity
- Real time implementation on a 30 DOF humanoid robot feasible



Computational complexity of various algorithms

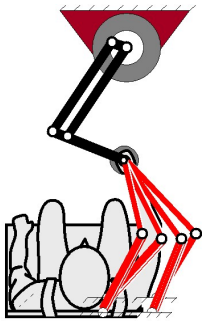
Q2: Memory-based active learning for optimizing noisycontinuous functions

Andrew W. Moore[1] [2], Jeff G. Schneider[1] [2], Justin A. Boyan[1] and Mary S. Lee[2]
[1]Carnegie Mellon University and [2]Schenley Park Research Inc.

Robots can teach people how to move their arm

F. A. Mussa-Ivaldi and J. L. Patton
Northwestern University

- Model: linear combination of arm-&-controller primitives
- Calculates a subject-specific,
- The subject grips a planar, 2-degree-of-freedom robot
- Implicitly learns motions after the force field is removed



Towards Programming Tools for Robots That Integrate Probabilistic Computation and Learning

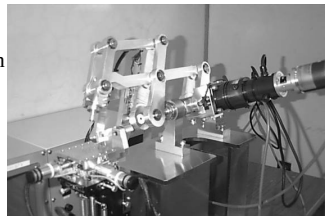
S. Thrun
Carnegie Mellon University

- Making robot programming easier
- Integrating learning and probabilistic computation into C++
- Enormous savings when developing robot software
- Learning can drastically speed up robot programming

Novel Transmission Methods
Chairs: Ron Fearing, L. Whitcomb

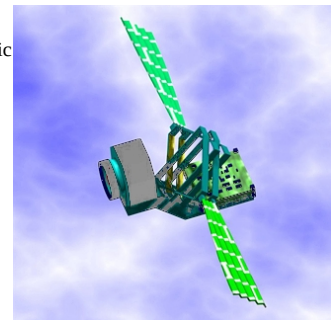
Development of Independently-Controlled Position and Orientation Manipulator for Minute Work
Hiroki Tokashiki[1], Kenji Kaneko[2] and Kazuo Tanie[2]
[1]University of the Ryukus and [2]Mechanical Engineering Laboratory

- Development of new type manipulator
- Independently-controlled position and orienatation mechanism
- Mechanical accuracy of interfernce < 50 micrometer
- Larger workspace and high precision



Wing Transmission for a Micromechanical Flying Insect
R. S. Fearing, K. H. Chiang, M. H. Dickinson, D. L. Pick, M. Sitti and J. Yan
University of California, Berkeley

- design 25 mm wing span biomimetic flying robot
- insect aerodynamics specify wing stroke and rotation
- thorax structures and actuator power requirements
- stainless steel with piezoelectric actuators

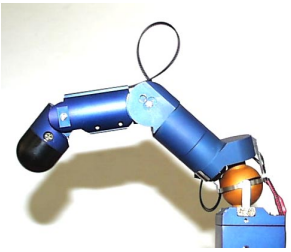


Structural Design and Analysis of a New Semi-Direct Drive Robot Arm: Theory and Experiment
J. Roy, R. Goldberg and L. L. Whitcomb
Johns Hopkins University

- Structural design, analysis, and experimental verification of novel arm
- Design optimized using FEA for high natural frequencies througout workspace
- Extensive structural vibration experiments reported
- Experiments corroborate FEA predictions througout the arm's workspace

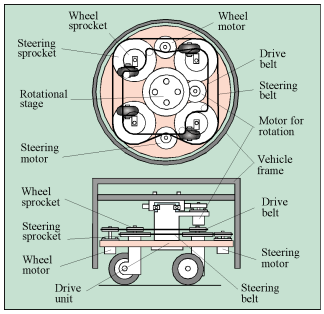
Anthropomorphic Joint Mechanism with Two Degrees of Freedom
H. R. Choi and S. M. Ryew
Sungkyunkwan University

- Two dof metacarpal joint for robot hands mimicking human finger
- Double Active Universal Joint
- Free of rolling, controllable compliance
- Applications: robot hand, inpipe inspection robot



Caster Drive Mechanisms for Holonomic and Omnidirectional Mobile Platforms with no Over Constraint
M. Wada, A. Takagi and S. Mori
Fuji Electric Corporate R&D, Ltd.

- Avoid an over constraint problem on the holonomic wheeled vehicle
- Synchro-drive configuration with decoupled caster drive wheels
- Kinematic and static analysis
- All wheel drive holonomic vehicle with simple kinematics driven by 3 motors



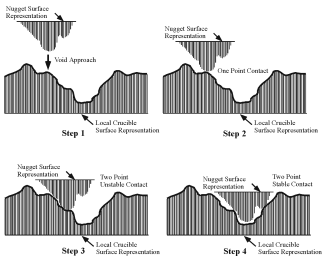
On the Energy Efficiency of CVT-Based Mobile Robots
J. Kim[1], H. Yeom[1], F. C. Park[1], Y. I. Park and M. Kim[2]
[1]Seoul National University and [2]Korean Institute of Science and Technology

- Increasing the run time and efficiency of a mobile robot with S-CVT.
- Development of an optimal control law for minimum energy, together with a numerical simulation based on B-splines.
- Benchmarking the energy efficiency of the CVT-based mobile robot against that of robots employing a reduction gear unit.
- Numerical results indicate that the run time of a mobile robot using a S-CVT can be increased by up to 25

Robotics in Manufacturing
Chairs: Steve Dubowsky, T. C. Steve Hsia

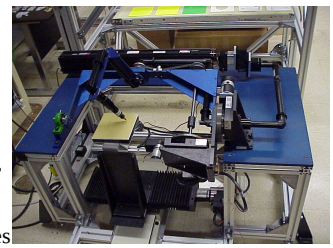
Application of a Model-free Algorithm for the Packing of Irregular Shaped Objects in Semiconductor Manufacture
V. A. Sujan and S. Dubowsky
Massachusetts Institute of Technology

- Online packing of highly irregular shaped objects
- An online Virtual Trial and Error algorithm developed
- Cost function optimization results in packing densities of 60
- The model-free algorithm applied to crucible packing in CZ wafer production with success



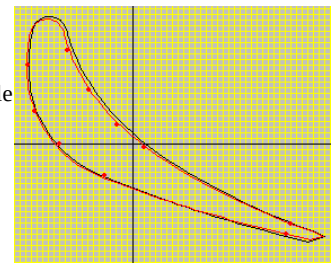
Design and Evaluation of a Laser-Cutting Robot for Laminated, Solid Freeform Fabrication
S. Choi and W. S. Newman
Case Western Reserve University

- Motivation: fast/accurate laser cutting for solid freeform fabrication
- Approach: 4-dof design with articulated optics
- Results: higher speed, accuracy, ease of control
- Conclusions: new design enables faster SFF method



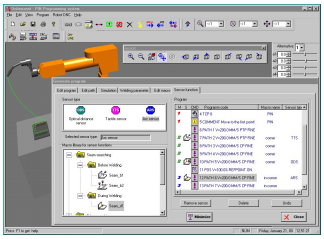
Optimal Profile Generation in Distorted Surface Finishing
Z. Gong, X. Q. Chen and H. Huang
Gintic Institute of Manufacturing Technology

- The problem: Find distorted airfoil surface
- Template-based optimal profile fitting
- Direct search minimization algorithm
- Application (video show)



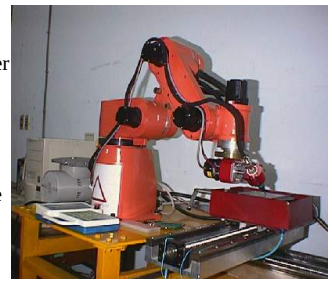
User Oriented Integration of Sensor Operations in a Offline programming System for Welding Robots
Wenrui Dai and Markus Kampker
European Center for Mechatronics, Germany

- Offline programming sensor operations for welding robots
- Icon-oriented user interface
- Macro programming techniques
- Low-cost (PC-based) and high performance



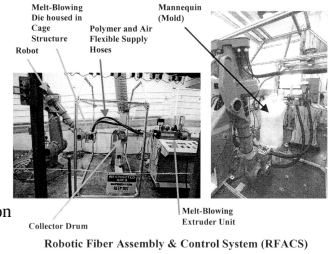
A Robot-Assisted Finishing System with an Active Torque Controller
Y. T. Wang and J. Y. Jan
Tamkang University

- Single-axis active torque controller
- Linear grinding-force model
- Software grinding force observer
- Grinding and polishing workpiece with 3D curved-surfaces



On the Use of Robotics for Melt-Blowing to Form Shaped/Molded Fabric Structures
Raoul Farer, Edward Grant, Tushar Ghosh, Abdelfattah Seyam and Gordon Lee
North Carolina State University

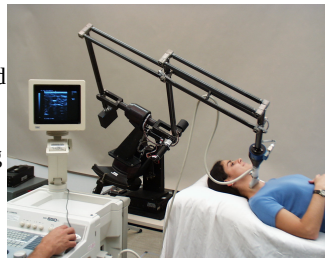
- Modified a robotic systems to work with a fiber assembly and control system for melt-blowing
- Developed models for the mannequin's geometry and its interaction with robot melt-blowing system
- Developed control algorithms for tool position/orientation and mannequin mold position/orientation
- Implemented control algorithms on an actual Robot System



Surgical Robots
Chairs: Paolo Dario, F. Pierrot

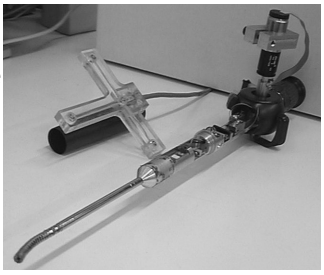
Motion/Force/Image Control of A Diagnostic Ultrasound Robot
W. H. Zhu, S. E. Salcudean, S. Bachmann and P. Abolmaesumi
University of British Columbia

- An Ergonomic Interface to Sonographers
- 6-DOF Fully Counterbalanced Robot Designed for Safety
- Velocity Controller Achieving Position/Force/Image Control
- Ultrasound Visual Servoing Demonstrated



A Semi-Automatic Handheld Mechatronic Endoscope with Collision-Avoidance Capabilities
S. D'Attanasio, O. Tonet, G. Megali, M. C. Carroza and P. Dario
Scuola Superiore Sant'Anna

- Add collision-avoidance loop in a servo-controlled endoscope
- Spatial accuracy of 1.8mm and refresh rate of 12Hz
- The sistem is suitable for clinical trials



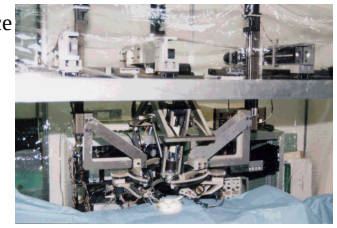
Realistic Force Feedback for Virtual Reality Based Diagnostic Surgery Simulators
V. Vuskovic, M. Kauer and G. Szekely
Swiss Federal Institute of Technology

- Modelling of soft tissue deformation is central for general surgery simulators
- Here, a nonlinear viscoelastic model for soft biological tissues is used
- A novel device for in-vivo measurement of material parameters is presented
- First experiments on dead animal tissues with validations are given

Biomechanical Modeling of the Small Intestine as Required for the Design and Operation of a Robotic Endoscope
H. D. Hoeg[1], A. B. Slatkin[1], J. W. Burdick[1] and W. S. Grundfest[2]
[1]California Institute of Technology and [2]Cedars Sinai Medical Center

Tele-mico-surgery system with intelligent user interface
M. Mitsuishi[1], S. Tomisaki[1], T. Yoshidome[1], H. Hashizume[2] and K. Fujiwara[2]
[1]University of Tokyo and [2]Okayama University Medical School

- A tele-micro-surgery system with an intelligent user interface was developed.
- Automatic 3D positioning was realized using
- A micro-blood-vessel of a rat of 0.3mm diameter was successfully sutured.



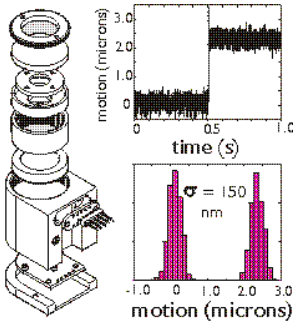
Robotized Reconstructive Surgery: Ongoing study and First Results
Francois Pierrot[1], Etienne Dombre[1], Luc Teot[2] and Eric Degoulange[3]
[1]LIRMM, [2]Lapeyronie Hospital and [3]SINTERS

- Goal: Help in surgery for severely burnt patients
- Background: Study of expert surgeons behavior
- Mean: Force controlled robot
- Result: Good skin grafts obtained (on animal)

Sensing Strategies and Control 1
Chairs: Ralph Hollis, Guillaume Morel

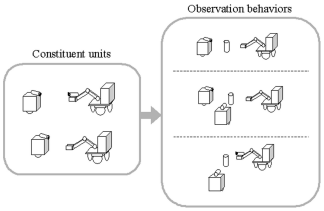
Optical Coordination Sensor for Precision Cooperating Robots
Wing-Choi Ma, Alfred A. Rizzi and Ralph L. Hollis
Carnegie Mellon University

- Sensor for precise mutual calibration of two robots
- Optical sensor on one robot, LEDs on the other
- Resolutions of 150 nm (1 sigma) achieved
- Allows fast calibration for executing cooperative tasks



Generation of Observation Behavior in Distributed Robotic System
T. Kaga and T. Fukuda
Nagoya University

- A study on the generation of observation behaviors for object recognition considering various components of heterogeneous robots
- A proposal of a method of autonomous positioning for active sensing by predicting sensory inputs of the next step.
- Simulation results suggest that robots are capable of generating observation behaviors in order to decrease sensing errors.



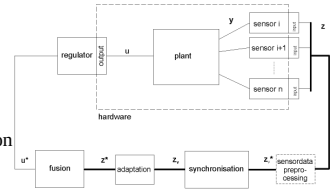
Self-learning Vision-guided Robots for Searching and Grasping Objects
M. C. Nguyen and V. Graefe
Bundeswehr University Munich

- Motivation: Conventional vision-based robots for grasping objects typically require, on the one hand, quantitatively correct models of the robots own characteristics and of the relevant parts of environments; on the other hand, the grasped object must be visible in both images, i.e., the robots work space is merely limited to the available initial fields of view of cameras. Such systems do not make use of available potentials of the robot and, thus, reduces its efficiency.
- Techniques and Proposed Approach: Direct transition from image data to motion control commands. If the grasped object is invisible in an image, a search motion is initiated. The principle of the object search is the conversion of passive
- Experimental Results: The paper describes a method that allows a calibration-free vision-guided manipulator learning to control its joints to grasp a variety of different shaped objects that may be located anywhere and in nearly arbitrary orientation in the robots 3-D space.
- Conclusion: The robot can learn the gain coefficients relating image motions to control word commands based on either the detected object or on the natural inhomogeneity of the robot's surroundings without the need of special landmarks. With the object search the robot can make use of its available potentials and, thus, increasing its efficiency.


Fig. 1: Objects used in experiments

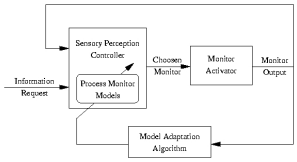
System Architecture for Synchronizing, Signal Level Fusing, Simulating and Implementing Sensors
C. Robl and G. Farber
Technische Universitat Munchen

- System architecture for signal-level sensor fusion
- Sensor models and sensor synchronization
- Sensor adaptation: Offset correction, integration, differentiation
- Simulation and real sample application



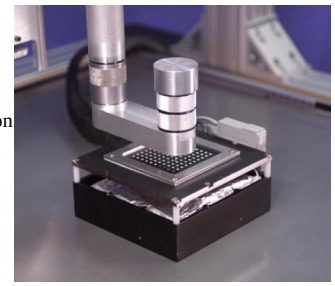
An Adaptive Sensory Perception Controller for Robotic Systems
T. Celinski and B. McCarragher
The Australian National University

- Control of Perception Improved Through Adaptation
- Perception Model Adaptation Based on Radial Basis Functions
- Applicable to Multi-Sensory Systems
- Contribution: Adaptive Perception Controller



Visually Guided coordination for Distributed Precision Assembly
Michael L. Chen, Shinji Kume, Alfred A. Rizzi and Ralph L. Hollis
Carnegie Mellon University

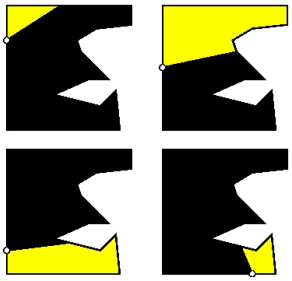
- Modular Distributed Precision Assembly
- Visually-guided Agent Coordination
- High-bandwidth Distributed Control
- Experimental Evaluation



Target Tracking
Chairs: Gregory Hager, A. Zelinsky

Pursuit-Evasion Using Beam Detection
B. Simov, G. Slutzki and S. M. LaValle
Iowa State University

- We present an algorithm for detecting an evader in a polygonal region
- The algorithm provides a schedule for single or multiple pursuers each of them equipped with a beam

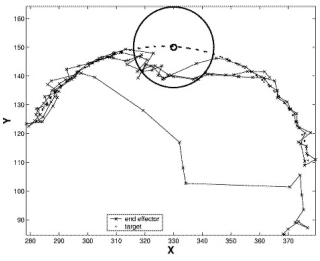


Tracking Techniques for Visual Servoing Tasks
D. Kragic and H. Christensen
Royal Institute of Technology

- Region tracking for manipulation tasks.
- Graddient vs. correlation based approach.
- Different motion models (T, R, A) and comparison results.
- Adaptive model selection as a future goal.

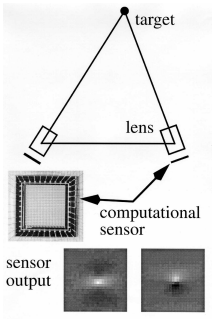
Uncalibrated Target Tracking with Obstacle Avoidance
J. A. Piepmeier[1] G. V. McMurray[2], A. Pfeiffer[3] and H. Lipkin[3]
[1]U.S. Naval Academy, [2]Georgia Tech Research Institute, and
[3]Georgia Institute of Technology

- Moving target tracking while avoiding an obstacle in path.
- Uses quasi-Newton method and RLS Jacobian estimation.
- Obstacle avoidance demonstrated with 2-link robot.
- Objective function used to effect desired behavior.



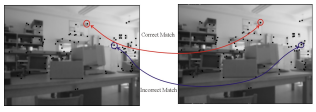
Visual Tracking with Subpixel Resolution Using an Analog VLSI Computational Sensor
Z. Lu and B. E. Shi
Hong Kong University of Science and Technology

- Active binocular vision system performs target tracking
- Computational sensors provide visual feedback at 250Hz
- Subpixel resolution of target motion via Gabor filter phase
- Estimation of 3D target motion via triangulation



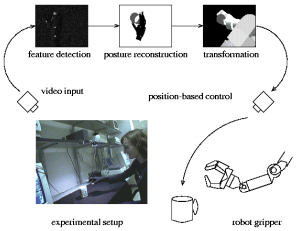
3D Motion Tracking of a Mobile Robot in a Natural Environment
P. Saeedi, P. Lawrence and D. Lowe
University of British Columbia

- To estimate the real-time 3D ego-motion of the camera from 2D images.
- Motion is estimated by tracking reconstructed 3D world features over the time.
- An average translational error of 15
- The algorithm demonstrates that this camera motion tracking method is feasible in unknown environments.



Visual Hand Posture Tracking in a Gripper Guiding Application
Fabienne Lathuiliere and Jean-Yves Herve
Ecole Polytechnique de Montreal

- Visual hand posture tracking in a gripper guiding application
- Kinematic hand model and pose estimation using a video camera and colored markers
- Validation on synthetic and real hand sequences and teleoperated gripping simulation
- Real-time hand pose tracking system improving grasp control



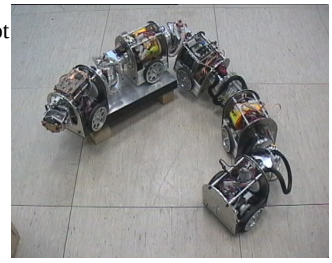
Redundant Manipulators
Chairs: Wankyun Chung, Anthony A Maciejewski

Motion Planning for Dynamic Eel Like Robots
K. McIsaac and J. Ostrowski
University of Pennsylvania

- Motion planning using feedback control for eel robot.
- We use a sampled feedback/feedforward technique, ignoring gait oscillation.
- The robot is approximated using a model of a steerable (Dubins) car.
- We achieve controlled starting, steering and stopping in the plane.

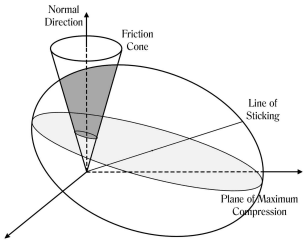
Controlling a Multijoint Robot for Autonomous Sewer Inspection
K. U. Scholl, V. Kepplin, K. Berns and R. Dillmann
Forschungszentrum Infromatik Karlsruhe

- very flexible autonomous robot
- sensor based motion planning
- successfully passed tests in real sewer pipes
- results led to improvements of mechanical structure



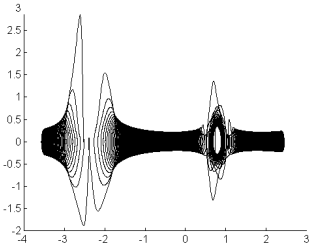
Towards impulsive manipulation: a general algebraic collision model for spatial robots
Ann Ramos Gravagne and Ian D. Walker
Clemson University

- Investigate 3D impact between a robot and its environment
- Modify Chatterjee's algebraic collision law for robotics
- Apply collision law to osprey landing & fishing simulation
- Energetically consistent model of impulsive manipulation is obtained



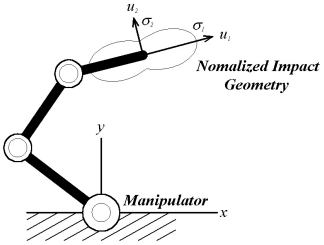
Chaos Dynamics in the Trajectory Control of Redundant Manipulators
F. B. M. Duarte[1] and J. A. T. Machado[2]
[1]Escola Superior Tecnologia Viseu and [2]Polytechnic Institute of Porto

- Kinematic and dynamic control using the generalized inverse control and the Open Loop Manipulability control are analyzed and its performances studied.
- The fractal dimension of the phase-plane joint trajectories, the statistical distribution of the joint variables and the frequency response of the closed-loop system.
- For the pseudoinverse method we have
- The CLP scheme leads to non-optimal responses, both for the manipulability and the repeatability perspectives while the OLM method revealed superior performances.



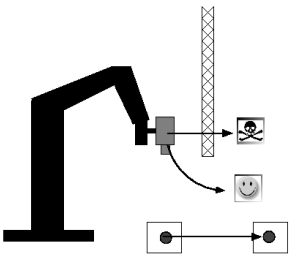
Normalized Impact Geometry and Performance Index for Redundant Manipulators
J. Kim, W. K. Chung and Y. Youm
Pohang University of Science & Technology (POSTECH)

- Impact Analysis and Control for Redundant Manipulators
- Description of Impact using Normalized Impact Geometry
- Impact Performance Index using Task Velocity Direction
- Guideline of impact control for unknown environment



A New Redundancy-based Iterative Scheme for Avoiding Joint Limits Application to Visual Servoing
Francois Chaumette and Eric Marchand
IRISA - Campus Universitaire de Beaulieu

- Avoiding robot joint limits is crucial in a reactive context
- Classical methods need a tedious gain tuning
- We present an iterative approach without any gain tuning
- The method is validated on a visual servoing gazing task



Mobile Robotics
Organizers & Chairs: Raja Chatila, Shin'ichi Yuta

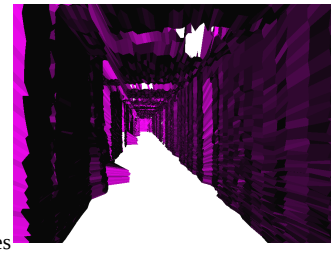
Overview of Mobile Robots
Raja Chatila
LAAS/CNRS

Mobile Robot Navigation in Indoor Environments using Object and Character Recognition
M. Tomono and S. Yuta
University of Tsukuba

- Model-based navigation in unknown indoor environments.
- Object and character recognition with position estimation.
- Navigation to the door designated by room number.
- The method enables navigation without an accurate map.

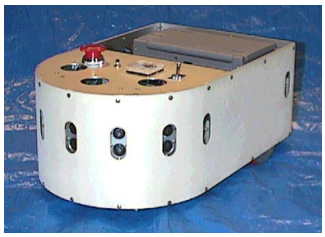
A Real-Time Algorithm for Mobile Robot Mapping With Applications to Multi-Robot and 3D Mapping
S. Thrun[1], W. Burgard[2] and D. Fox[1]
[1]Carnegie Mellon University and [2]University of Freiburg

- Building 3D Maps online with teams of mobile robots
- Fast probabilistic techniques for simultaneous localization and mapping
- 3D maps of building interiors acquired in real-time
- Opens up many new opportunities



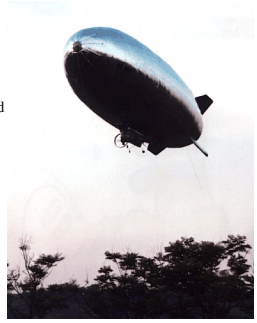
It's Time to Make Mobile Robots Programmable
Y. J. Kanayama[1] and C. T. Wu[2]
[1]MotionLab Inc. and [2]Naval Postgraduate School

- Design and implement practical high-level programmability for mobile robots.
- A Java-based Motion Description Language (MDL) that is built on the solid mathematical foundation is proposed.
- MDL is implemented successfully and running on a prototype robot Swan.
- MDL is the FIRST high-level mobile robot language and a good candidate for the STANDARD language.



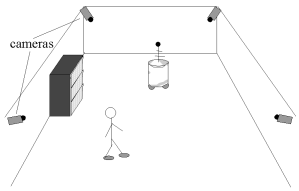
Towards Dynamic Object Identification Using Stochastic Lattice Models and Optimal Design of Experiments
A. Elfes, M. Bergerman and J. R. H. Carvalho
Center for Information Technology, Brazil

- We are developing robotic airships for cost-effective environmental, biodiversity and agricultural research and monitoring.
- Autonomous identification of man-made structures, pollution sources, fauna and flora, crop types, disease-affected plantation areas, and animal herds are some of the typical recognition tasks that the AURORA I robotic airship will be used for.
- The paper describes a dynamic approach to target identification that uses stochastic lattice models and optimal design of experiments for effective selection, recognition and tracking of relevant targets.
- Results are shown for identification of man-made structures and animal herds.



Sensor Network Perception for Mobile Robotics
A. Hoover[1] and B. D. Olsen[2]
[1]Clemson University and [2]Aalborg University

- Third-person sensing
- Gestalt control
- Prototype demonstration
- High speed + precise geometry



Grasping and Contact
Organizers & Chairs: Antonio Bicchi, Vijay Kumar

Robotic Grasping and Contact: A Review
A. Bicchi[1] and V. Kumar[2]
[1]University of Pisa and [2]University of Pennsylvania

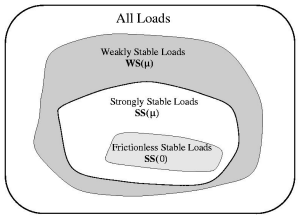
- Fixturing, Dexterous Manipulation and Enveloping
- Closure Properties of Grasps
- Force Analysis
- Kinematics of Contact and Contact Compliance

Controllability of Single Input Rolling Manipulation
P. Choudhury and K. Lynch
Northwestern University

- Controllability of underactuated systems with rolling contacts.
- Geometric mechanics and non linear control.
- Single input system consisting of a ball rolling inside an ellipsoid is globally controllable.
- Controllability can be achieved for underactuated systems with assymetries in motion and curvature.

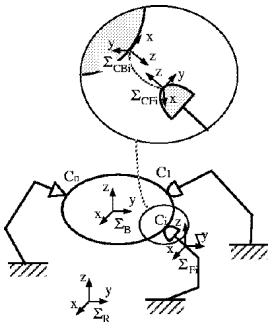
Stability Characterizations of Fixtured Rigid Bodies with Coulomb Friction
J. S. Pang[1] and J. C. Trinkle[2]
[1]Johns Hopkins University and [2]Sandia National Labs

- Is an object fixtured without form closure stable?
- Past analyses are overly conservative.
- Can determine stability with friction accurately using complementarity theory.
- Can construct the exact set of stable loads using complementary cones.



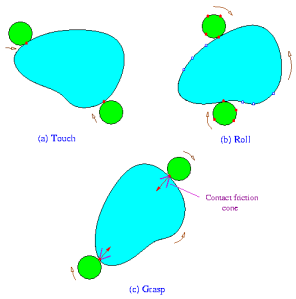
Control Algorithm for Grasping and Manipulation by Multifingered Robot Hands Using Virtual Truss Model Representation of Internal Force
T. Yoshikawa
Kyoto University

- System Description and Constraint Conditions
- Internal Force Representation Based on Virtual Truss Model
- Control Algorithm for Fixed and/or Rolling Contacts
- Extension to Case of Sliding Contacts



Grasping Curved Objects through Rolling
Y. B. Jia
Iowa State University

- Introduction
- Finger Localization Using Total Curvature
- Grasp Achievement under Rolling
- Simulation Results

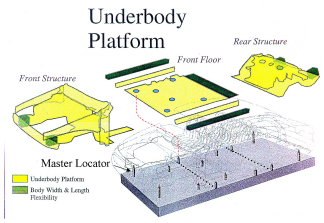


Flexible Automation
Organizers & Chairs: Peter Luh, Dan Whitney

Research Issues in Manufacturing Flexibility - An Invited Review Paper for ICRA 2000 Symposium on Flexibility

D. E. Whitney
Massachusetts Institute of Technology

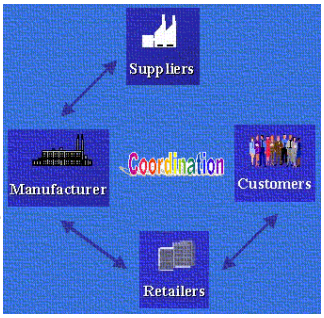
- This paper reviews flexibility issues in manufacturing
- Flexibility occurs in design, manufacturing, distribution, and general business practices
- Typical approaches include CAD/CAE, platform product design, and delayed committment
- Flexibility is not always good, and business-technical trades must be considered.



Scheduling and Coordination in Manufacturing Enterprise Automation

H. Chen and P. B. Luh
University of Connecticut

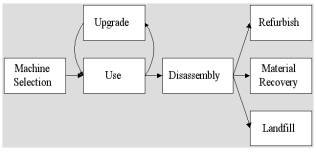
- The Importance of Coordination for Manufacturing Enterprises
- Overview of Existing Approaches
- Challenging Issues
- Price-Based Coordination Architecture and Methodology



A Life Cycle Engineering Approach to FMS Development

P. Yan, M. Zhou and R. Caudill
New Jersey Institute of Technology

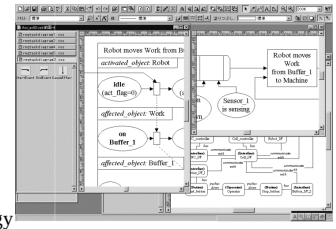
- Provide a life cycle engineering approach to FMS development;
- A timed IPPD methodology;
- A case study considering FMS machine selection and decisions along its life;
- A new way to develop cost-effective, high-quality and environmentally conscious FMS.



Object-Oriented Graphical Specification and Seamless Design Procedure for Manufacturing Cell Control Software Development

Satoshi Kanai[1], Takeshi Kishinami[1] and Toyoaki Tomura[2]
[1]Hokkaido University and [2]Asahikawa National College of Technology

- Rapid prototyping methodology of cell control software
- Diagram based programming and clear design method: refinement, translation and transformation
- Computer-aided prototyping and code-generating tool
- Validation of proposed methodology through co-simulation



Supply Chain Engineering and Automation

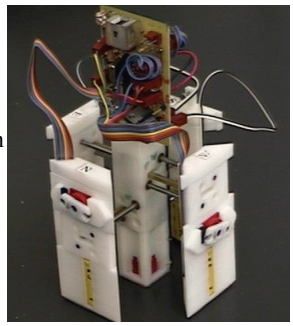
N. Viswanadham
The National University of Singapore

- A theme paper that describes the architecture of an Integrated supply Chain Network (ISN) using collaborative and communication technologies
- The central problem in ISNs is: When, Where, What product and How much to manufacture and store and for whom.
- We identify the decision and performance modelling problems in ISNs
- We Identify possible future research issues in Supply Chain Engineering

Reconfigurable Robots
Chairs: Aydan Erkmen, Pradeep Khosla

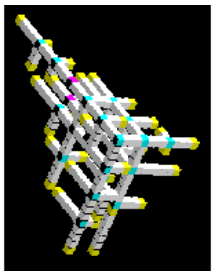
A physical implementation of the self-reconfiguring crystalline robot
Daniela Rus and Marsette Vona
Dartmouth College

- Crystalline Robot Concept and Advantages
- Details of Robot Hardware Design
- 10 Units Built
- Experimental Procedures and Results



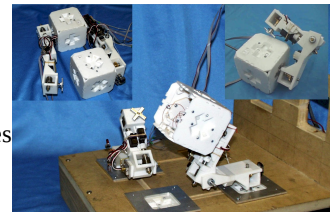
Emergent Structures in Modular Self-reconfigurable Robots
Hristo Bojinov, Arancha Casal and Tad Hogg
Xerox Corporation

- Biologically-inspired approach to self-reconfiguration for modular metamorphic robots
- Use of local simple rules result in the
- Design and evaluation of control algorithms through simulation
- Resulting structures are of pseudo-random shape but posses desired functionality. Approach does not require a priori exact target shape description, which is of advantage in uncertain environments.



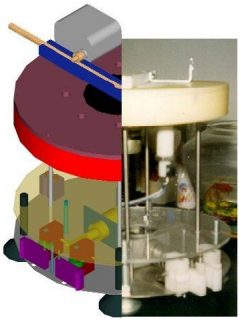
Mechatronic Design of a Modular Self-Reconfigurable Robotic System
Cem Unsal and Pradeep Khosla
Carnegie Mellon University

- 3-D Self-reconfiguration
- Design and Implementation of the Bipartite System
- Experiments with Prototypes
- Discussion and Concluding Remarks



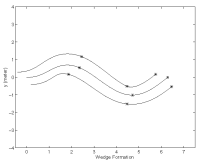
Self Localization of a Holon in the Reconfiguration Task Space of a Robotic Colony
M. Durna, I. Erkmen and A. M. Erkmen
Middle East Technical University

- Self-Localization of an intelligent robotic agent in a robotic colony.
- Distributed computation of a Coalition Law is proposed.
- The method is simulated.
- Localization is attained by each agent which than be used for Reconfiguration of the whole system.



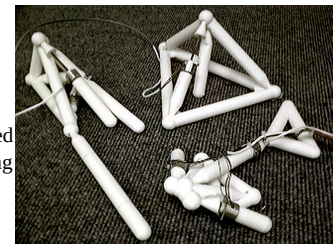
Formation Control of Autonomous Agents in 3D Workspace
W. Kang[1], N. Xi[2] and A. Sarks[3]
[1]Naval Postgraduate School, [2]Michigan State University and [3]Wright-Patterson AFB

- A general method of formation control of multi-vehicles.
- Multiple vehicle coordination and formation reconfiguration.
- Design algorithm and mobile robot simulation.
- Stability of the formation controllers.



Towards Continuously Reconfigurable Self-Designing Robotics
H. Lipson and J. B. Pollack
Brandeis University

- From Sims To Reality:
- Electro-Mechanical systems evolve in simulation for the task of locomotion
- Successful machines are replicated into reality using rapid prototyping equipment
- Robots perform and then melt for reuse



Underwater Robotics
Chairs: Sang-Rok Oh, D. Yoerger

In-situ Attitude Calibration for High Resolution Bathymetric Surveys with Underwater Robotic Vehicles

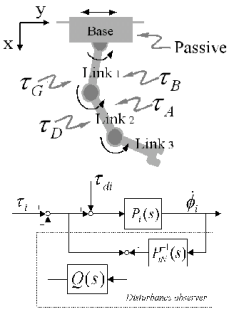
H. Singh[1], O. Pizarro[1], L. L. Whitcomb[2] and D. Yoerger[1]
[1]Woods Hole Oceanographic Institution and [2]Johns Hopkins University

- High Resolution Mapping from underwater vehicles is limited by attitudinal calibration offsets
- An in-situ methodology is proposed based on specific vehicles maneuvers
- The Jason ROV was used to collect data at archaeological sites of interest in the Mediterranean Sea
- Our technique improves upon the state of the art by an order of magnitude

Disturbance Observer-Based Robust Control for Underwater Robotic Systems with Passive Joints

G. B. Chung[1], K. S. Eom[1], B. J. Yi[1], I. H. Suh[1] and S. R. Oh[2]
[1]Hanyang University and [2]KIST, Korea

- Motivation and Problem Statement: Difficulty in control due many hydrodynamic forces, passive mode of underwater vehicle
- Techniques and Proposed Approach: Nonholonomic motion control, disturbance observer-based robust control
- Simulation Results: Robust motion control under passive joint
- Conclusions: Disturbance observer is good for robust control of underwater robot



An Inertial Navigation System for Small Autonomous Underwater Vehicles

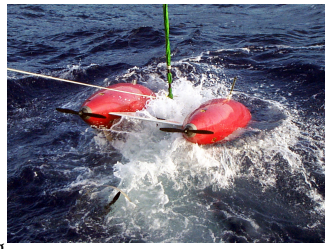
X. Yun, E. R. Bachmann and S. Arslan
Naval Postgraduate School

- Low-cost, small-size navigation system for AUV
- Integrated INS/GPS with asynchronous Kalman filter
- Land vehicle test validated the approach and achieved 15m accuracy
- Post-processing at-sea data confirmed the feasibility of the system

Fine Scale Seafloor Survey in Rugged Deep-Ocean Terrain with an Autonomous robot

D. Yoerger[1], A. Bradley[1], B. Walden[1], M. Cormier[2] and W. Ryan[2]
[1]Woods Hole Oceanographic Institution and [2]Lamont-Doherty Earth Observatory

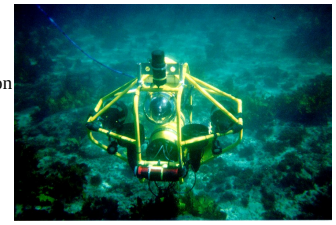
- Fully autonomous deep sea geological survey
- Survey in rugged terrain at 2600 meters depth
- Coregistered sonar bathymetry, video stills, and magnetics
- Automated navigation, track following, and bottom following



Autonomous Underwater Simultaneous Localisation and Map Building

Stefan B. Williams, Paul Newman, Gamini Dissanayake and Hugh Durrant-Whyte
ACFR, University of Sydney

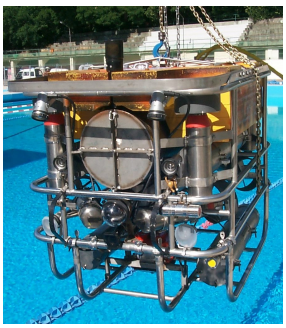
- The ACFR's Autonomous Underwater Vehicle - Oberon
- Underwater Simultaneous Localisation and Map Building
- Distributed AUV software control architecture
- Conclusions and future work



Guidance of unmanned underwater vehicles: experimental results

M. Caccia, G. Bruzzone and G. Veruggio
Consiglio Nazionale delle Ricerche

- Free space and environment-related guidance of UUVs
- Lyapunov-based task functions handling system kinematics
- Acoustic-based estimators of the operational variables
- Free-space maneuvering and wall-following pool trials

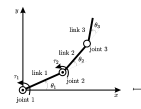


Nonholonomic Motion Planning
Chairs: Kostas Kyriakopoulos, Yoshi Nakamura

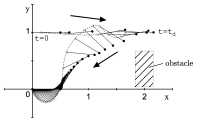
Design of a Desirable Trajectory and Convergent Control for 3-D.O.F. Manipulator with a Nonholonomic Constraint

T. Yoshikawa[1], K. Kobayashi[2] and T. Watanabe[1]
[1]Kyoto University and [2]Osaka University

- This paper is concerned with control of a 3 link planar underactuated manipulator. We have already proposed a control law that guarantees the convergence of its state to a given desirable trajectory and to any desired final point, and a design method of the desirable trajectory, but this method has a limitation on the location of the initial state.
- In this paper, we propose a design method of a desirable trajectory that starts from any given initial point, converges to any given desired final point, and on the way passes through any given desired passing point that can be specifyed rather freely.
- We did simulation to verify the validity of our approach. We show the convergence of the state of the system to the desirable trajectory which we design and finally to the origin even when there exists an initial error. We also show that we can derive a desirable trajectory that satisfies some given requirements such as avoiding obstacles.
- In this paper, we have propsed a design method of a desirable trajectory that satisfies given requirements much better than the previous method. We have presented simulation results in order to show the validity of this method.



3 link planar manipulator

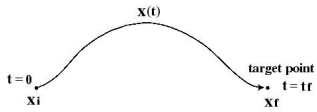


The behavior of link 3

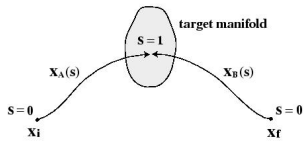
Near-Optimal Motion Planning for Nonholonomic Systems Using Time-Axis Transformation and Gradient Method

Makoto Iwamura, Motoji Yamamoto and Akira Mohri
Kyushu University

- In this study, an optimal motion planning scheme using time-axis transformation and gradient method is proposed for nonholonomic systems. The motion planning of nonholonomic systems is formulated as a nonlinear optimal control problem.
- The optimal control problem is too difficult to solve due to peculiar difficulty in the control of the nonholonomic systems. To alleviate the difficulty, we convert the optimal control problem to a bidirectional, fixed-domain optimal control problem by using quasi-time variable.
- A numerical algorithm which is based on the gradient method is developed for the optimal control problem and its convergence property with respect to final state error is proved.
- The optimal motion planning scheme is apllied to a 2-link planar free-joint manipulator. Simulation results show the effectiveness of the proposed optimal motion planning scheme.



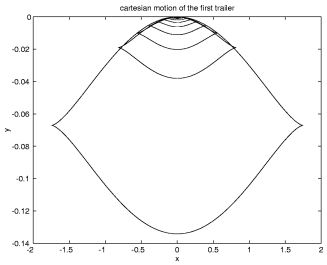
(a) original optimal control problem



(b) bidirectional optimal control problem

Stabilization of the general two-trailer system

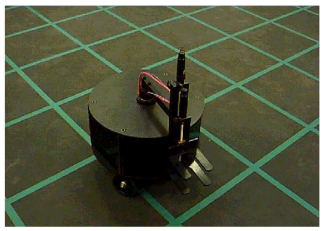
M. Vendittelli and G. Oriolo
Universit di Roma "La Sapienza"



Two Hybrid Control Schemes for Nonholonomic Robots

B. Young, J. Lawton and R. Beard
Brigham Young University

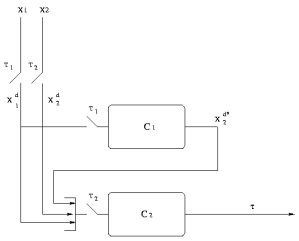
- The objective of the paper is to develop hybrid control strategies that regulate a differentially driven mobile robot to within a specified ball of a desired position and angle, where the ball is not greater than the variance of the sensor noise.
- Using the geometry of the problem, the maneuvers are broken into two components. One maneuver changes robot orientation and the other maneuver drives (or shoots) the robot toward its goal. By combining these two maneuvers, control laws are obtained which practically regulate a robot. The control laws use a dynamic model, which includes static friction.
- Two hybrid controls are derived which are shown to practically regulate a differentially driven mobile robot. Convergence proofs for both control laws are shown and guidelines for choosing the control gains are given.
- Hardware results show that the control strategies practically regulate a differentially driven mobile robot. In addition, the gains for the control strategies agreed with guidelines presented in the proofs.



Multi-Level Stabilizing Control of an Nonholonomic Vehicle and Its Discreate-Time Multirate Implementation

L. Palopoli, F. Conticelli and B. Allotta
Scuola Superiore Sant' Anna

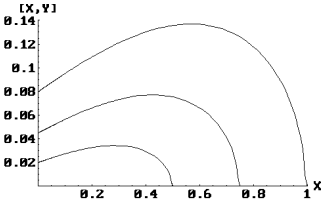
- The addressed problem is controlling the relative position between a moving target and an autonomous nonholonomic vehicle. The purpose is to analyse the performance loss when a continuous time control law is approximated by a multirate digital controller.
- The continuous time control law is synthesized using the backstepping approach. The control law structure naturally leads to a multilevel and multirate digital approximation.
- The controller performance is assessed by using a quadratic index, assigning different frequencies to each subcontroller.
- The results show that the outer frequency has a greater influence on the system performance than the inner one.



Small Radius Attainability Spheres for Driftless Non-holonomic Systems

Ignacy Duleba
Wroclaw University of Technology

- Design nonholonomic spheres for driftless nonholonomic systems centered at the origin of the Ph. Hall frame.
- Directions of motion (weighted Ph. Hall basis elements) produced with controls applying the generalized C-B-H-D formula.
- Simulations for unicycle-type robots.
- The analytic and constructive solution, applicable to motion planning.



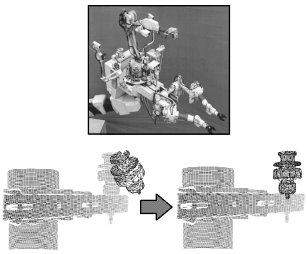
Applications of Sensing
Chairs: Fraichard Thierry, Katsushi Ikeuchi

Vision-Guided Autonomous Stair Climbing
Yalin Xiong and Larry Matthies
Jet Propulsion Laboratory

- Autonomous Navigation in Urban Environment
- Visual Recognition and Servoing
- Climbing Multi-flight Stairs Autnomously
- Robust in Various Lighting Conditions

Robust Localization for 3D Object Recognition Using Local EGI and 3D Template Matching with M-Estimators
Kentaro Kawamura[1], Kiminori Hasegawa[2], Osamu Yamashita[1], Yoichi Sato[2] and Katsushi Ikeuchi[2]
[1]Kyushu Electric Power Co., Inc. and [2]The University of Tokyo

- Develop a system which automatically aligns a robot with respect to an object
- Estimate object pose via segmentation-based method
- Evaluate pose using 3D template matching algorithm
- Our resulting system achieves a wide degree of convergence for object localization

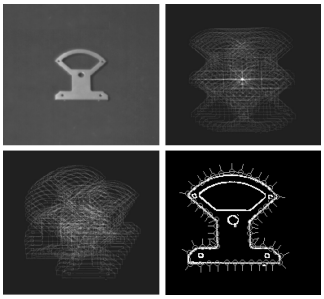


Development of image stabilization system for a remote operation of walking robots
R. Kurazume and S. Hirose
Tokyo Institute of Technology

- Need for an image stabilization system for a remote operation of walking robots.
- Combination of template matching with high speed camera and gyro sensors using MMX instruction set.
- Image stabilization experiments and body attitude control using 3-axis attitude estimation from images.
- Fast and low cost image stabilization system is developed, and the performance of attitude control using images is almost same as the case using an attitude sensor.

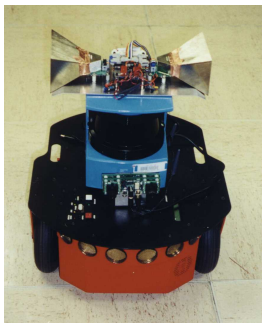
A Comparison of Four Fast Vision Based Object Recognition Methods
Markus Ehrenmann, Despina Ambela, Peter Steinhaus and Ruediger Dillmann
Universitat of Karlsruhe

- Programing by Demonstration requires robust and fast object recognition
- Outline of four methods (Pattern Mat., PCA, Graph Mat. and GHT)
- Analysis and Comparison
- Drawbacks/advantages can be used to cope with specific requirements



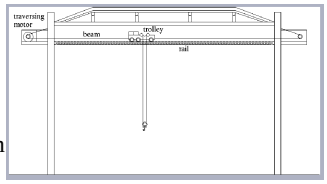
Robot-mounted through-wall radar for detecting, locating, and identifying building occupants
David G. Falconer, Robert W. Ficklin and Kurt G. Konolige
SRI International

- Detect and locate people moving behind building walls
- Mount pulse-Doppler radar on robot platform; develop signal prcessing software
- Building inhabitants detected and their activities classified
- Higher-power, lower-frequency radars needed for outdoor operations



Observing the Load Dynamic of an Overhead Crane with Minimal Sensor Equipment
Claudio Altafini[1], Ruggero Frezza[2] and Johann Galic[3]
[1]Royal Institute of Technology, [2]Universita di Padova and [3]ADtranz

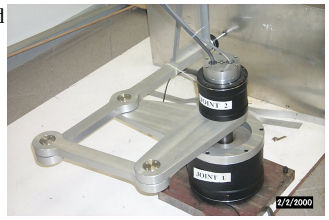
- Sensorless reconstruction of the load dynamics
- Estimation of the load torque on the traslational drive
- Application as back-up system
- Swing angle is observable



Neural Network Systems
Chairs: Marcelo H. Jr. Ang, Sukhan Lee

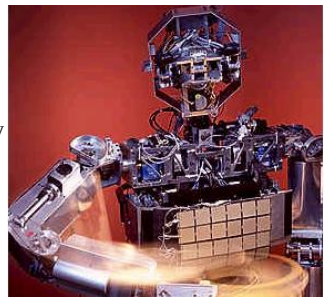
Neural Network Controller for Constrained Robot Manipulators
Shenghai Hu, Marcelo Ang Jr. and Hariharan Krishnan
The National University of Singapore

- Force and Motion Control using nonlinear transformatrion in task space to achieve decoupled dynamics
- New training signal for neural network compensation of errors leading to new learning laws
- Real-time implementation on experimental robot in lab
- Improved motion tracking



Tuning of Neural Oscillators for the Design of Rhythmic Motions
A. M. Arsenio
Massachusetts Institute of Technology

- No automatic parameter tuning methods available to date
- Internal dynamics analysis - Describing Functions, Symmetry
- Results for oscillator connected to (non) linear systems
- Automatic tuning using algebraic equations



Fast and Efficient Incremental Learning for High-dimensional Movement Systems
S. Vijayakumar and S. Schaal
University of Southern California

- Local linear regression spanned by few univariate regressions
- Adjusts local kernel metrics based on local information
- Computational complexity linear in number of inputs
- Handles redundant & high dimensional data efficiently

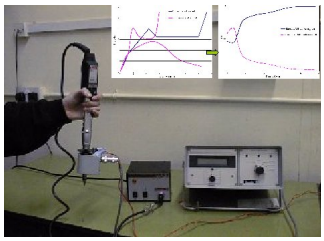
Vision-based Motion Planning For A Robot Arm Using Topology Representing Networks
Y. Fu[1], R. Sharma[1] and M. Zeller[2]
[1]Pennsylvania State University and [2]H&F Aeronautical Tech., Inc.

Stabilizing and Robustifying the Error Backpropagation Method in Neurocontrol Applications
M. O. Efe and O. Kaynak
Bogazici University

- Stabilization and Robustification
- Variable Structure Systems
- Neurocontrol
- Robotics

Radial Basis Artificial Neural Networks for Screw Insertions Classification
B. Lara, L. D. Seneviratne and K. Althoefer
King's College London

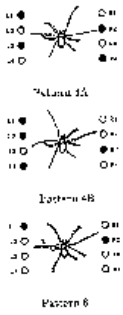
- Monitoring of screw insertions is vitally important for the automation of this process
- Radial Basis Function Neural Networks are used to distinguish successful from failed insertions
- After modest training, the network correctly classifies insertions
- A successful strategy for monitoring screw fastenings is presented



Locomotion
Organizers & Chairs: Hirofumi Miura, Shigeo Hirose

Research on Locomotion
Hirofumi Miura
Kogakuin University

- Researches on 2,4,6,8 Legged Robots will be discussed.
- There are Many Different Motivations for Development of Legged Robot.
- Main Subject will be Researche on The Biped.
- Video Tape of Examples of Legged Robots will be shown in The Talk.

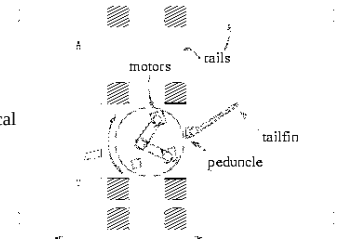


Study on Quadruped Walking Robot in Tokyo Institut of Technology- Past, Present and Future
Shigeo Hirose and Keisuke Kato
Tokyo Institute of Technology

A Minimally Actuated Hopping Rover for Exploration of Celestial Bodies
E. Hale, N. Schara, J. W. Burdick and P. Fiorini
California Institute of Technology

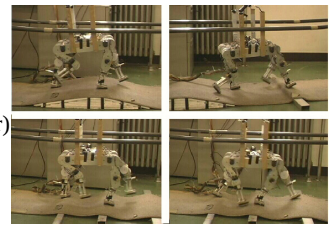
Experiments in Carangiform Robotic Fish Locomotion
R. Mason and J. W. Burdick
California Institute of Technology

- Fishlike swimming robot
- Three-link
- Fish swims in realistic fluid-mechanical regime
- Most effective swimming gaits found



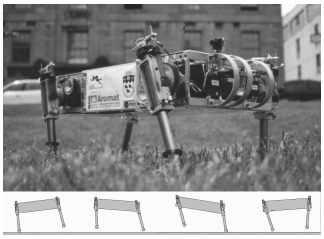
Adaptive Dynamic Walking of the Quadruped on Irregular Terrain - Autonomous Adaptation Using Neural System Model
Hiroshi Kimura and Yasuhiro Fukuoka
University of Electro-Communications, Japan

- Autonomous Adaptation to Irregular Terrain
- Neural System Model
- CPG(Central Pattern Generator) and Reflexes via CPG
- Realization by Very Simple Method



Stable Running in a Quadruped Robot with Compliant Legs
D. Papadopoulos and M. Buehler
McGill University

- Mechanically simple, autonomous mobile robot with only four motors and four compliant legs
- Dynamically stable, robust locomotion with new (task level) open and closed loop controllers
- Body pitch and roll stability without active control
- Experimental bounding at 1.2 m/s



Cooperative Robots
Organizers & Chairs: Kazuhiro Kosuge, Daniela Rus

Distributed Manipulation of Multiple Objects using Ropes
B. R. Donald, L. Gariepy and D. Rus
Dartmouth College

- Algorithms for manipulating multiple (unknown) objects using ropes
- Details of binding, ratcheting, and flossing algorithms
- Analysis of binding algorithm
- Experimental procedures with three robots and results

Distributed Robot Helpers Handling a Single Object in Cooperation with a Human
Y. Hirata and K. Kosuge
Tohoku University

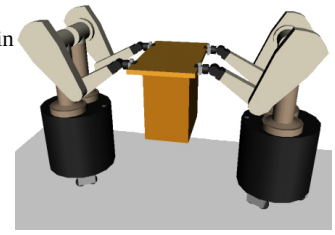
- Human-Robots Cooperation
- Distributed Mobile Robot Helpers
- Mobile Robot is Controlled as if it has a Caster-like Mechanism
- Human Transport a Refrigerator in Cooperation with Multiple Robots

Knowledge Sharing and Cooperation of Autonomous Robots by Intelligent Data Carrier System
D. Kurabayashi and H. Asama
The Institute of Physical and Chemical Research (RIKEN)

- Effective execution of tasks by autonomous robots without map.
- An algorithm to acquire and share knowledge autonomously.
- Verification by simulations and experiments.

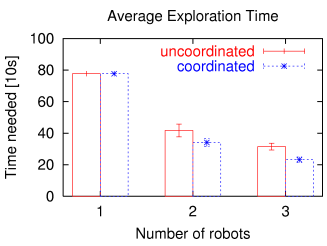
The Augmented Object Model: Cooperative Manipulation and Parallel Mechanism Dynamics
Kyong-Sok Chang, Robert Holmberg and Oussama Khatib
Stanford University

- Branching Mechanisms
- Operational Space Closed-chain Dynamics
- Closed-chain Task/Posture Behavior Control
- Application: Powered-Caster Vehicle



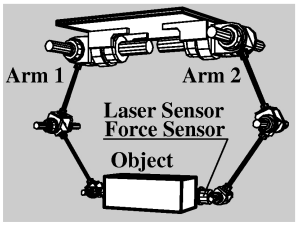
Collaborative Multi-Robot Exploration
W. Burgard[1], M. Moors[2], D. Fox[3], R. Simmons[3] and S. Thrun[3]
[1]Universitt Freiburg, [2]University of Bonn and [3]Carnegie Mellon University

- Teams of mobile robots need to be coordinated whenever they explore or map unknown environments.
- Our approach coordinaties the robots by trading off the utility of target locations and the costs of moving there.
- The approach has been implemented and evaluated on real robots and in simulation runs.
- The coordination yields a significant speed-up compared to previous approaches.



Experiments on Capturing a Floating Object by Two Flexible Manipulators
M. Yamano, A. Konno and M. Uchiyama
Tohoku University

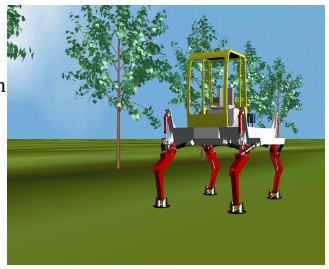
- hybrid position/force control of two manipulators
- vibration suppression of flexible links
- procedure of capturing a floating object in 3D space
- experiments using 7-DOF flexible manipulators



Mechatronics
Organizers & Chairs: Manfred Hiller, Okyay Kaynak

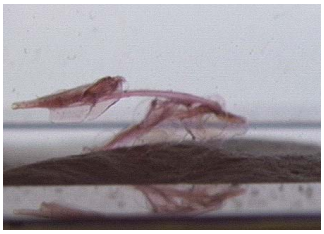
An Overview of Mechatronics
Manfred Hiller
Gerhard-Mercator-Universitt-Duisburg

- Large Scale and Heavy Mobile Manipulators in Unstructured Terrain
- Design, Modelling and Simulation as Mechatronic Systems
- ALDURO: Anthropomorphically Legged and Wheeled Duisburg Robot
- Virtual Prototyping for a wide Class of Heavy Manipulators



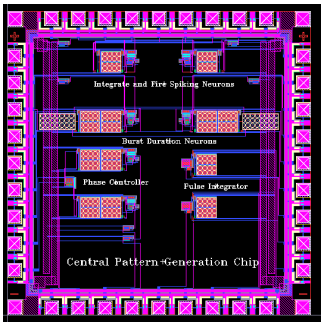
Kinematics of Gel Robots made of Electo-Active Polymer PAMPS Gel
M. Otake, M. Inaba and H. Inoue
The University of Tokyo

- To control elastic robots made of ionic gel
- Kinematic model based on chemical reaction
- Simulation and experimental deformation of the gel
- Applicable to various shapes of the gel and various types of the electric field



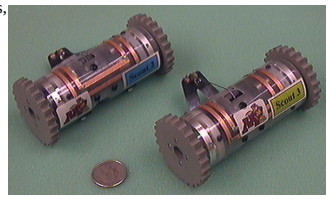
Toward Biomorphic Control Using Custom aVLSI CPG Chips
M. A. Lewis[1], R. Etienne-Cummings[2], A. H. Cohen[3] and M. Hartmann[4]
[1]Iguana Robotics, Inc.,[2] John's Hopkins University,[3] University of Maryland, and [4] CA. Institute of Technology

- Future robots will need powerful, miniature controllers.
- An adaptive CPG chip was designed following biological principles.
- Chip was used to control an under-actuated, running robot leg.
- Successful 1st demonstration of robotic control using an adaptive CPG chip.



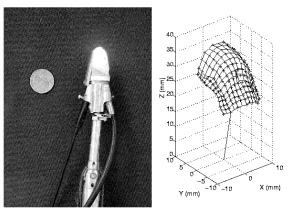
A Miniature Robotic System for Reconnaissance and Surveillance
D. F. Hougen, S. Benjaafar, J. C. Bonney, J. R. Budenske, M. Dvorak, M. Gini, H. French, D. G. Krantz, P. Y. Li, F. Malver, B. Nelson, N. Papanikolopoulos, P. E. Rybski, S. A. Stoeter, R. Voyles and K. B. Yesin
University of Minnesota

- The objective is to construct a miniature robot that can roll and hop.
- Several sensors (e.g., video, magnetometers, tiltmeters, etc.) were integrated along with two CPUs and various communication units in each robot. The robot is 110mm long and 40mm wide.
- The robot can clear various obstacle courses and its jump has an average height of 200mm.
- It is a powerful design with a lot of potential.



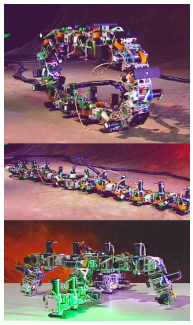
The performance of a deformable-membrane tactile sensor:basic results on geometrically-defined tasks
Dimitris Hristu[1], Nicola J. Ferrier[2] and Roger W. Brockett[3]
[1]University of Maryland, [2]University of Wisconsin and [3]Harvard University

- Rigid, force-sensing devices are not well suited for the study of manipulation tasks.
- A deformable sensor, capable of estimating the shape of the tactile surface.
- Quantitative assesment: a battery of generally-applicable tactile sensing experiments.
- Numerical statements defining contact localization, spatial resolution, curvature discrimination.



PolyBot: a Modular Reconfigurable Robot
Mark Yim, David G. Duff and Kimon D. Roufas
Xerox Palo Alto Research Center

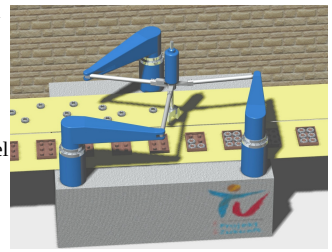
- N-modular systems may be versatile, robust and inexpensive
- PolyBot is 2-modular with up to 32 modules built (so far)
- Demonstrated locomotion, and distributed manipulation and control
- 1st system to self-reconfigure into topologically different gaits



Parallel Manipulators
Chairs: David Cannon, F. C. Park

A Mixed Elastic and Rigid-Body Dynamic Model of an Actuation Redundant Parallel Robot with High-Reduction Gears
S. Kock and W. Schumacher
Technical University Braunschweig

- New redundantly actuated parallel manipulator with gearboxes
- Rigid-body cartesian model for motion d.o.f.
- Decoupled elastic null space model for force d.o.f.
- Experimental validation allowing full feedback control



Control of a Fast Parallel Robot with a Redundant Chain and Gearboxes: Experimental Results
S. Kock and W. Schumacher
Technical University Braunschweig

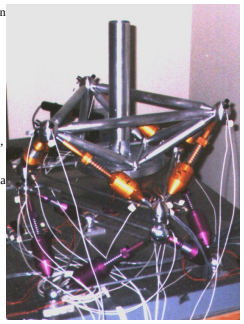
- Parallel manipulator prototype with force redundancy
- Internal force sensors, feedback control of null space torques
- Experimental results with high accelerations (> 10 g)
- Video shows high-speed pick-and-place application

Application of a Nonlinear Adaptive Controller to a 6 dof Parallel Manipulator
M. Honegger, R. Brega and G. Schweitzer
Swiss Federal Institute of Technology

- The dynamics of this parallel manipulator is highly nonlinear
- A nonlinear motion controller was successfully applied
- Adaptive algorithms identify dynamic parameters on-line
- A fast CPU and a novel hard real-time OS were required

Identification and Decoupling Control of Flexure Jointed Hexapods
Yixin Chen and John McInroy
University of Wyoming

- Flexure jointed hexapods, or Stewart platforms, are developed for micro-precision applications. A flexure joint bends material to achieve motion, rather than sliding or rolling across two surfaces. This does eliminate friction and backlash, but adds spring dynamics and limits the workspace. The linearized dynamic model is a highly coupled MIMO model.
- Decoupling the MIMO model into independent channels can greatly simplify the compensator design, and facilitate SISO adaptive and nonlinear algorithms. Previous decoupling methods impose severe constraints on the allowable geometry, workspace, and payload. The new approach removes these constraints, thus greatly expanding the potential applications.
- The new decoupling method is based on diagonalizing the joint space mass-inertia matrix. An identification algorithm is introduced to identify the joint space mass-inertia matrix using payload accelerations and base forces. This algorithm can be used for precision payload calibration, thus improving performance and removing the labor required to design the control for different payloads.
- The new decoupling algorithm is experimentally compared to earlier techniques. These experimental results indicate that the new approach is practical, and improves performance. Using the new decoupling method, nearly 20dB decoupling across all frequencies is achieved.



Elasto-Kinematic Analysis of Parallel Mechanisms
J. Kim[1], F. C. Park[1] and M. Kim[2]
[1]Seoul National University and [2]Korea Institute of Science and Technology

Optimal Force Distribution Applied to Robotic Crane with Flexible Cables
Wei-Jung Shiang, David Cannon and Jason Gorman
Pennsylvania State University

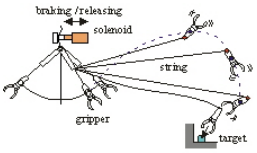
Applications of Grasping
Chairs: Zexiang Li, Kimon Valavanis

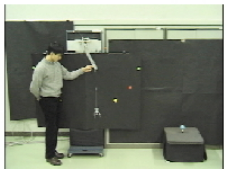
Flexible Object Manipulation by Dual Manipulator System
T. Fukuda, T. Matsuno and F. Arai
Nagoya University

- Dual 6 D.O.F direct drive manipulator
- The manipulator ties the rope around a cylinder
- The manipulator confirms having a rope in both hands by the force sensor
- A flexible object model and a vision system are used to recognize the shape of the rope

Casting Manipulation (Braking Control for Catching Motion)
H. Arisumi, K. Yokoi and K. Komoriya
Mechanical Engineering Laboratory (MEL)

- A manipulator system with a string for catching inaccessible object
- The motion of the gripper is controlled by applying force to the gripper
- The gripper can catch the object by control of the string movement
- The desired motion of the gripper can be realized by braking control





The Design and Implementation of a Robot Assisted Crucible Charging System
V. A. Sujan[1], S. Dubowsky[1] and Y. Ohkami[2]
[1]Massachusetts Institute of Technology and [2]Tokyo Institute of Technology

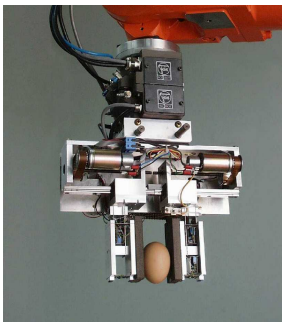
- Manual packing of silicon nuggets in CZ wafer production is not practical
- Robotic system consisting of gripper, vision, packing algorithm and hybrid control developed
- 36 inch diameter crucibles packed in about 4 1/2 hours with the robotic system
- The integrated system achieves high production rates, required precision and cost effectiveness

Grasp Force Control in Two-Finger Grippers with Pneumatic Actuation
Erika Ottaviano, Maria Toti and Marco Ceccarelli
Universit degli Studi di Cassino

- The aim of the paper is to design a force control for two-finger gripper with pneumatic actuation by using standard components in order to maintain the simplicity of the mechanical design and operation of the gripper with a low-cost layout.
- The control system based on PI scheme makes the gripper capable to maintain the grasp with a prescribed force in presence of significant movements of the gripper or impulsive external forces.
- Experimental tests have been carried out at the Laboratory of Robotics and Mechatronics in Cassino.
- Practical feasibility of two-finger grippers with force controlled pneumatic actuation is proved.

Sensory Gripping System for Variable Products
W. Friedrich, H. Nicholls and P. Lim
Industrial Research Ltd.

- Handling of delicate objects
- Gripper design philosophy
- Grasp establishment
- Experimental results



Design and Analysis of a Reconfigurable Robotic Gripper for Limp Material Handling
R. Kolluru, K. P. Valavanis, S. A. Smith and N. Tsourveloudis
University of Southwestern Louisiana

Teleoperation 1
Chairs: Antal Bejczy, R. Fournier

Machine-Assisted Teleoperation of Arm Manipulators in a Complex Environment
I. Ivanisevic and V. Lumelsky
University of Wisconsin, Madison

A Telerobot Control System for Accident Response
Robert J. Anderson, David L. Shirey and William D. Morse
Sandia National Laboratory

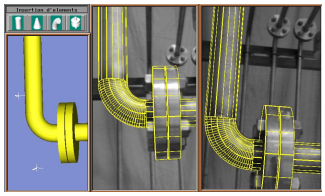
- Paper describes the control system implemented on a remotely controlled teleoperation platform used for accident response
- Systems utilizes SMART (Sandia's Modular Architecture for Robotics and Teleoperation) to implement telerobotic behaviors.
- Implemented behaviors include: dual arm coordinated control, .camera frame based operation, automatic tool pick-ups, and straight-line motion.
- The final system is faster, safer, more flexible and less fatiguing for the operator.

Effective Vehicle Teleoperation on the World Wide Web
Sebastian Grange[1], Terrence Fong[2] and Charles Baur[1]
[1]Ecole Polytechnique Federale de Lausanne and [2]Carnegie Mellon University

- Existing vehicle teleoperation interfaces are cumbersome and require extensive training to use.
- Web-based tools offer an attractive alternative, yet they raise numerous research issues and impose new constraints on system design.
- Our system, the WebDriver, enables safe and efficient vehicle teleoperation via an active user interface and safeguarded autonomy.
- The WebDriver allows a wide range of users to remotely drive in dynamic, unknown, and unstructured environments.

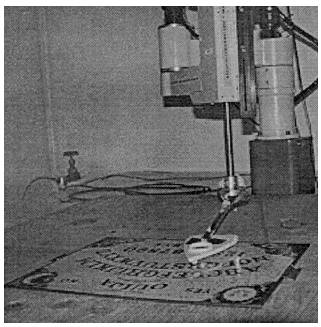
Using Structural Knowledge for Interactive 3-D Modeling of Piping Environments
P. Even, R. Fournier and R. Gelin
French Atomic Energy Commission

- Integration of structural knowledge through specialized workshops
- Goal : speed up an interactive modeling tool
- Design and test of a piping workshop on realistic sites
- Elbow automatic insertion and interactive edition



Collaborative Teleoperation on the Internet
K. Goldberg, S. Bui, B. Chen, B. Farzin, J. Heitler, D. Poon, R. Solomon and G. Smith
University of California, Berkeley

- This paper describes a systems that allows a distributed user group to teleoperate an industrial robot arm via the Internet
- We experiment with a control model where motion commands from multiple simultaneous users are aggregates in real time using java
- http://ouija.berkeley.edu



Internet Based Operations for the Mars Polar Lander Mission
P. Backes[1], K. Tso[2], J. Norris[1], G. Tharp[2], J. Slostad[1], R. Bonitz[1] and K. Ali[1]
[1]Jet Propulsion Laboratory, California Institute of Technology and [2]IA Tech Inc.

- Internet-based operations for the MPL mission using the Web Interface for Telescience (WITS)
- Java2, Java3D, Java Cryptography, NASA Public Key Infrastructure
- Successful field test in Death Valley, California, using the MPL mockup
- With WITS, the MPL mission was the first planetary mission to utilize Internet-based ground operations.