t h u r s d a y

April 27, 2000

Thursday, April 27th

Mobile Robots 2
Chairs: Yutaka Kanayama, Yangsheng Xu

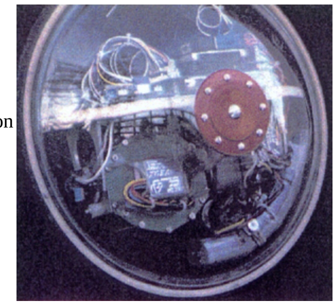
Robust Damping Control of Wheeled Mobile Robots
S. Lin and A. A. Goldenberg
University of Toronto

- Control of wheeled mobile robots with unknown dynamics and disturbances;
- Robust Damping Controller (RDC) proposed, global uniform boundedness guaranteed;
- Illustration of RDC's effectiveness through simulations and comparison;
- Simple controller structure and low computation cost.


MR-1 in Actions
(Engineering Services Inc., Canada)

Path Following of a Single Wheel Robot
Kwok Wai Au and Yangsheng Xu
The Chinese University of Hong Kong

- Development of an autonomous single wheel robot
- Model the robot's dynamics and study its nonholonomic nature and gyroscopical stabilization
- Design a velocity/torque control law to solve the path following problem
- Develop a controller for the robot following a straight line with balance



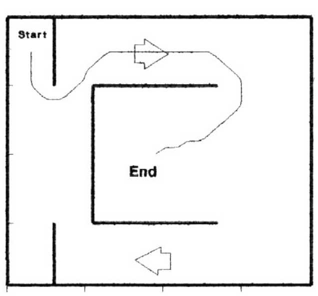
Interactive Motion Planning Using Hardware Accelerated Computation of Generalized Voronoi Diagrams
K. Hoff, T. Culver, J. Keyser, M. Lin and D. Manocha
University of North Carolina

- Fast motion planning in both static and dynamic environments
- Use discrete approximations of generalized Voronoi diagrams computed by polygon rasterization graphics hardware and standard Z-buffer
- Real-time path planning in a complex dynamic environment composed of more than 140,000 polygons and upto one order of performance improvement near narrow passages in configuration space
- Extensible to articluated and deformable objects

Path Tracking Control of Tracked Vehicles
M. Ahmadi, V. Polotski and R. Hurteau
cole Polytechnique Montral

Motion Planning in the Presence of Directional and Obstacle Avoidance Constraints Using Nonlinear, Anisotropic, Harmonic Potential Fields
Ahmad Masoud and Samer Masoud
Jordan University of Science and Technology

- A novel and complete motion planning method is suggested for guiding an agent to a target set along an obstacle-free trajectory while regulating the direction along with which motion is allowed to proceed inside the workspace.
- Nonlinear, Anisotropic, Harmonic potential fields are used for constructing the planner.
- Simulation experiments to verify the ability of the suggested planner to work in the presence of joint avoidance and directional constraints are provided.



Control of a Nonholonomic System with a Drift Term
F. Matsuno and K. Saito
Tokyo Institute of Technology

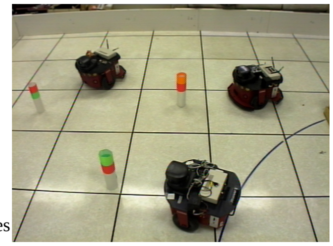
Localization

Chairs: George Bekey, Gamini Dissanayake

Collective Localization: A distributed Kalman filter approach to localization of groups of mobile robots

S. I. Roumeliotis and G. A. Bekey
University of Southern California

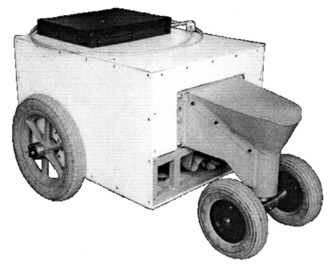
- Improved localization accuracy for teams of mobile robots
- Distributed multi-robot sensor fusion schema - Kalman filtering
- Reduced position uncertainty for the case of 3 mobile robots
- Shared group knowledge appears as position estimates inter-dependencies



Algorithms and Architectures for Acoustic Localization based on Microphone Array in Service Robotics

E. Mumolo[1], M. Nolich[1] and G. Vercelli[2]
[1]University of Trieste and [2]University of Genoa

- Surveillance and transportation tasks in indoor environments
- Cross-correlation and Neural Networks approaches using a 4 element Linear Microphone Array
- Real-time operation with a distributed architecture
- Absolute localization error with a true speaker is below 50cm



Extracting Topology-Based Maps from Gridmaps

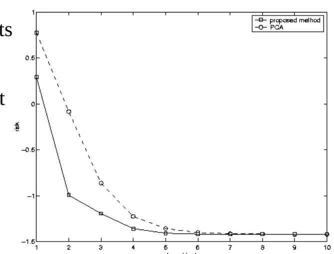
E. Fabrizi[1] and A. Saffiotti[2]
[1]Universit di Roma Tre and [2]Orebro University

- New type of maps
- Represent the topology induced by the shape of the free space
- Extracted by image processing from fuzzy occupancy grids
- Extraction is fast and robust

Supervised Linear Feature Extraction for Mobile Robot Localization

N. Vlassis[1], Y. Motomura[2] and B. Krose[1]
[1]University of Amsterdam and [2]Electrotechnical Laboratory

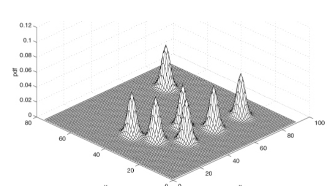
- WHAT? Extract 'task-relevant' features from sensor measurements
- WHY? Because PCA and related methods are task-irrelevant
- HOW? By Supervised Projection Pursuit optimizing Mutual Information
- RESULT? Improved average robot localization performance



Bayesian estimation and Kalman filtering: A unified framework for Mobile Robot Localization

S. I. Roumeliotis and G. A. Bekey
University of Southern California

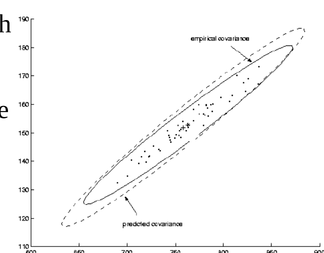
- Filter out odometric error & reduce landmark related uncertainty
- Bayesian decision making & Kalman filter estimation
- Global localization in an office environment
- Optimal fusion of proprioceptive and exteroceptive measurements



Computing the Sensory Uncertainty Field of a Vision-based Localization Sensor

A. Adam, E. Rivlin and I. Shimshoni
Technion - Isreal Institute of Technology

- Sensor accuracy varies with place
- Goal: obtain a performance map
- Method of prediction
- Statistical validation



Control 2
Chairs: Jim Bobrow, Genther Schmidt

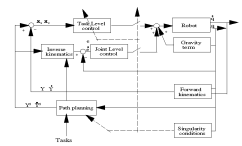
Energy-efficient Motion Control of a Hydraulic Manipulator

J. Mattila and T. Virvalo
Tampere University of Technology

Hybrid System Design for Singularityless Task Level Robot Controllers

J. Tan and N. Xi
Michigan State University

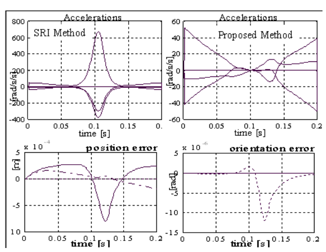
- Overcoming singularities in task level robot controller.
- A hybrid system for analysis and design of the controller
- Implementing and testing on a PUMA560 robot
- First stable task level controller for robot to pass singularities



Bordered Matrix for Singularity Robust Inverse Kinematics: AMethodological Aspect

J. Foret[1], M. Xie[1] and J. G. Fontaine[2]
[1]Nanyang Technological Univeristy and [2]Ecole Nationale Superieure D'Ingenieurs de Bourges

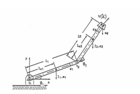
- Motivations: In the context of remote or tele-operated control it is important to insure the feasibility of the desired motion of a robot. Therefore, we present in this paper a new way to make a serial manipulator passing through singular configurations by insuring the continuity of the acceleration and velocity profiles.
- Proposed Approach: The author used the properties of bordered matrices to insure the smooth profile of the acceleration profile. The method presented relies on the knowledge of a complete singular value decomposition of the Jacobian of the system, and is concise enough to expect real-time applications.
- Simulation Results: In the results, are compared the Singular Robust Inverse (SRI) method and the proposed one named Bordered Matrix Singular Robust Inverse (BMSRI). These two method, have been compared since they offer almost the same simple computational aspect and amount of position error. When the proposed method is use, the acceleration profile and position/orientation error at the singular point gives almost 0, whereas using the SRI both reach their maximum.

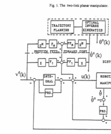


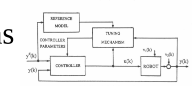
Preview and Stochastic Controllers for Motion Control of Robotics Manipulator with Control Input Constraints

M. Negm
Technical College at Dammam

- Optimal Preview Controller
- Stochastic Adaptive Controller
- Simulation Results
- Recomendations and Conclusions



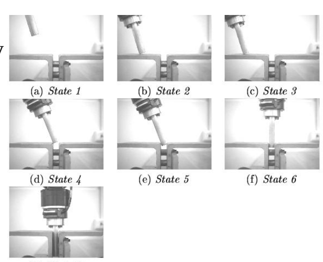




Hybrid Force/Velocity Discrete Event Controller Synthesis for Assembly Tasks with Friction

D. Austin[1] and B. McCarragher[2]
[1]NADA and [2] Australian National University

- Discrete event for error recovery
- Force control gives compliance
- Velocity control overcomes friction
- Robust to 50mm,10degree errors



(a) *State 1* (b) *State 2* (c) *State 3* (d) *State 4* (e) *State 5* (f) *State 6* (g) *State 7*

Observer Based Coordinated Adaptive Robust Control of Robot Manipulators Driven by Single-Rod Hydraulic Actuators

F. Bu and B. Yao
Purdue University

- Control of a hydraulic arm is difficult due to strong coupling effects and rich nonlinear dynamics
- Physical model based control approach is used to explicitly take into account the strong coupling among various joints
- Adaptive robust control approach is employed to improve tracking accuracy in the presence of model uncertainties
- Simulation and experimental results illustrate the proposed algorithm

Robot Dynamics

Organizers & Chairs: Roy Featherstone, David Orin

Robot Dynamics: Equations and Algorithms

R. Featherstone[1] and D. E. Orin[2]
[1]University of Wales and [2]Ohio State University

- Reviews accomplishments in robot dynamics research
- Equations given for most important computations
- Recursive Newton-Euler, Composite-Rigid-Body, and Articulated-Body Algorithms
- Closed-loop systems & global analysis techniques discussed

for $i = 1$ **to** N **do**
$\mathbf{v}_i = {}^i\mathbf{X}^M_{\lambda(i)}\,\mathbf{v}_{\lambda(i)} + \mathbf{h}_i\,\dot{\mathbf{q}}_i;$
$\mathbf{a}_i = {}^i\mathbf{X}^M_{\lambda(i)}\,\mathbf{a}_{\lambda(i)} + \dot{\mathbf{h}}_i\,\dot{\mathbf{q}}_i + \mathbf{h}_i\,\ddot{\mathbf{q}}_i;$
$\mathbf{f}^J_i = \mathbf{I}_i\,\mathbf{a}_i + \mathbf{v}_i \times \mathbf{I}_i\,\mathbf{v}_i - \mathbf{f}^x_i$
end
for $i = N$ **to** 1 **do**
$\boldsymbol{\tau}_i = \mathbf{h}^T_i\,\mathbf{f}^J_i;$
if $\lambda(i) \neq 0$ **then** $\mathbf{f}^J_{\lambda(i)} = \mathbf{f}^J_{\lambda(i)} + {}^{\lambda(i)}\mathbf{X}^F_i\,\mathbf{f}^J_i$
end

Practical Models for Practical Flexible Arms

W. J. Book[1] and K. Obergfell[2]
[1]Georgia Institute of Technology and [2]Seagate Technology

Computational Robot Dynamics Using Spatial Operators

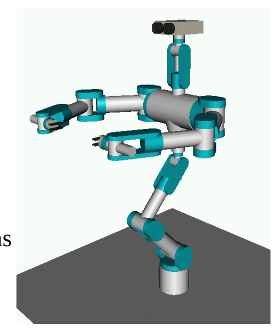
A. Jain and G. Rodriguez
California Insitute of Technology

- Computational dynamics techniques for robotic systems
- A review of the Spatial Operator Algebra framework
- A look at standard dynamics problems, as well as novel ones, eg. diagonalized dynamics
- Open areas of research such as sensitivity analysis and optimization

Operational Space Dynamics: Efficient Algorithms for Modeling and Control of Branching Mechanisms

Kyong-Sok Chang and Oussama Khatib
Stanford University

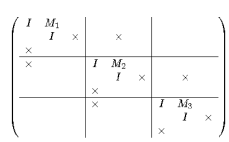
- Branching Mechanisms
- Task/Posture Behavior Control
- Modified Spatial Notation
- Efficient Recursive O(n) Algorithms



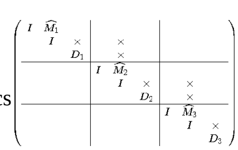
Forward Dynamics Algorithms for Multibody Chains and Contact

D. K. Pai, U. M. Ascher and P. G. Kry
University of British Columbia

- Framework for derivation of forward dynamics algorithms.
- Formulate augmented matrix; block matrix elimination.
- Derives many algorithms: existing (ABM, CRBM) & new (contact evolution). Stability.
- Framework unifies many forward dynamics algorithms and contact evolution.



$\Longrightarrow$



Visual Modeling and Reconstruction
Organizers & Chairs: Shree Nayar, Jean Ponce

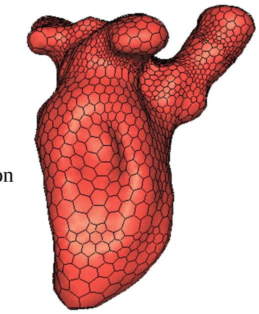
Sensors for Robot Vision

Shree Nayar
Columbia University

Surface Simplex Meshes for 3D Medical Image Segmentation

J. Montagnat, H. Delingette, N. Scapel and N. Ayache
INRIA, Sophia-Antipolis

- Deformable surface based modeling and segmentation of 3D medical images
- Shape and global regularizing constraints, adaptable topology, automatic initialization
- CT, MRI and US images segmentation
- Fast and robust 3D images segmentation



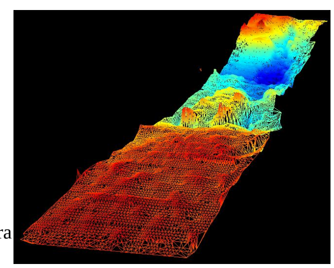
Constructing Geometric Object Models From Images

J. Ponce, Y. Genc and S. Sullivan
University of Illinois

Terrain Reconstruction for Ground and Underwater Robots

R. Mandelbaum, G. Salgian, H. Sawhney and M. Hansen
Sarnoff Corporation

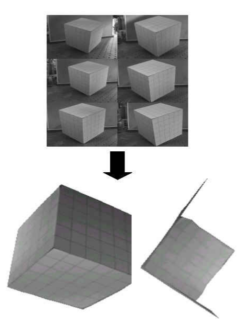
- New image-processing for egomotion and terrain structure recovery
- Correlation-based, iterative, multi-resolution approach
- Suited for outdoor ground-based and underwater scenes
- Can accommodate both single-camera and multiple-camera rigs



Self-calibration using the linear projective reconstruction

J. E. Ha[1], J. Y. Yang[2] and I. S. Kweon[1]
[1]Korea Advanced Institute of Science and Technology (KAIST) and
[2]Samsung Electronics Co.

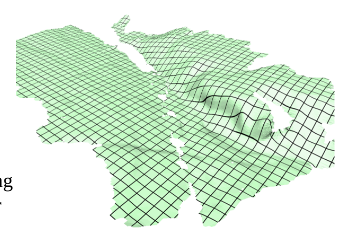
- Self-calibration algorithm that only requires a linear projective reconstruction
- Linear initialization method based on the property of the absolute quadric
- Adding another constraint on the principal point to improve robustness to the image noise



3-D Map Reconstruction from Range Data

Daniel Huber, Owen Carmichael and Martial Hebert
Carnegie Mellon University

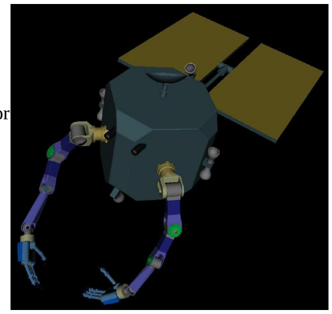
- Building large 3-D maps from sensor data
- Matching 3-D patches using local signatures fro registration of partial views of the environment
- The techniques have been applied to 11 different sensors (passive and active) and has been used for building models of individual objects, indoor environments, large terrain maps, and sonar maps



Human Frontier Environments
Organizers & Chairs: Paolo Fiorini, Gerd Hirzinger

Advances in Orbital Robotics
G. Hirzinger, B. Brunner, R. Lampariello, K. Landzettel, J. Schott and B. M. Steinmetz
German Aerospace Center (DLR)

- ROTEX - the first remotely controlled space robot
- Free-flying space robots - Experiences with the lab demonstrator ESS and the Japanese ETS VII
- DLR's task level, sensor-based teleprogramming system MARCO
- Future perspectives in space robotics

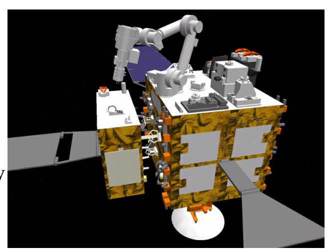


Ground Mobility Systems for Planetary Exploration
P. Fiorini
California Institute of Technology

- Summary of the state of the art of ground mobility of Planetary exploration
- The aim is to increase scientific return using different mobility paradigms
- A promising new approach is hopping, capable of large obstacle avoidance
- Mobility must be optimized depending on terrain type and exploration scope.

Experience and Lesson Learned From the ETS-VII Robot Satellite Mission
Mitsushige Oda
National Space Development Agency of Japan

- The world first satellite mounted space robot system, launched in Nov.1997
- Robot arm is tele-operated from the on-ground control station in Japan
- Automated satellite capture and many other experiments were conducted
- Tech. to be used in operation of the space station



Behavior-Based Control for Autonomous Underwater Exploration
J. Rosenblatt, S. Williams and H. F. Durrant-Whyte
University of Sydney

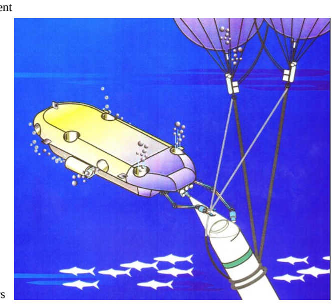
- Autonomous control of an underwater vehicle for surveillance of coral reefs
- Sonar and vision-based behaviors combined by fuzzy logic and utility fusion arbiters
- Behaviors selected by task-level controller according to mission plan
- AUV follows targets, maintains altitude, and avoids collisions in natural coastal terrain

Enhanced Mars Rover Navigation Techniques
R. Volpe, T. Estlin, S. Laubach, C. Olson and J. Balaram
California Institute of Technology

- Mars rover operations are constrained by infrequent communication, unknown terrain, low power, and limited computing.
- Robust navigation through natural Mars terrain is needed to maximize science return by missions.
- Progress has been made in four relevant areas: position estimation, visual localization, sensor constrained path planning, and dynamic activity planning.
- Ongoing simulation and experimentation demonstrate improved performance and autonomy.

Underwater Robotics
J. Yuh
University of Hawaii

- During 1990s, numerous worldwide research and development activities have occurred in underwater robotics, especially in the area of autonomous underwater vehicles (AUVs). As the ocean attracts great attention on environmental issues and resources as well as scientific and military tasks, the need for and use of underwater robotic systems has become more apparent. This paper surveys some key areas in current state-of-the art underwater robotic technologies.
- This paper focuses on several sub areas of underwater robotics: Dynamics, Control, Navigation and Sensors, Communications, Power systems, Pressure Hulls, and Manipulators.
- Evaluation and comparison on various subsystems are presented in this paper.
- While not providing a complete survey, it is hoped that this survey can help provide a direction for future advancements in the subject area and attract more researchers and potential users of underwate robots.

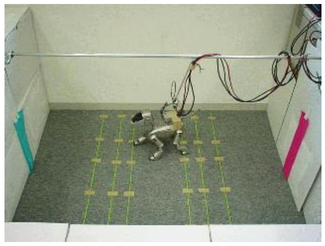


Legged Locomotion 2
Chairs: Marco Ceccarelli, Eiji Nakano

Evolving Robot Gaits with AIBO

G. S. Hornby[1], S. Takamura[2], J. Yokono[2], O. Hanagata[2], T. Yamamoto[2] and M. Fujita[2]
[1]Brandeis University and [2]Sony Corporation

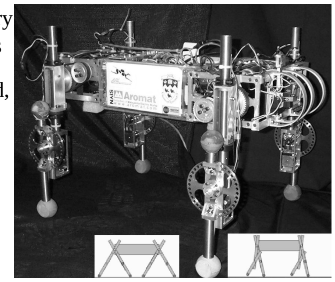
- Gaits are generated by an evolutionary algorithm.
- By sculpting the environment, robust gaits are found.



Quadruped Trotting with Passive Knees - Design, Control, and Experiments

G. Hawker and M. Buehler
McGill University

- Single leg model for leg trajectory parameters and initial conditions
- Mechanical design of unactuated, locking knee
- Experimental implementation of single leg control
- Experimental trotting gait on Scout II quadruped



Motion Analysis and Experiments of Passive Walking Robot QUARTET II

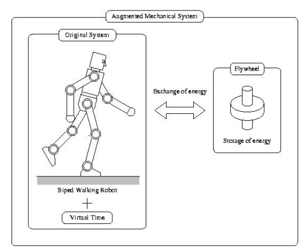
K. Osuka[1] and K. Kirihara[2]
[1]Kyoto University and [2]JR West

- It is well known that, in passive walking simulations, we can observe a bifurcation or chaotic phenomenon. Here, we had a question. Can we observe such a phenomenon in passive walking experiments?
- We developed a passive walking robot QUARTET II and carried out passive walking experiments and tried to show the occurrence of the behaviors.
- We could show that a bifurcation phenomenon can be observed in the real world. We could observe a two-period walking in passive walking.
- In this paper, at first, we introduced our developed passive walking robot QUARTET II. Then, we confirmed that, in passive walking, a gait recovery and a bifurcation were observed via some numerical simulations. And finally, we showed that those behaviors occur in walking experiments.

Passive velocity field control of Biped Walking Robot

Masaki Yamakita, Fumihiko Asano and Katsuhisa Furuta
Tokyo Institute of Technology

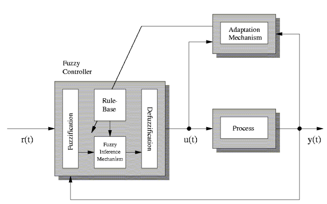
- Realization of safe and energy-effective control for biped walking robots.
- Passive Velocity Field Control (PVFC) and Virtual Passive Dynamic Walking
- The validity of proposed method has been confirmed by compass-like biped robot.
- Passivity based control of biped walking robots on the floor is realized without any gait design.



Fuzzy Control of Quadrupedal Running

D. W. Marhefka and D. E. Orin
Ohio State University

- Direct adaptive fuzzy controller developed.
- Learns necessary leg touchdown angles and leg thrusts.
- Can shift to desired running height and velocity change in only one stride.
- Good performance with modeling errors.



Rapid Prototyping
Chairs: Ren C. Luo, Dinos Mavroidis

Deformation Transition Graphs in Forming Operations of Rheologic Objects

S. Hirai, S. Tokumoto and Y. Fujita
Ritsumeikan University

Rapid Prototyping of Robotic Systems

J. Won, K. DeLaurentis and C. Mavroidis
Rutgers University

- Rapid Prototyping fabrication of non-assembly robotic systems
- Using Stereolithography and Selective Laser Sintering
- Successful non-assembly multi-joint, multi-DoF one step fabrication
- Several robotic systems fabricated using this technique

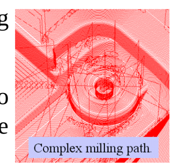
The Development of LCD Panel Display Based Rapid Prototyping System for Advanced Manufacturing

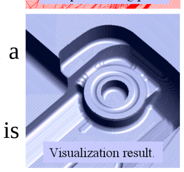
R. C. Luo, J. H. Tzou and W. Z. Lee
National Chung Cheng University

Fast Visualization of NC Milling Result Using Graphics Acceleration Hardware

Masatomo Inui
Ibaraki University

- Fast and fine visualization of the NC milling result for avoiding gouging problems.
- Geometric milling simulation is transformed to a 3D rendering problem. Graphics hardware acceleration.
- Complex milling result can be visualized in a second.
- Integration with the path generation software is our future work.

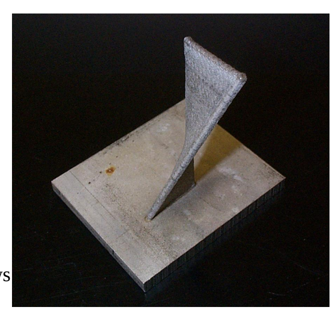

Complex milling path


Visualization result

Motion Planning for a Direct Metal Deposition Rapid Prototyping System

D. M. Hensinger, A. L. Ames and J. L. Kuhlmann
Sandia National Laboratories

- Extend 2.5 Dimensional Direct Deposition Manufacturing System to 3D
- Exploited Access to CAD and Flexibility of Robotic Positioning
- Produced Unique 3D Parts from CAD Data using 6 DOF Robot
- Application of Robotic Systems to Deposition Manufacturing Shows Great Potential



Agent-Based Product Design and Planning for Distributed Concurrent Engineering

J. Sun[1], Y. F. Zhang[2] and A. Y. C. Nee[2]
[1]Gintic Institute of Manufacturing Technology and [2]National University of Singapore

- Motivation: to integrate geographically dispersed product design, manufacturability analysis, process planning, and assembly
- Proposed Approach: a heterogeneous multi-agent system
- Experimental Result: a prototype for concurrent design and planning on machining processes
- Discussion and Conclusion

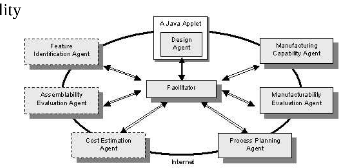


Figure. System Architecture

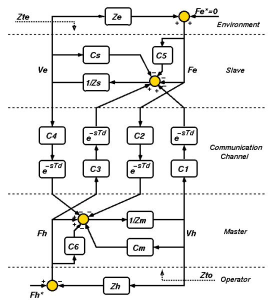
Teleoperation 3

Chairs: Robert Anderson, Junku Yuh

Analysis and Evaluation of Stability and Performance Robustness for Teleoperation Control Architectures

K. Hashtrudi-Zaad and S. E. Salcudean
University of British Columbia

- Operator/Environment uncertainties and time-delays compromise stability and performance.
- Robustness analysis using Llewellyn's criterion and impedances minima/Z-width's.
- Tradeoffs for control architectures presented.
- Design guidelines given.

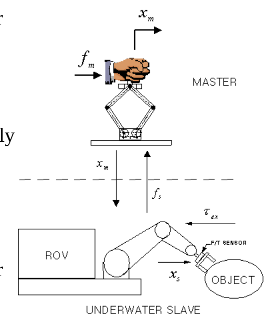


Block Diagram of a Bilateral Teleoperation Control System

Design of a Teleoperation Controller for an Underwater Manipulator

Dong-Soo Kwon[1], Jee-Hwan Ryu[1], Pan-Mook Lee[2] and Seok-Won Hong[2]
[1]Korea Advanced Institute of Science and Technology and [2]Korea Research Institute of Ships and Ocean Engineering

- Teleoperation of an underwater manipulator is harder then other teleoperations
- To achieve a transparency, adaptive sliding mode control and disturbance observer are used for the slave and the master, respectively
- We got an excellent results for free motion, continuous contact motion and intermittent contact motion simulations
- A teleoperation controller for an underwater manipulator is proposed.

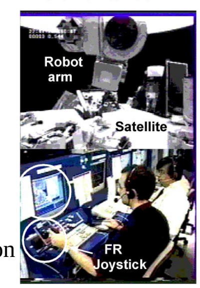


Force Reflection for Time-Delayed Teleoperation of Space Robots

L. F. Penin, K. Matsumoto and Sachiko Wakabayashi
National Aerospace Laboratory, Japan

- How to use force reflection to improve time-delayed teleoperation?
- Use force-reflecting hand controllers as displaying tools with and without a model.
- Experiments conducted teleoperating the robot onboard ETS-7 satellite.
- First extensive application of force reflection on a real space robot.

Overview camera



Teleoperation Station

Network-Based Force-Reflecting Teleoperation

A. Sano, H. Fujimoto and T. Takai
Nagoya Institute of Technology

- This study aims to develop a practical force-reflecting teleoperator through the Internet.
- The design of controllers incorporating adjustment to the time delay could be realized in the framework of gain scheduling.
- Pushing the wall, inserting the video cassette, and holding the raw egg, have been performed with haptic senses.
- The proposed control strategy is well suited to the network-based teleoperation.

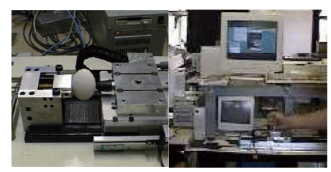
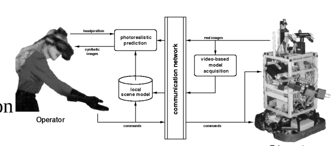


Photo-Realistic Scene Prediction of Partially Unknown Environments for the Compensation of Time Delays in Telepresence Applications

M. Barth, T. Burkert, C. Eberst, N. O. Stoffler and G. Farber
Technische Universitat Munchen

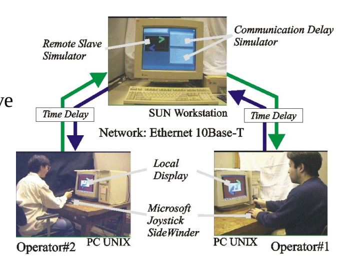
- Delays in the visual Feedback of a Teleoperation System
- Model from Camera Images, photo-realism by Texture Mapping
- Scene Reconstruction and Prediction in structured Environments
- Photo-realistic Prediction can be achieved



Remote Coordinated Controls in Multiple Telerobot Cooperation

N. Y. Chong[3], T. Kotoku[1], K. Ohba[1], K. Komoriya[1], N. Matsuhira[2] and K. Tanie[1]
[1]Mechanical Engineering Laboratory (MEL), [2]Toshiba Corp. and [3]NEDO

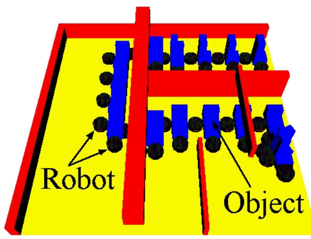
- Multi-Operator-Multi-Robot tele-collaboration with time delay.
- Coordinated control with predictive graphic simulators.
- Larger master instructions and less task completion time.
- Development of local coordinated controls in MOMR teleoperation.



Robotics Cooperation 2
Chairs: Kamal Gupta, Kevin Lynch

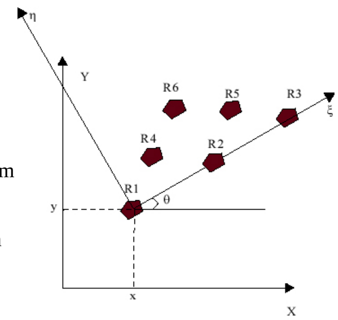
Motion Planning for Cooperative Transportation of a Large Object by Multiple Mobile Robots in a 3D Environment
A. Yamashita[1], M. Fukuchi[1], J. Ota[1], T. Arai[1] and H. Asama[2]
[1]The University of Tokyo and [2]The Institute of Physical and Chemical Research (RIKEN)

- A motion planning method for high DOF problems
- A local planner for stable manipulation
- A global planner for practical path searching
- Simulations and experiments in 3D environments



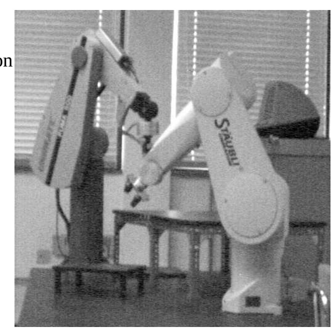
Robot Group Formations: A Dynamic Programming Approach for a Shortest Path Computation
Federico Gentili and Francesco Martinelli
Universit di Roma Tor Vergata

- Problem formulation
- A variational approach to solve the problem
- A dynamic programming algorithm gives an approximate solution
- Application to a 2 robot formation and comparison with heuristics



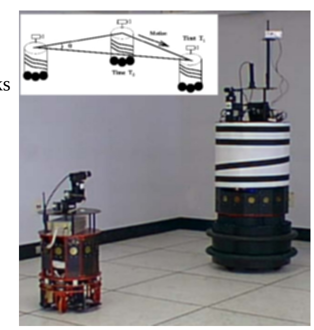
Analysis and Classification of Multiple Robot Coordination Methods
E. Todt, G. Raush and R. Suarez
Universidad Politecnica de Cataluna

- Review of multiple-robot coordination methods
- Definition of a unified terminology for the problem
- Discussion of the used tools and proposed approaches
- Introduction to the field and a framework for new works



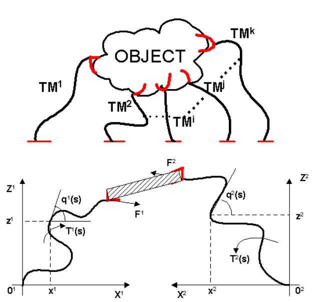
Multi-Robot Collaboration for Robust Exploration
I. M. Rekleitis[1], E. Milios[2] and G. Dudek[1]
[1]McGill University and [2]York University

- Explore large areas with a pair (or team) of mobile robots.
- Keep some robots as mobile landmarks that help the localization of the mobile robots.
- Systematically explore the entire environment by subdividing it into trapezoids.
- Uncertainty reduction in the position of the robots leads to more accurate mapping.



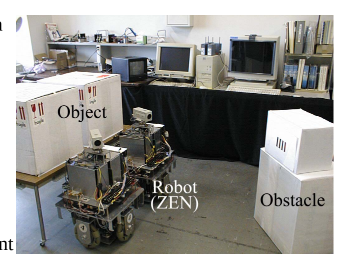
A Two Level Hierarchical Fuzzy Controller for Hyperredundant Cooperative Robots
M. Ivanescu and N. Bizdoaca
University of Craiova

- Control of tentacle manipulators in cooperative tasks
- Two level controls: a conventional and an adaptive fuzzy controller
- Line and ellipse trajectory cooperative task simulations
- Simple fuzzy rules sets , notable stability and robustness control



Cooperative Transport in Unknown Environment
N. Miyata, J. Ota, Y. Aiyama, H. Asama and T. Arai
University of Tokyo

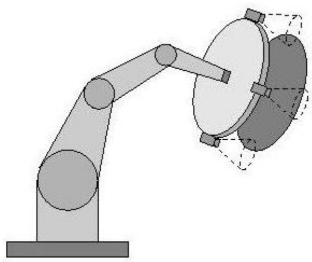
- Needs to assign various tasks keeping order or timing of execution
- Priority calculation for each unit of task that can be executed by one robot in a short time
- Task-assignment formulated as gassignment problemh using the priority
- Verification by a transport experiment using two real robots



Vision-Based Control
Chairs: Sylvie Boudet, Nicola Ferrier

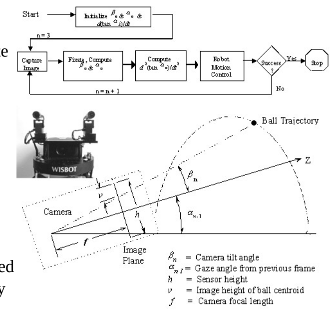
Multi-Cameras Visual Servoing
Ezio Malis[1], Francois Chaumette[2] and Sylvie Boudet[3]
[1]University of Cambridge, [2]IRISA / INRIA and [3]EDF-DER

- In this work, the classical visual servoing techniques have been extended to the use of several cameras observing different parts of an object.
- A multi-cameras visual servoing task of maintenance in the steam generator of a nuclear power plant is considered.
- The multi-camera visual servoing has been designed as a part of the task function approach. The particular choice of the task function allows us to simplify the design of the control law and the stability analysis.
- A positioning task on a cumbersome object has been realized using 2D and 2 1/2 D visual servoings with two cameras, mounted on a manipulator robot, and observing two different parts of the object.



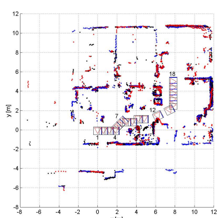
Interception of a Projectile Using a Human Vision-Based Strategy
Justin Borgstadt and Nicola J. Ferrier
University of Wisconsin, Madison

- Based on human studies a robot motion control strategy using only a single image-based parameter (without elaborate 3D modeling) is proposed
- Direction of motion is determined by the sign of the second derivative of the vertical angle of gaze between the robot and the projectile
- Various strategies for control of the magnitude of motion are evaluated
- A constant acceleration strategy, combined with the human-based directional strategy is demonstrated on a mobile robot



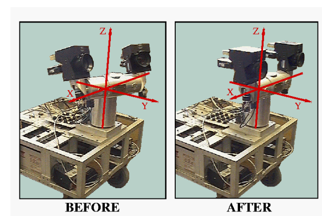
Motion Estimation by Iterative 2-D Features Matching in Range Images
G. A. Borges and M. J. Aldon
LIRMM

- Motion estimation by fusing simple geometrical features.
- Alternated features matching and motion estimation.
- Experimentation with different indoor cluttered environments.
- Good performance from experimental results.



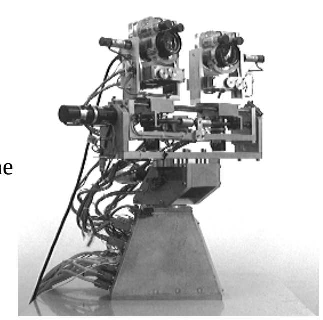
Active Visual Alignment of a Mobile Stereo Camera Platform
J. Knight and I. Reid
University of Oxford

- Four DOF head/eye platform mounted on mobile vehicle
- Initial alignment essential precursor to visual navigation
- Alignment and calibration achieved from visual cues and controlled motion alone
- Tests show 1 degree alignment error and good calibration



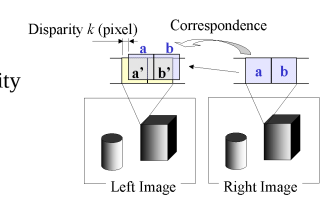
A focusing by Vergence System Controlled by Retinal Motion Disparity
J. Batista, P. Peixoto and H. Araujo
University of Coimbra

- Real-time binocular focusing.
- Velocity Control.
- Combination of vergence and focus motor calibration (off-line calibration).
- Focusing velocity controlled by retinal motion disparity.



Subpixel Stereo Method: a New Methodology of Stereo Vision
K. Umeda and T. Takahashi
Chuo University

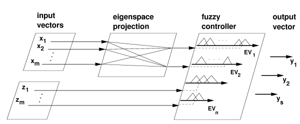
- Control of Disparity less than One Pixel
- Simple Introduction of Disparity as k = (bf-b)/(a-b)
- Avoidance of Correspondence Problem
- Although not Accurate, very Simple and Practical



Learning 1
Chairs: Antti Koivo, Karl F. MacDorman

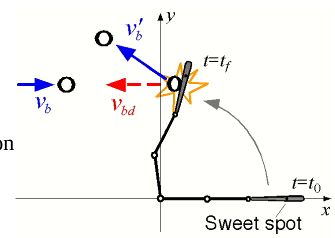
A General Learning Approach to Multisensor Based Control using Statistic Indices
Y. von Collani, M. Ferch, J. Zhang and A. Knoll
University of Bielefeld

- General fuzzy description for high dim. systems and sensor fusion.
- Principal component analysis and B-Spline fuzzy controller.
- Fusion of different sensor data can be handeld by the controller.
- B-spline model may be utilised for sensor fusion and different problems.



A Learning and Dynamic Pattern Generating Architecture for Skillful Robotic Baseball Batting System
X. Z. Zheng[1], W. Inamura[2], K. Shibata[1] and K. Ito[1]
[1]Tokyo Institute of Technology and [2]Ishikawajima-Harima Heavy Industries

- Alternative approach to robotic dynamic manipulation
- Iterative learning combined with optimal control and ANN
- Computer simulation verification on a 3-DOF manipulator
- Effective and robust batting without given trajectory

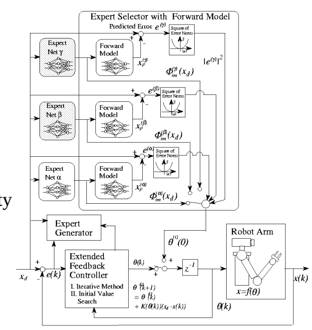


On-Line Learning of the Sensors Fuzzy Membership Functions in Autonomous Mobile Robots
Hani Hagras, Victor Callaghan and Martin Colley
University of Essex

- There is a necessity for online self-calibration for the fuzzy Membership Functions (MF) for fast changing and dynamic environments and difficult accessible environments.
- Our work reports on an approach based on the use of patented Genetic techniques to evolve the fuzzy MF of the individual behaviours.
- Our system learns the MF of the individual behaviours online and through interaction of the real sensors with the real world in a very short time interval of 4 minutes in outdoor challenging environments.
- This system can be applied to environments which are difficult to access such as nuclear reactors, space and under water environments.

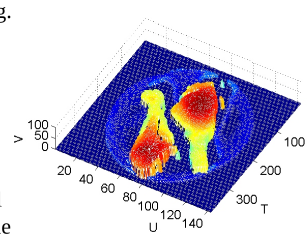
Modular Neural Net System for Inverse Kinematics Learning
E. Oyama[1] and S. Tachi[2]
[1]Mechanical Engineering Laboratory (MEL) and [2]The University of Tokyo

- Learning of the Discontinuous Inverse Kinematics Function
- Appropriate Switching of Multiple Continuous Neural Networks
- Success in Inverse Kinematics Learning of a 7-DOF arm Modular Neural Net System Can Handle the Discontinuity
- ¹Mechanical Engineering Laboratory (MEL) and ²The University of Tokyo



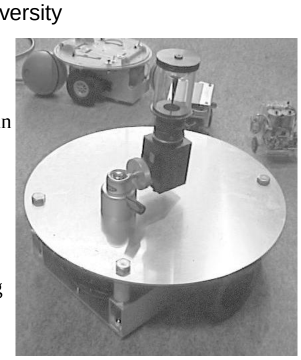
Teaching by Example in Food Assembly by Robot
T. G. Williams, J. J. Rowland, M. H. Lee and M. J. Neal
University of Wales, Aberystwyth

- Flexible assembly - make new products without reprogramming.
- Sensing real product examples to learn component placement.
- Initial results demonstrate the feasibility of the technique.
- Later results illustrate successful approximate matching of variable shapes.



Responding to Affordances: Learning and Projecting a Sensorimotor Mapping
Karl F. MacDorman
Osaka University

- To learn to recognize opportunities from experience
- Adaptive sensorimotor maps; Bayesian classification of affordance invariance in wavelet domain; Projection of maps to exploit affordances
- Effective in mobile robot
- Planned extention to abstract planning in a high DoF robot with complex dynamics



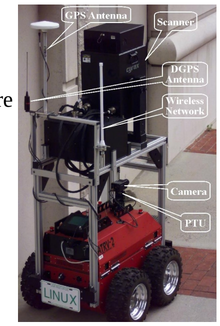
Control and Architectures
Chairs: James Albus, Ning Xi

4-D/RCS Reference Model Architecture for Unmanned Ground Vehicles
J. S. Albus
National Institute of Standards and Technology

- Hierarchical structure of plans and commands
- Representation of the world at five hierarchical levels
- Planning, replanning, and reacting at five levels
- Many sensors – stereo CCD & FLIR, LADAR, radar, inertial, acoustic, internal

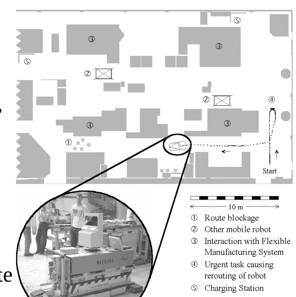
Design, Architecture and Control of a Mobile Site-Modeling Robot
A. Gueorguiev, P. Allen, E. Gold and P. Blaer
Columbia University

- Autonomous robot navigation
- Sensor integration and distributed architecture
- Successfully followed a 210m complex trajectory
- Sensor integration leads to higher accuracy; distributed computing helps process large amounts of data



A New Approach for Context-Based Exception Handling in Autonomous Mobile Service Robots
D. Glueer and G. Schmidt
Technische Universitat Munchen

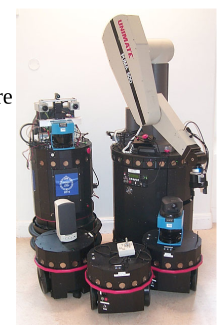
- Task oriented exception handling for free navigating robots
- Relational Algebra, Petri Net models, hierarchical system structure
- Evaluated in Shop-Floor and office environments
- Significant reduction of MTBF, cascaded exceptions covered, alternate therapies applicable



Shop floor layout, path of mobile robot and sample causes of exceptions.

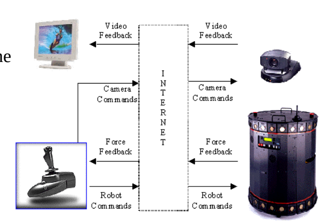
BERRA : A Research Architecture for Service Robots
M. Lindstrom, A. Oreback and H. Christensen
Royal Institute of Technology

- Requirements on a Service Robot Architecture
- Design and Implementation Issues
- Experiments performed on our Robots
- Comparisons with other Architectures



Real-Time Control of Internet Based Teleoperation with Force Reflection
Imad Elhajj[1], Ning Xi[1] and Yun-hui Liu[2]
[1]Michigan State University and [2]The Chinese University of Hong Kong

- Overcoming random time delay in Internet-based tele-operation with force reflection
- Event-based control applied to overcome the instability and de-synchronization caused by delay
- Tele-operation with force reflection was experimented between a robot in Michigan State and an operator in Hong Kong
- First real-time tele-operation with force reflection over the Internet



A Hybrid Architecture for Hierarchical Reinforcement Learning
Manfred Huber
University of Texas, Arlington

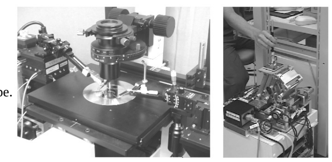
- Efficient acquisition of closed-loop control policies
- Uniform treatment of basic actions and learned strategies
- Skill transfer to improve learning speed and quality
- Application to increasingly complex locomotion tasks

MEMS
Organizers & Chairs: Peter Will, Bradley J. Nelson

MEMS and Robotics: Promises and Problems
Peter Will
USC/Information Sciences Institute

3D Viewpoint Selection and bilateral Control for Bio-Micromanipulation
F. Arai[1], T. Sugiyama[1], T. Fukuda[1] and K. Itoigawa[2]
[1]Nagoya University and [2]Tokai Rika Co

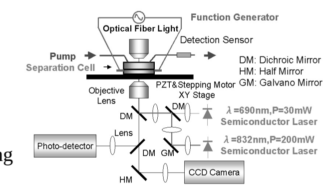
- The image of the microscope is two dimensional, so it is hard to manipulate the biological small target in the 3D space. The object is fragile, so it is hard to manipulate safely.
- We propose a viewpoint selection method in the VR space, and a new bilateral control system using a micro tri-axial force sensor to improve manipulation of the micro object under the microscope.
- We were able to feel the strength of the cell in x, y, and z direction. It is the fist achievement in the teleoperation of the biological small object to demonstrate the real 3D bilateral control.
- We developed the bilateral 3D bio-micromanipulation system. We improved the operability by the free viewpoint selection strategy and bilateral control.


(a) 3D Bio-micromanipulator (b) Master Manipulator
Bilateral 3D Bio-Micromanipulation System

Track-following Controller Design of MEMS Based Dual-stage Servos in Magnetic Hard Disk Drives
Yunfeng Li and Roberto Horowitz
University of California, Berkeley

Issues in Precision Motion Control and Microhandling
Hannes Bleuler, Reymond Clavel, Jean-Marc Breguet and Eric Pernette
Institute of Robotic Systems - EPFL

- Small devices for precision position control & microfactory
- Size of the devices: Between MEMS and
- Piezo-actuators, SMA micro gripper, Micro Discharge Machining
- Closed loop control is a must for precision applications



Bilateral Laser Scanning Manipulation System

Micropart Feature Design for Visually Servoed Microassembly
Bradley J. Nelson and Bharath Mukundakrishnan
University of Minnesota

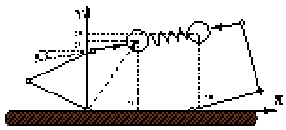
Stiffness and Compliance

Chairs: Herman Bruyninckx, Imin Kao

Internal force-based Impedance Control Of Dual-arm Manipulation of Flexible Objects

A. S. AlYahmadi and T. C. Hsia
University of California, Davis

- Simple, efficient scheme for handling flexible objects
- Object dynamics compensated for using sensed forces
- Internal force is used to deform an object
- Simulation of two arms inserting a flexible object into a fixture



Minimal Realization of an Arbitrary Spatial Stiffness Matrix with a Parallel Connection of Simple and Complex Springs

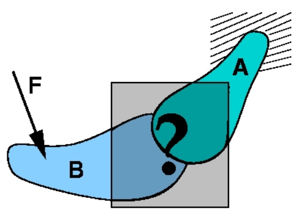
Rodney G. Roberts
Florida State University

- Any spatial stiffness matrix K can be realized with simple and complex springs.
- The minimum total number of springs is equal to the rank of K.
- To reduce complexity, one should minimize the number of complex springs.
- An algorithm is introduced to realize K with the minimum number of complex springs and the minimum total number of springs.

An Eigenscrew Analysis of Mechanism Compliance

P. L. McAllister and R. E. Ellis
Queen's University

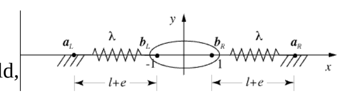
- Compliance (C) of devices of unkown geometry cannot be found analytically
- An SPSD approximation to C was obtained from simulated noisy statics data
- Eigenscrew decomposition yielded directions and magnitudes of compliance
- Simulations showed the method was reliable for well-conditioned poses



The Spatial Stiffness Matrix from Simple Stretched Springs

J. M. Selig
South Bank University

- Systems of simple stretched springs considered.
- Stiffness matrix derived from the potential function.
- Differentiation on group manifold, no constraints used.
- Form of the stiffness matrix investigated.



Classification Structure and Compliance Modeling for Serial Manipulators

Jeffrey Hudgens[1], Daniel Cox[2] and Delbert Tesar[2]
[1]Applied Materials, Inc. and [2]University of Texas, Austin

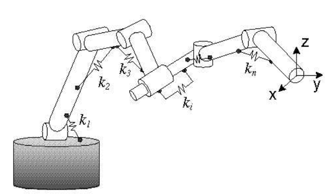
- Robot manipulators are inherently flexible when subjected to a load disturbance. The result is inaccurate knowledge of the end-effector pose under load. The objective of this paper is to develop a structural compliance model for a general serial manipulator that includes both joint and link compliance sources in any general distribution of revolute and prismatic joints.
- The compliance modeling strategy accommodates both joint and link compliance sources. A more reliable method for placing the link compliance frames is introduced. Special consideration is given to modeling the variable local compliance properties of a robot containing one or more prismatic joints.
- The distinct structures for prismatic joints are (1) Constant, (2) Proximally Variable, (3) Distally Variable, and (4) Fully Variable. The link is segmented into variable and constant compliance segments and the compliance of each segment is treated separately. The link compliance modeling strategy addresses the four distinct link structures.
- A structural compliance model for a general serial manipulator that includes both joint and link compliance sources is developed. An improved linear quasi-static compliance model for serial robot structure comprised of both revolute and/or prismatic joint is provided. The model can be used with parameter estimation techniques to determine compliance parameters for the manipulator which can be applied in real-time on-line deflection compensation schemes.

Type	Schematic	Name	Membership
1		Constant	R – R
			$P_{proximal} - R$
			$R - P_{distal}$
			$P_{proximal} - P_{distal}$
2		Proximally Variable	$P_{distal} - R$
			$P_{distal} - P_{distal}$
3		Distally Variable	$R - P_{proximal}$
			$P_{proximal} - P_{proximal}$
4		Fully Variable	$P_{distal} - P_{proximal}$

Synthesis of Spatial Compliances with Simple Serial Elastic Mechanisms

Shugang Huang and Joseph M. Schimmels
Marquette University

- compliance synthesis and realization
- use serial mechanism with springs loaded across individual prismatic and revolute joints
- not all compliances are realizable with mechanisms of this type; restriction on compliance matrices identified
- serial mechanism synthesis procedure for compliances satisfying restriction defined



Biped Robots

Chairs: Bernard Espiau, Friedrich Pfeiffer

A Biped Robot that Jogs

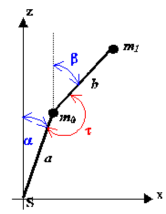
M. Gienger, K. Loffler and F. Pfeiffer
Technische Universitat Munchen

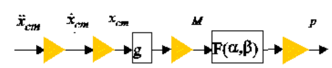
- Design and Control of a Biped Walking Robot
- Dynamically Stable Walking and Jogging
- Realization of an Autonomous Robot
- Hardware in Progress, Results End of 2000

On the Stability of Biped With Point Foot-Ground Contact

R. Stojic and C. Chevallereau
Institut de Recherche en Cybernetique de Nantes

- Control of simple biped in under-actuated phase
- Rewritten of system equation with new variables
- Definition of a control law for stabilization and tracking
- Case of 2 links and 3 links system

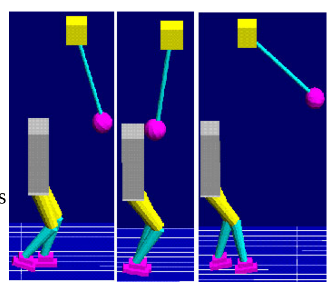




Balance Control of a Biped Robot Combining Off-line Pattern with Real-time Modification

Q. Huang[1], K. Kaneko[1], K. Yokoi[1], S. Kajita[1], T. Kotoku[1], N. Koyachi[1], H. Arai[1], N. Imamura[2], K. Komoriya[1] and K. Tanie[1]
[1]Mechanical Engineering Laboratory (MEL) and [2]Kobe City College of Technology

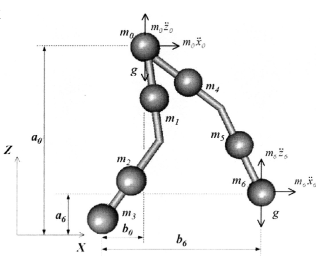
- Balance control of a biped robot
- Off-line walking pattern with real-time modification
- Walking on rough terrain and in environments with disturbances
- Confirmation by a biped dynamic simulator



An Online Trajectory Modifier for The Base Link of Biped Robots To Enhance Locomotion Stability

J. Park and H. Cho
Hanyang University

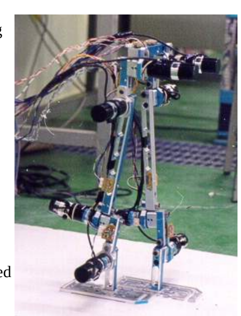
- For sable locomotion, biped robots should have robust properties against various disturbances.
- The base trajectory
- in the vertical direction is modified depending on the magnitude of ZMP deviation form its safety boundary.
- A series of simulations show that the robot can walk with the proposed algorithms even when there is a certain amount of disturbance force.



Design of Small Power Biped Robot by Load Sharing of Walking Gait

D. J. Kim[1], K. I. Kim[1], Yuan Fan Zheng[2], Zengqi Sun[3] and Fuchun Sun[3]
[1]Myong Ji University and [2]Ohio State University and [3]Tsinghua University

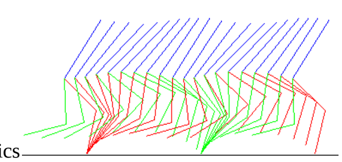
- Walking can be divided into one-foot and two-foot standing during the common speed smooth walking. In two-foot standing, the weight of the robot can be distributed to all joints. However, in one-foot standing, it is burdened to one foot, especially to the ankle joint.
- This problem is solved by a load sharing method, which distributes the load of the ankle to other joints.
- The current of ankle is significantly reduced to become less than the critical value.
- Load concentration problem has been solved by the load sharing method, which calculates the current to be consumed at each joint, and reprograms the motions of all the joints accordingly.



Design and Actuation Optimization of a 4 axes Biped Robot for Walking and Running

C. Chevallereau and P. Sardain
Universite de Poitiers

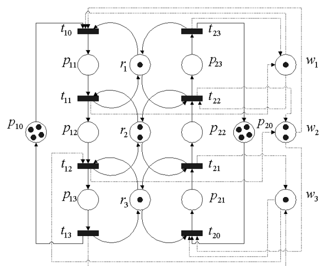
- Under-Actuated Robot
- Walking AND Running
- Optimal Reference Trajectories
- Adequation Technology-Dynamics



Discrete Event Dynamic Systems 2
Chairs: M. A. Jafari, Okyay Kaynak

Structural approaches to deadlock avoidance in concurrent resource allocation systems
Jonghun Park and Spyros Reveliotis
Georgia Institute of Technology

- Development of an ANALYTICAL / ALGEBRAIC criterion for testing the correctness of tentative algebraic deadlock avoidance policies (DAP's) for Single-Unit Sequential Resource Allocation Systems (SU-RAS)
- The behavior of SU-RAS controlled by algebraic DAP's is modeled by a PN class in which liveness is equivalent to the non-existence of reachable empty siphons. But the latter property can be tested algebraically.
- The included example demonstrates that the proposed methodology can effectively expand the class of algebraic DAP's for SU-RAS.
- The proposed work has expanded the class of effectively computable algebraic DAP's for SU-RAS, potentially enhancing the operational flexibility of these systems. Future work will extend these results to broader RAS classes.



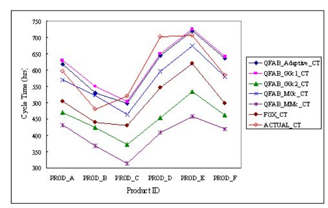
Resource-oriented petri nets for deadlock avoidance in automated manufacturing
Naiqi Wu[1] and Mengchu Zhou[2]
[1]Guangdong University of Technology and [2]New Jersey Institute of Technology

- Introduction
- Petri nets and system modeling
- Liveness of interactive subnets
- Performance improvement through an example

Deadlock avoidance for manufacturing systems with partially ordered process plans
Widodo Sulistyono and Mark A. Lawley
Purdue University

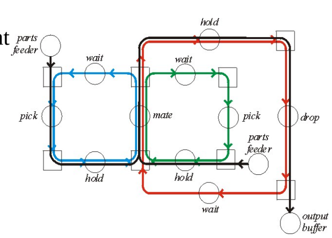
Queuing Network Analysis for an IC Foundry
J. Y. Juang and H. P. Huang
National Taiwan University

- A tool-group based hybrid decomposed queueing network model
- System diagnosis: arrival and service pattern analysis
- System prediction: product cycle time, lot remaining cycle time, N-step cycle time, tool group move, stage move, tool group utilization
- Successfully applied to a famous IC foundry



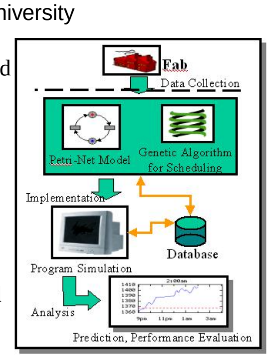
A Formalism for the Composition of Concurrent Robot Behaviors
Eric Klavins and D. E. Koditschek
University of Michigan

- Synthesis of Hybrid, Concurrent Robot Behaviors
- Applications in Automated Manufacturing
- Compositional Petri Nets are Live and Reversible



Petri-Net and GA Based Approach to Modeling, Scheduling, and Performance Evaluation for Wafer Fabrication
J. H. Chen and L. C. Fu
National Taiwan University

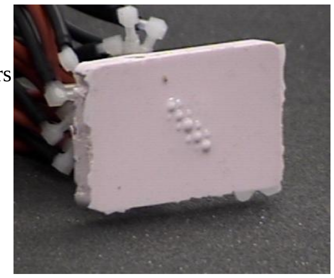
- Provide an effective scheduling method for wafer fabrication.
- Use Petri-Net for modeling tools & GA for scheduling approach.
- Two cases of simulations to show the superiority of this method.
- Present a systematic modeling method & an effective scheduling policy.



Haptic Interface 2
Chairs: Blake Hannaford, Christian Laugier

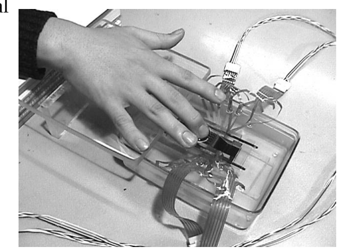
A Compliant Tactile Display for Teletaction
G. Moy, C. Wagner and R. S. Fearing
University of California, Berkeley

- Cheap, compliant, leak free, frictionless tactile display
- One step molds sealed chambers for pneumatic actuation
- 5x5 array, 2.5mm spacing, 180mN peak force, 0.8mm peak displacement
- Grating orientation detectable with 10



Artificial Tactile Feel Display Using Soft Gel Actuators
M. Konyo[1], S. Tadokoro[1], T. Takamori[1] and Keisuke Oguro[2]
[1]Kobe University and [2]Osaka National Research Institute

- Display delicate touch as a surface of cloth using a mechanical device.
- Ciliary device using soft high polymer gel actuator makes various stimuli.
- Comparison with material samples showed variety of generated feels.
- This device can display subtle difference of touch of cloth.

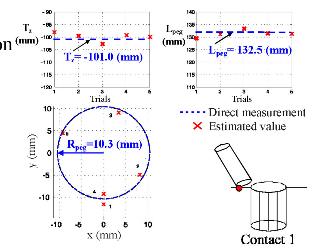


Fingernail Touch Sensors: Spatially Distributed Measurement and Hemodynamic Modeling
S. Mascaro and H. H. Asada
Massachusetts Institute of Technology

- Motivation and Principle
- Vascular Anatomy and Hemodynamic Modeling
- Model Simulation
- Experimental Validation and Conclusion

Automatic Identification of Local Geometric Properties During Teleoperation
T. Debus[1], P. Dupont[1] and R. D. Howe[2]
[1]Boston University and [2]Harvard University

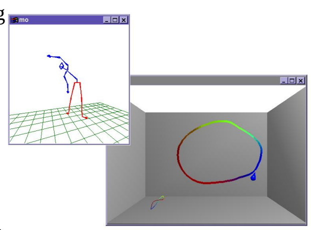
- Use robot sensors to estimate object properties during manipulation
- How: interpret task as sequence of contact states
- Result: method to segment sensor data stream by contact state
- Validation: estimation of 3-D peg-in-hole dimensions during insertion



Properties estimated during contact 1. T_z, L_{peg}, and R_{peg}, are the vertical offset of the hole, the length and radius of the peg.

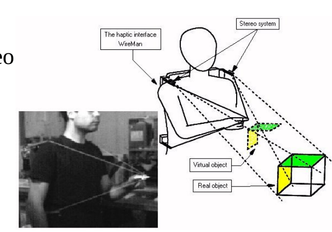
Using Haptic Vector Fields for Animation Motion Control
B. R. Donald and F. Henle
Dartmouth College

- Want natural method for authoring and editing motions
- C-space is reparameterized by haptic control space
- Haptic force fields implement static/dynamic constraints
- System encourages good motions, discourages bad motions



Perception of Depth Information by Means of a Wire-Actuated Haptic Interface
P. Arcara, L. Di Stefano, S. Mattoccia, C. Melchiorri and G. Vassura
University of Bologna

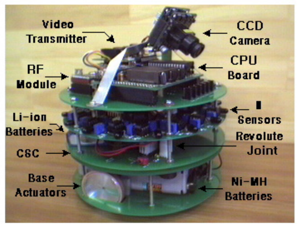
- Robotic Aid for Blind Persons
- Scene Reconstruction by Stereo Vision
- Perception by Wire-Actuated Haptic Interface
- Experiments with Real-World Scenes



Manipulator Path Planning
Chairs: Sunil K. Agrawal, S. Zeghloul

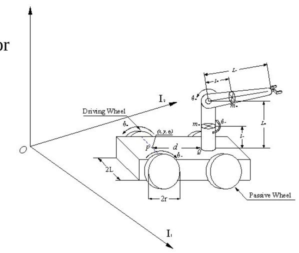
Omni-directional Mobile Base OK-II
Myung-Jin Jung, Heung-Soo Kim, Sinn Kim and Jong-Hwan Kim
KAIST

- Omni-directional motion with 2-WMR and revolute joint
- Kinematic, dynamic models and control laws derived
- Semi-autonomous: object locating, path planning and following
- OK-III, fully-autonomous robot, under development



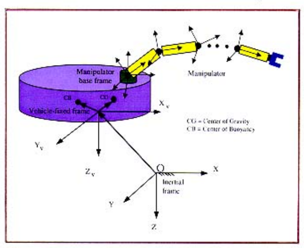
On Tracking Control of Mobile Manipulator
Wenjie Dong, Yangsheng Xu and Qi Wang
The Chinese University of Hong Kong

- Study the tracking control problem of mobile manipulators with regard to the dynamic interaction between the mobile platform and the manipulator
- Investigate its nonholonomic nature
- Propose a global tracking controller based on extended Barbalat's lemma
- Ensure the stability of the full state of the system in presence of dynamic interaction and system uncertainty



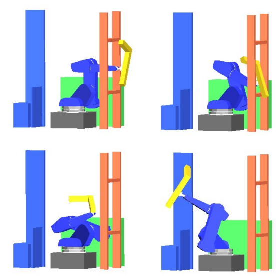
Dynamic Trajectory Planning for Autonomous Underwater Vehicle- Manipulator Systems
T. Podder and N. Sarkar
University of Hawaii at Manoa

- Dynamics-based motion planning for heterogeneous systems
- Fourier series representation and weighted pseudoinverse
- Simulation results
- Smoother motion of the heavy subsystem and reduction of power and energy



A Local-based Method for Manipulators Path Planning in Heavy Cluttered Environments
C. Helguera and S. Zeghloul
Universite de Poitiers

- The constraints method
- A new task description
- The zig-zaging phenomenon
- Solving blockages with a local graph

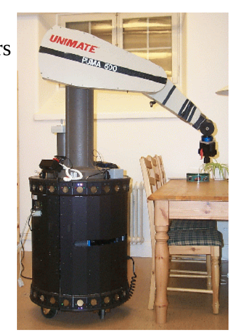


Reactive Mobile Manipulation Using Dynamic Trajectory Tracking
P. Ogren, M. Egerstedt and X. Hu
Royal Institute of Technology

- Gripper trajectory tracking for a mobile manipulator is studied.
- Tracking is coordinated with obstacle avoidance base control.
- Deadlock free, robust and safe performance is proven.
- The algorithm is currently beeing implemented on the hardware.

Coordinated Trajectory Following for Mobile Manipulation
M. Egerstedt and X. Hu
Royal Institute of Technology

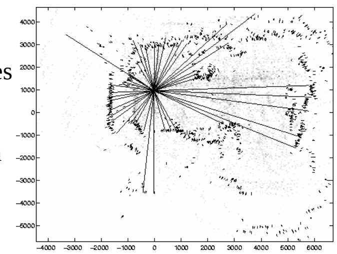
- Motion coordination for mobile manipulators is studied
- A model independent coordination strategy for multiple robot platforms is proposed
- A virtual vehicle approach is exploited for the coordinated tracking task
- A proven stable and robust coordinated performance is achieved



Mapping and Localization 3
Chairs: Bruce Donald, P. Jensfelt

Practical Mobile Robot Self-Localization
Jon Howell and Bruce Randall Donald
Dartmouth College

- mapmaking & localization without explicit landmarks
- compute likely feasible poses based on range data
- repeatably localize to within 5 cm & 1 degree
- result: a simple, effective online algorithm



Environmental Map Generation and Ego-motion Estimation in a Dynamic Environment for an Omnidirectional Image Sensor
Yasushi Yagi, Kouichi Shouya and Masahiko Yachida
Osaka University

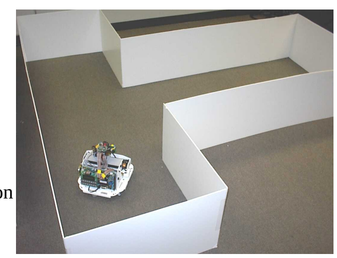
- Generation of a stationary environmental map is one of the important tasks for vision based robot navigation.
- In this paper, under the assumption of unknown translational motions of the robot, we propose a method to generate a stationary environmental map and estimate the egomotion of a robot in a dynamic environment, by using an omnidirectional image sensor.
- Two experiments were conducted for evaluating accuracy of measurements and effectiveness in our computer room (6m x 4m). Average errors of the location measurement of the robot and stationary environmental map were approximately 4 cm and 18cm,respectively
- Since both robot and objects move in the environment, the method can detect a moving object and find occlusion and mismatching by evaluating estimation error of each object location.

Civil Engineering Articulated Vehicle Localization: Solutions to deal with GPS Masking Phases
D. Bouvet and G. Garcia
Ecole Centrale de Nantes

- We propose a reliable 2-D localization system for compactors
- Position error must be lower than 20 cm even during GPS masking phases
- Experimental validation on an instrumented machine

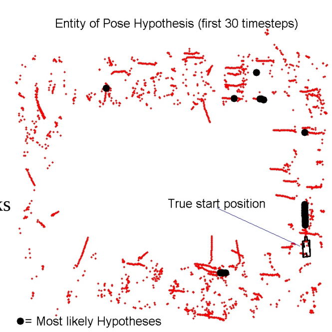
Localization based on Visibility Sectors using Range Sensors
S. Lee, N. M. Amato and J. Fellers
Texas A&M University

- Precise localization without any landmarks using range sensors
- Preprocessing partitions the workspace into visibility sectors
- Analyze range sensor readings and localize first to a sector, and then to a particular configuration within that sector
- Applicable from any configuration in the environment



Mobile Robot Self Localization Using PDAB
J. Reuter
TU-Berlin

- Kidnapped robot probl. in sparse modeled Env.
- Target-detection in dense clutter solved by MHT
- Maps of natural pointlike-landmarks
- Appr. converges fast, seems to be robust



Position Estimation in Outdoor Environments using Pixel Tracking and Stereovision
A. Mallet[1], S. Lacroix[1] and L. Gallo[2]
[1]LAAS-CNRS and [2]Aerospatiale, Chatillion France

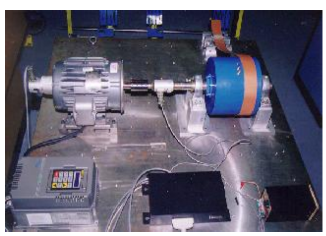
Modeling and Control
Chairs: Richard Klafter, Imre Rudas

A New Data Fusion Method and its Application to State Estimation of Nonlinear Dynamic Systems
Jae-Won Lee and Sukhan Lee
Samsung Advanced Institute of Technology

Non-Conventional Integration of the Fundamental Elements of Soft Computing and Traditional Methods in Adaptive Robot Control
I. J. Rudas, J. K. Tar, J. F. Bito and K. Kozlowski
Bnki Dont Polytechnic

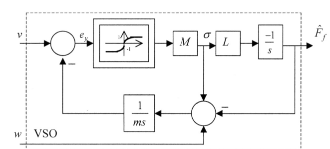
Advanced Torque Control of Robot Manipulators Driven by AC Induction Motors
Dong Sun and James K. Mills
University of Toronto

- Demand for the design of a feasible control method for AC induction motors which can exhibit better motion performance than PID.
- A torque feed-forward plus a PI-type torque feedback control.
- The implementation is greatly simplified through linearization of the torque dynamics while making partial compensation via current feedback and flux estimation.
- Experiments conducted on a commercial AC induction servo system demonstrate the effectiveness of the proposed torque control method.



Variable Structure Systems Approach to Friction Estimation and Compensation
Q. P. Ha, A. Bonchis, D. C. Rye and H. F. Durrant-Whyte
The University of Sydney

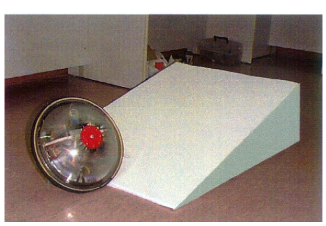
- Using a VSS-based technique in designing observers for friction estimation and compensation
- Model-based approach: VSO for friction compensation with and without velocity information
- Non model-based approach: Friction cancellation with a robust sliding mode controller
- Robustness verified with friction of both static and dynamic types



$$\dot{\hat{F}}_f = -L\sigma,$$
$$\dot{\hat{y}} = (-\hat{F}_f + w + \sigma)/m,$$
$$\sigma = M \tanh(e_y / \gamma_{e_y})$$

Stabilization of A Gyroscopically Stabilized Robot on an Inclined Plane
Yangsheng Xu and Loi Wah Sun
The Chinese University of Hong Kong

- Develop a control system for a gyroscopically stabilized robot on an inclined plane
- Develop a complete dynamic model
- Study its stabilization on inclined plane
- Propose the backstepping control for trajectory tracking and stabilization



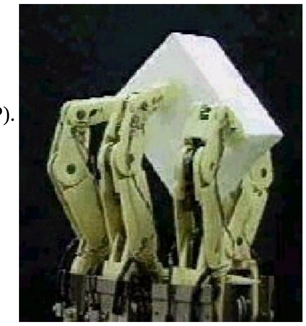
Fuzzy Logic Based Optimization for Manipulators
M. C. Ramos and A. J. Koivo
Purdue University

Grasp Analysis and Optimization
Chairs: R. D. Howe, H. Lipkin

Metrics for analysis and optimization of grasps and fixtures
Thomas G. Sugar[1] and Vijay Kumar[2]
[1]Arizona State University and [2]University of Pennsylvania

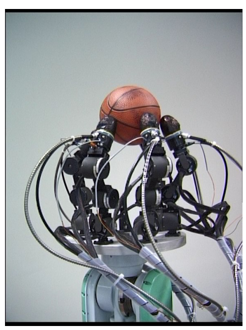
Regrasping Behavior Generation for Rectangular Solid Object
Y. Hasegawa, J. Matsuno and T. Fukuda
Nagoya University

- Generation of regrasping motion for a four-fingered robot hand.
- Using Evolutionary Programming(EP).
- Rotation of rectangular solid object with regrasping motion.
- We control the real robot hand using the controller designed in computer simulations.



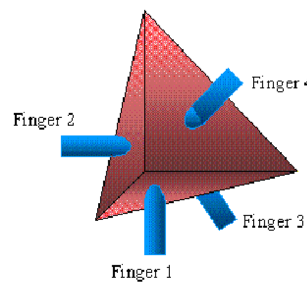
Computing 3-D Optimal Form Closure Grasps
D. Ding, Y. Liu and S. Wang
The Chinese University of Hong Kong

- Constructing a form-closure grasp is of significance for grasp and regrasp planning.
- Given grip points of more than 2 fingers, find optimal grip points for the other fingers.
- The problem is formulated as a NLP problem.
- The performance is verified by two examples.



The Synthesis of 3-D Form Closure Grasps
D. Ding[1], Y. Liu[1] and S. Wang[2]
[1]The Chinese University of Hong Kong and [2]Harbin Institute of Technology

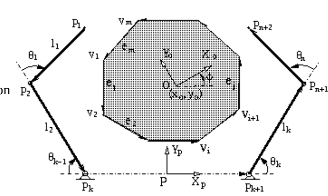
- A formulation of the synthesis of 3-D frictional form-closure grasps.
- By a recursive reduction technique, the 6-D problem is transformed to a 3-D one.
- The form-closure condition is equivalent to the inconsistancy of linear inequalities.
- Numerical simulation results are provided to show the efficiency.



Precision Localization and Robust Force Closure in Fixture Layout Design for 3D Workspaces
M. Y. Wang and D. Pelinescu
University of Maryland

Kinematic Graspability of a 2D Multifingered Hand
Y. Guan and H. Zhang
University of Alberta

- Kinematic feasibility analysis is to determine whether a desired grasp is achieved by the hand with respect to the object, under the consideration of hand kinematics and object geometry.
- Two constraints in a grasp, contact constraint and collision-free constraint, are evaluated in terms of triangular areas. The analysis is then modeled as a constrained nonlinear global optimization problem.
- Numerical examples including the grasps of a rectangle and a disk by a two-fingered hand are provided.
- The unified and effective method gives a definitive answer to kinematic graspability analysis. It is applicable to various 2D grasps including fingertip grasps and power grasps.



Education

Chair: Aydan Erkmen, Robin Murphy, and Takashi Tsubouchi

Panelists:

Paolo Dario, ARTS-SSSUP, Pisa
Matthew T. Mason, The Robotics Institute, Carnegie Mellon University
Shankar Sastry, Electronics Research Lab, EECS, UC-Berkeley
Harry Stephanou, Center for Automation Technologies, RPI
Kazuo Tanie, Mechanical Engineering Laboratory, AIST-MITI
Peter M. Will, USC/Information Sciences Institute

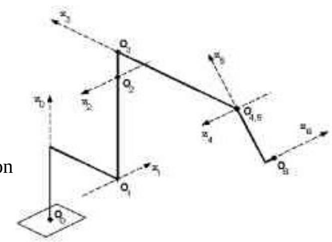
The Education Panel will begin with the six following presentations:

- *Mechatronics Education,*
  Paolo Dario ARTS-SSSUP, Pisa
- *Robotics Education,*
  Matthew T. Mason, The Robotics Institute, Carnegie Mellon University
- *Education,*
  Shankar Sastry, Electronics Research Lab, EECS, UC-Berkeley
- *The University's New Role In Industrial Research,*
  Harry Stephanou, Center for Automation Technologies, RPI
- *What are Mechatronics Engineers and Education of Mechatronics,*
  Kazuo Tanie, Mechanical Engineering Laboratory, AIST-MITI
- *Mechatronics at the Crossroads of Education and Industry:*
  The Robotics Research and Design Experience,
  Peter M. Will, USC/Information Sciences Institute

Identification
Chairs: Wisama Khalil, Jan Swevers

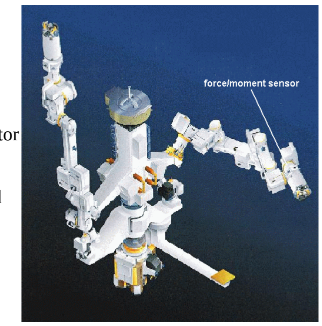
Calibration of a Motoman P8 Robot Based on Laser Tracking
W. S. Newman[1], C. E. Birkhimer[1], R. J. Horning[1] and A. T. Wilkey[2]
[1]Case Western Reserve University and [2]Ktech Corp.

- Motivation: improved calibration of an industrial robot
- Approach: use SMX laser tracker; compare circle-point to search methods
- Results: circle-point had higher RMS error, but better fit to validation data
- Conclusions: circle-point method is more reliable than alternative methods



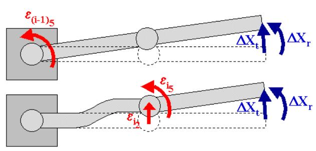
On-Orbit Calibration of the SPDM Force/Moment Sensor
Farhad Aghili
Canadian Space Agency

- The calibration matrix of the SPDM force/moment sensor needs to be updated on orbit
- Inertial forces are applied as a result of the movement of the manipulator payload
- An Extended Kalman filter is employed to estimate the sensor's gain matrix
- Simulation results demonstrated the convergence property of the estimator



An Analytical Method to Eliminate the Redundant Parameters in Robot Calibration
M. Meggiolaro and S. Dubowsky
Massachusetts Institute of Technology

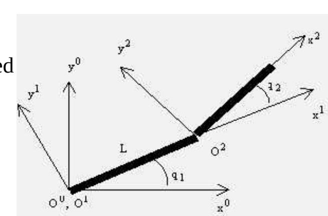
- To improve robot calibration, redundant error parameters must be eliminated
- A general analytical method to eliminate the redundant parameters is presented
- Simulations are conducted to verify the method
- The method allows for improved calibration accuracy of any serial manipulator



Fuzzy linear regression for contact identification
M. Oussalah
Katholieke Universiteit Leuven

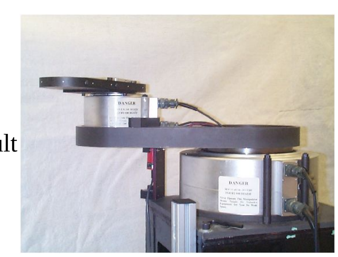
Comparison of weighted least squares and extended kalman filtering methods for dynamic identification of robots
Ph. Poignet[1] and M. Gautier[2]
[1]Laboratoire de Vision et Robotique de Bourges(A.S.A.R.) and
[2]Institut de Recherche en Cybernetique de Nantes(IRCyN)

- Identification of robot dynamic parameters
- Weighted least squares compared with extended kalman filtering
- Experimental identification of a 2 dof SCARA robot
- Close results provided good initial values for EKF



Fault Detection for Robot Manipulators with Parametric Uncertainty: A Predictive Error-Based Approach
W. E. Dixon, I. D. Walker, D. M. Dawson and J. P. Hartranft
Clemson University

- Problem Motivation
- Dynamic Model
- Prediction Error Based Fault Detection
- Experimental Results

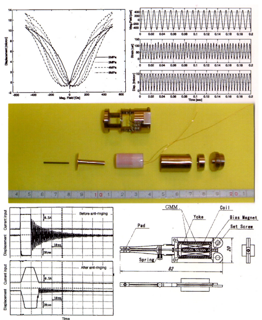


Actuators 2
Chairs: Howie Choset, Yoshio Yamamoto

Micro Positioning and Actuation Devices Using Giant Magnetostriction Materials

Yoshio Yamamoto[1], Takaaki Makino[2] and Hiro Matsui[2]
[1]Tokai University and [2]Moritex Corporation

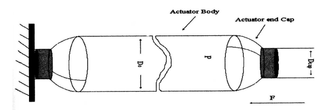
- Novel applications of Giant Magetostriction Materials
- Self-sensing and thermal compensation mechanism
- Design optimization via FEM analysis
- Micro positioning and wire clamping



Improved Modelled and Assessment of pneumatic Muscle Actuators

N. Tsagarakis and D. G. Caldwell
University of Salford

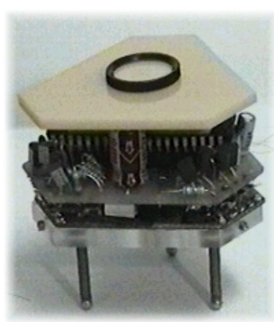
- Modelling of Bio-mimetic pneumatic Muscle Actuators.
- Improved prediction of forces and displacements
- Comparison of theoretical and experimentation using ultra large actuators
- Better planning of designs and assessment of performance requirements



Development of Platform for Micro-Positioning Actuated by Piezo-Legs

L. Juhas, A. Vujanic, N. Adamovic, L. Nagy and B. Borovac
University of Novi Sad

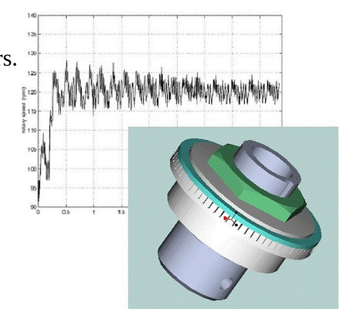
- In this paper we present the design and testing results of a simple platform for micropositioning.
- The platform has three legs, and can move freely over the supporting surface.
- With the onboard control electronics, translation, as well as complex planar motion can be achieved.
- With its practically unlimited range of motion and the simultaneous possibility of highly precise positioning, the present platform performances represent a good basis for whole spectrum of laboratory and industrial applications.



A ZPET-Repetitive Speed Controller for Ultrasonic Motors

H. Rodriguez, J. L. Pons and R. Ceres
Consejo Superior de Investigaciones Cientificas, Spain

- To Reduce the Speed Ripples of Rotary Piezoelectric Motors.
- Zero Phase Error Tracking with Repetitive Control is used.
- Results: A 77
- Fair Control of Ripples but still Room for Improvement.

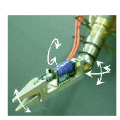


Characteristics of an Ultrasonic Motor Capable of Generating a Multi-Degrees of Freedom Motion

Kenjiro Takemura and Takashi Maeno
Keio University

- Multi-DOF actuators are effective for dexterous robots.
- A multi-DOF ultrasonic motor is constructed using three natural vibrations of the stator.
- Driving and control characteristics of the multi-DOF ultrasonic motor are measured.
- The multi-DOF ultrasonic motor is applied to the multi-DOF forceps for a laparoscopic surgery.

Multi-DOF ultrasonic motor



Multi-DOF forceps for laparoscopic surgery

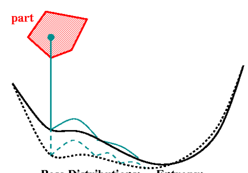
Closed-Loop Operation of Actuator Arrays

J. E. Luntz, W. Messner and H. Choset
Carnegie Mellon University

Flexible Assembly Systems
Chairs: Daniel Cox, M. A. Erdmann

Uncertainty Reduction Using Dynamics
M. Moll and M. A. Erdmann
Carnegie Mellon University

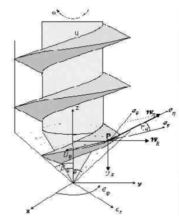
- For assembly tasks parts often have to be oriented before they can be put in an assembly. The results presented in this paper are a component of the automated design of parts orienting devices.
- We optimize the shape of the support surface and drop height that minimize the entropy of the pose distribution of a part. We use dynamic simulation in combination with quasi-capture regions to quickly compute the pose distribution.
- Our simulation and experimental results confirm that our dynamic simulator can be used to find the true pose distribution of an object.
- This new approach is a feasible way to assist in the design of parts orienting devices.



	Pose Distributions:					Entropy:
Surface 1:	.20	.15	.30	.10	.25	1.54
Surface 2:	.15	.10	.50	.10	.15	1.38

Flexible Handling in Disassembly with Screwnail Indentation
B. R. Zuo, A. Stenzel and G. Seliger
Technical University Berlin

- Flexible handling in disassembly
- Generate new surfaces with a screwnail to transmit the forces and torque's
- Development and validation of a mathematical model to calculate the indentation torque for the screwnail
- Realizable and cost-effective solution for handling in disassembly

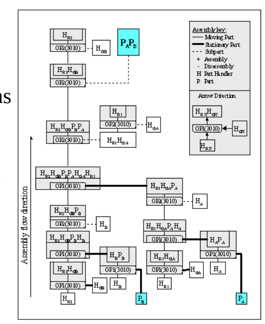


Flexible Robot-Assembly Using a Multi-Sensory Approach
Stefan Joerg[1], Joerg Langwald[1], Johannes Stelter[1], Gerd Hirzinger[1] and Ciro Natale[2]
[1]German Aerospace Center and [2]Universita degli Studi di Napoli Federico II

- Integrated Assembly Cell for flexible Robot-Assembly on moving parts
- Model-based real-time vision system for 3 D Pose Estimation and Tracking, force control using innovative compliant 6 DOF F/T sensor, automatic force controller design
- The system's robustness was demonstrated with great success at the KUKA booth during the Hannover Fair 1999
- Complex assembly problems can be solved with sensor-controlled robots.

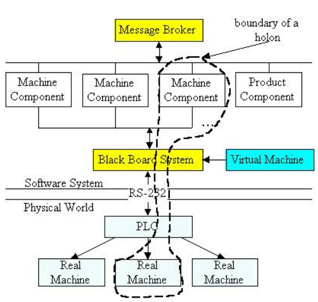
A system for automatic assembly and disassembly operations
Swee M. Mok[1], Chi-haur Wu[2] and D. T. Lee[3]
[1]Motorola Inc., [2]Northwestern University and [2]Academia Sinica

- To Represent Parts, Tools, and Operations
- Propose a Binary Tree
- Simulated Cellular Telephone Assembly
- Parts and Handlers Tree for Analysis



A Component-Based Approach to the Holonic Control of a Robot Assembly Cell
Jin-Lung Chirn and Duncan C. McFarlane
University of Cambridge

- reconfigurable manufacturing control architecture to long-term changes
- component-based development and holonic manufacturing systems
- execution control systems for a robot assembly cell
- implementation of plug-and-play manufacturing control



Automatic Object Recognition as Part of an Integrated Supervisory Control System
T. Tuytelaars, A. Zaatri, Luc Van Gool and H. Van Brussel
University of Leuven

- Easy interaction with objects under tele-operation
- through an automatic object recognition module
- viewpoint & illumination invariant
- integrated in a robust ISCS with different control levels, error recovery, anticipation, ...

Collision Detection and Distance Computation
Chairs: Stephen Cameron, Ming Lin

Computing Signed Distances between Free-Form Objects

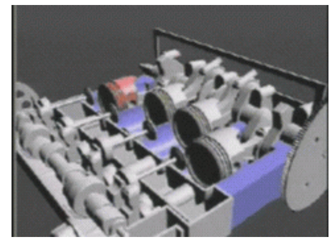
F. Thomas[1], C. Turnbull[2], L. Ros[1] and S. Cameron[2]
[1]Oxford University and [2]CSIC-UPC, Barcelona

- NURBS used to represent free-form surfaces
- Descent technique to track the minimum distance
- Bounds on patch applicability from control points
- Sub-division used to focus in on solution

Fast Distance Queries with Rectangular Swept Sphere Volumes

E. Larsen, S. Gottschalk, M. Lin and D. Manocha
University of North Carolina, Chapel Hill

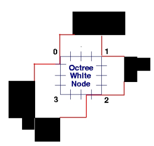
- Distance computation is essential in robot motion planning, dynamic simulation, virtual prototyping, simulation-based design and haptic rendering.
- Use of efficient bounding volume hierarchy of rectangle swept spheres, traversal coherence, and priority directed search
- Achieve upto an order of magnitude speedup over the state of art on many benchmarks from motion planning, dynamic simulation and virtual prototyping applications
- Plan to explore the possibility of hybrid hierarchy for general proximity queries

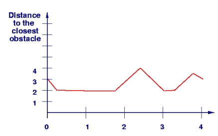


EODM- A Novel Representation for Collision Detection

M. Benitez, K. Gupta and B. Bhattacharya
Simon Fraser University

- Discretized Distance Maps speed-up collision detection, however, their memory requirements may be excessive. Octrees are memory efficient but slow for collision detection.
- The Extended Octree Distance Map (EODM) is a novel representation for efficient collision detection in static environments. It captures the distance to the obstacles in a hierarchical manner using octrees.
- EODM requires only a simple constant-time test, essentially a look up in the stored distance. EODM is computed once and repeatedly used for collision detection queries.
- Our preliminary experiments in 2D show that EODM speeds up collision detection by a factor of three to six compared to an octree.

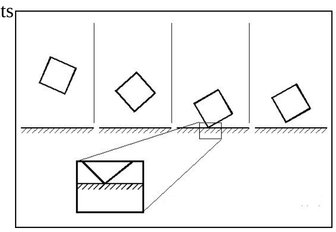




An Algebraic Solution to the Problem of Collision Detection for Rigid Polyhedral Objects

S. Redon[1], A. Kheddar[2] and S. Coquillart[1]
[1]INRIA - Rocquencoart and [2]University d'Evry, France

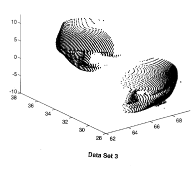
- Realistic and intuitive object manipulation in Virtual Environments
- Continuous collision detection using an arbitrary screwing-derived in-between motion
- The manipulation can be done at interactive rates
- Valuable approach for Collision Detection systems in Virtual Environments

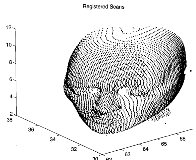


Registration of Range Data Using a Hybrid Simulated Annealing and Iterative Closest Point Algorithm

J. Luck[1], C. Little[2] and W. Hoff[1]
[1]Colorado School of Mines and [2]Sandia National Laboratory

- Robust and efficient registration of range data
- A hybrid algorithm combining ICP and Simulated Annealing
- The algorithm is superior to either individual technique
- The algorithm is both robust and efficient.

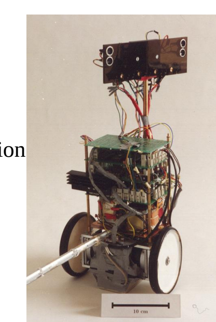




Neural-Network Based Target Differentiation Using Sonar for Robotics Applications

Billur Barshan[1], Birsel Ayrulu[1] and Simukai W. Utete[2]
[1]Bilkent University and [2]University of Oxford

- Motivation and Problem Statement
- Neural-Network Based Target Differentiation
- Experimental Results
- Conclusions

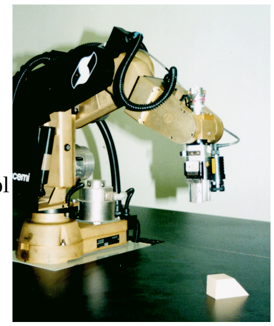


Sensing Strategies and Control 2
Chairs: D. Kriegman, Alfred A. Rizzi

High Speed Visual Servoing of a 6 DOF robot Using MIMO Predictive Control

J. Gangloff and M. de Mathelin
Ecole Nationale Superieure de Strasbourg(ENSPS)

- 120 Hz visual servoing
- Dynamical model of the visual loop
- MIMO Generalized Predictive Control
- 6 DOF target tracking experiment



Robust Video Based Object Recognition Integrating Highly Redundant Cues for Indexing and Verification

C. Eberst, M. Barth, K. Lutz, A. Mair, S. Schmidt and G. Farber
Technische Universitat Munchen

- robust and inexpensive object recognition for mobile robots
- combination of diversitary strategies for hypothesis generation/verification
- robustness against scene complexity and sensing conditions
- reusing joint features for performance at little cost

Towards Robust Sensor-Based Maneuvers for a Car-Like Vehicle

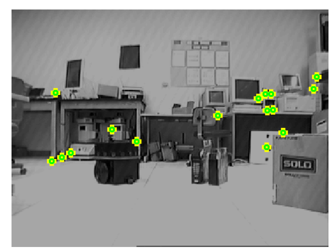
F. Large, S. Sekhavat, C. Laugier and E. Gauthier
INRIA, Rhone-Alpes

- Reactive Control Architecture for a Car-Like Vehicle
- Artificial Neural Networks to modelize the robot kinematics
- Real-time Adaptation using Online Learning
- Experimental results for the trajectory following maneuver

Selecting Promising Landmarks

Markus Knapek [1], Ricardo Swain-Oropeza [2] and David J. Kriegman [2]
[1]Technical University of Munich and [2]University of Illinois at Urbana-Champaign

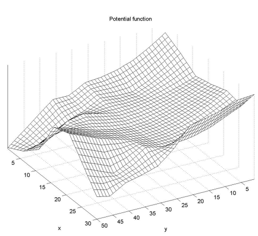
- Selecting best landmarks for visual-based navigation tasks
- Only perceptually salient and visually distinctive landmarks are selected
- Harris detector, K-jets and Mahalanobis distance are used in this method
- Experimental results performed in indoor environments



Dealing with robustness in mobile robot guidance while operating with visual strategies

G. Bianco[1] and A. Zelinsky[2]
[1]University of Verona and [2]The Australian National University

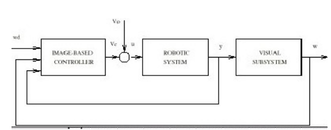
- Studying features related to visual guidance methods
- Analysis of the visual navigation vector field
- Visual learning and robustness features are measured
- Motion fields provide bases for addressing motion features



Two-Level Visual Control of Dynamic Look-and-Move Systems

F. Conticelli and B. Allotta
Scuola Superiore Sant' Anna

- In this paper, the problem of controlling dynamic look-and-move systems, taking into account the linear robot dynamics in the visual control loop, is solved by applying backstepping approach.
- Assuming the existence of a local smooth stabilizing control law for the visual system, the proposed control algorithms address the problem of the stabilization of the interconnected system including the linear robot dynamics.
- Experimental results obtained with the PUMA 560 robot eye-in-hand configuration show that system performance is satisfactory in the positioning with respect to target objects in real conditions.
- Typical tasks based on the proposed approach could be: high-performance vision-based manipulation, and assembly operations.



Sensing for Navigation
Chairs: Kurt Konolige, Edwin Prassler

Autonomous Control of Underground Mining Vehicles using Reactive Navigation

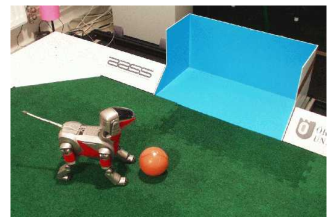
J. M. Roberts[1 3], E. S. Duff[1 3], P. I. Corke[1 3], P. Sikka[1], G. J. Winstanley[1 3] and J. Cunningham[2 3]
[1]CSIRO, [2]CSISO and [3]CRC

- Automation of a class of underground mining vehicles (LHDs)
- Reactive navigation using wall following and nodal maps
- Full-speed performance of an LHD has been demonstrated
- Automation of LHDs is possible without adding navigation infrastructure

Active Perceptual Anchoring of Robot Behavior in a Dynamic Environment

A. Saffiotti and K. LeBlanc
Orebro University

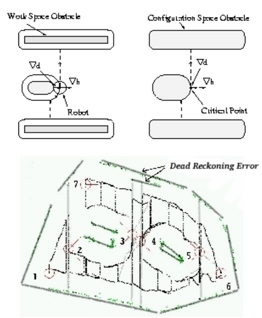
- Perception must be relevant to the current task
- Anchor: model of a physical object, used by the controller
- Perceptual focus based on 'measure of importance' of anchors
- Used in RoboCup'99 to track several objects simultaneously



Critical Point Sensing in Unknown Environments

E. Acar and H. Choset
Carnegie Mellon University

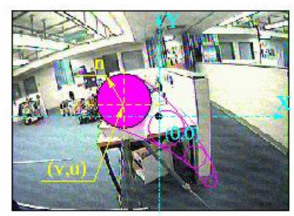
- Complete Sensor Based Coverage of Unknown Environments
- Exact Cellular Decomposition in Terms of Critical Points
- Critical Point Sensing and Algorithms to Encounter All of Them
- Experimental Verification of the Theoretical Results on a Mobile Robot



Optimal Motion Planning in the Image Plane for Mobile Robots

H. Zhang and J. Ostrowski
University of Pennsylvania

- Intro to Visual Motion Planning
- Example for planar robots
- Example for a 3-D robot
- Summary and discussion



High Accuracy Navigation Using Laser Range Sensors in outdoor Applications

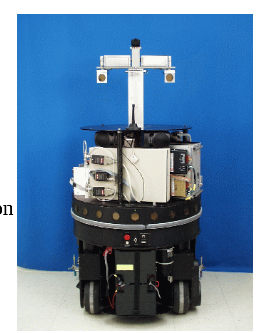
Jose Guivant, Eduardo Nebot and Stefan Baiker
University of Sydney

- Autonomous Navigation: Long term / Large areas
- Simultaneous Localization and Map building
- Natural Feature Recognition / Validation
- Outdoor Experimental Results

Feature Extraction for Autonomous Navigation using an Active Sonar Head

E. G. Araujo and R. A. Grupen
University of Massachusetts

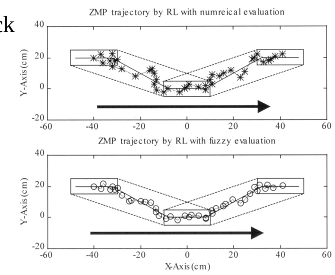
- Feature Acquisition for Reliable Indoor Navigation
- Use of Binaural Sonar Head to Extract 2D Features
- Millimeter Precision in Feature Localization
- Active Sensing Allows Reliable Feature Extraction



Learning 2
Chairs: Koji Ito, C. S. George Lee

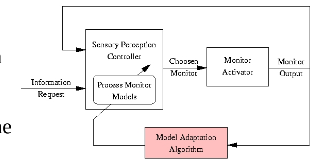
Reinforcement Learning with Fuzzy Evaluative Feedback for a Biped Robot
C. Zhou and Q. Meng
Singapore Polytechnic

- Why fuzzy evaluative feedback for biped learning.
- Fuzzy reinforcement learning (FRL) .
- Biped gait synthesis based on FRL.
- Simulation results.



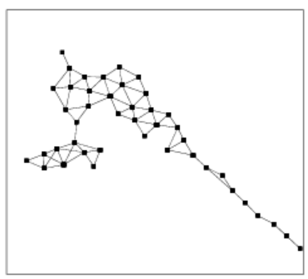
Learning and Adaptation of Sensory Perception Models in Robotic Systems
T. Celinski and B. McCarragher
Australian National University

- Adaptive Control of Perception Requires Good Perception Models
- Good Perception Models Can Be Achieved Through Adaptation
- Radial Basis Functions Over Fixed-Size Grids Allow Real-Time Model Adaptation
- Applicable to Sensory Systems with Time-Varying Characteristics



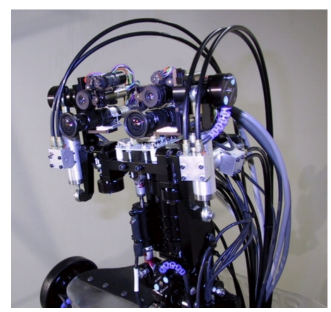
Learning Globally Consistent Maps by Relaxation
Tom Duckett[1], Stephen Marsland[2] and Jonathan Shapiro[2]
[1]University of Orebro and [2]University of Manchester

- Fast, on-line map learning algorithm
- Generates geometrically consistent maps
- Proven to converge to a globally optimal solution
- Experiments in large, real world environments



Fast Learning of Biomimetic Oculomotor Control with Nonparametric Regression Networks
T. Shibata[1] and S. Schaal[2]
[1]Japan Science and Technology Corporation and [2]The University of Southern California

- Learning accurate oculomotor reflexes for visual stabilization during body-movement
- Combining a biologically inspired cerebellar learning scheme with a state-of-the-art statistical learning network
- Using a biomimetic active vision system on our humanoid robot, accurate stabilization reflexes are learned in less than 60 seconds
- Biomimetic learning and control circuits combined with modern statistical learning methods lead to autonomous acquisition of high performance oculomotor control

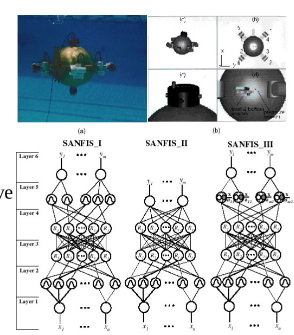


Evolution Based Virtual Training in Extracting Fuzzy Knowledge for Deburring Tasks
S. F. Su[1], T. J. Horng[2] and K. Y. Young[2]
[1]National Taiwan University of Science and [2]Technology and National Chiao Tung University

- To obtain optimal parameters (skill) through virtual training.
- Fuzzu rules are the skill knowledge to be found.
- Evolution Strategies are used to search for the best fuzzy rules.
- The results of deburring are more satisfactory than that of the previous work.

Self-Adaptive Neuro-Fuzzy Systems with Fast Parameter Learning for Autonomous Underwater Vehicle Control
J. S. Wang[1], C. S. G. Lee[1] and J. Yuh[2]
[1]Purdue University and [2]University of Hawaii

- A Generic Multi-Layer Neuro-Fuzzy Control Architecture
- Linear and Nonlinear Optimization for Fast Parameter Learning
- Neuro-Fuzzy Networks with Self-Adaptive and Self-Organizing Capabilities
- Computer Simulation Verification for Controlling an AUV

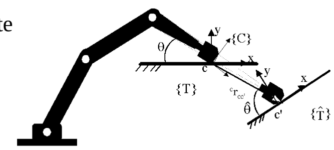


Grasping and Force Control
Chairs: Suguru Arimoto, Bruno Siciliano

A Position/Force Control for a Soft Tip Robot Finger Under Kinematic Uncertainties

Zoe Doulgeri[1], Andreas Simeonidis[1] and Suguru Arimoto[2]
[1]Aristotle University of Thessaloniki and [2]Ritsumeikan University

- Control with uncertain contact point and surface orientation
- Adaptive control with composite parameter update law
- Simulation results for a 3 dof planar robotic finger
- Asymptotic stability of force and estimated position errors



Geometrically Consistent Impedance Control for Dual-Robot Manipulation

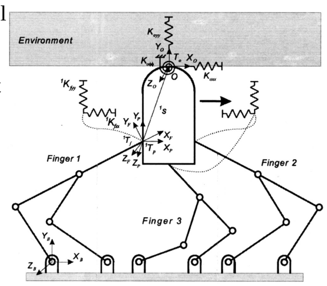
Fabrizio Caccavale[1], Stefano Chiaverini[2], Ciro Natale[1], Bruno Siciliano[1] and Luigi Villani[1]
[1]Universit degli Studi di Napoli Federico II and [2]Universit degli Studi di Cassino

- Two Robots Grasping a Rigid Object
- Task-Oriented Formulation
- Six-DOF Impedance Control
- Experimental Results

A Biomimetic Compliance Control of Robot Hand by Considering Structures of Human Finger

B. H. Kim[1], B. J. Yi[1], I. H. Suh[1], S. R. Oh[2] and Y. S. Hong[2]
[1]Hanyang University and [2]KIST

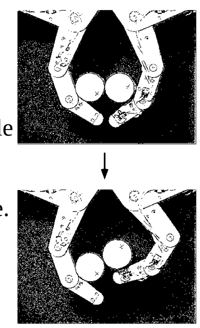
- Biomimetric Compliance Control Method
- Resolved Inter-Finger/Inter-Joint Decoupling Solver
- Improved Compliance Control
- Grasp Geometry and Geometric Structure of Finger important for successful compliance control



Rolling Based Manipulation for Multiple Objects

K. Harada, M. Kaneko and T. Tsuji
Hiroshima University

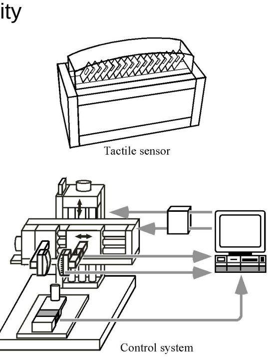
- We formulate the manipulation theory of multiple objects.
- We discuss the motion constraint of multiple objects.
- We discuss the dependency of contact force.
- Experimental results are shown to verify our idea.



Control of Grasping Force by Detecting Stick/Slip Distribution at the Curved Surface of an Elastic Finger

Takashi Maeno, Shinichi Hiromitsu and Takashi Kawai
Keio University

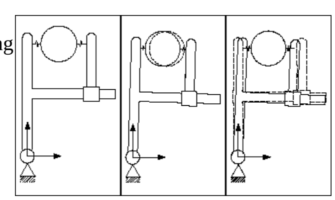
- Tactile sensor for grasping unknown object is expected to be developed.
- A method for grasping object using curved elastic finger is proposed.
- It is confirmed that object is grasped and lifted without slippage.
- The proposed sensor can be used for robot hands.



Motion-decoupled internal force control in grasping with visco-elastic contacts

D. Prattichizzo and P. Mercorelli
Universit di Siena

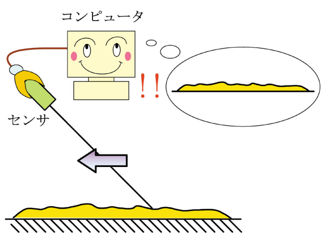
- General manipulation systems.
- Non-rigid contacts. Noninteracting force/motion control.
- State space design. Geometric approach.
- Force/motion decoupling as a structural property.



Novel Sensing Devices
Chairs: Makoto Kaneko, Richard Voyles

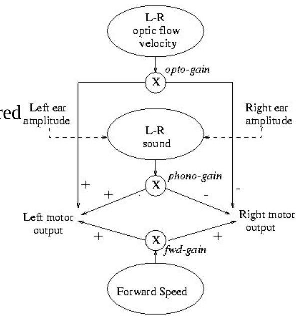
A Whisker Tracing Sensor with 5μm Sensitivity
Makoto Kaneko and Toshio Tsuji
Hiroshima University

- Motivation: Detection of a small burr after drilling process.
- Approach: Whisker sensor anchored at base with torque sensor.
- Result: The sensor can detect irregularities with 5 micro meter.
- Advantage: The sensor can be inserted into a small hole.



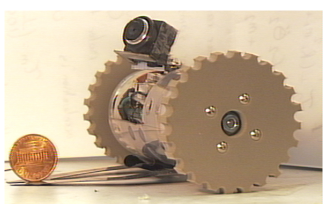
Eyes and ears: combining sensory motor systems modelled on insect physiology
Barbara Webb[1] and Reid Harrison[2]
[1]University of Stirling and [2]California Institute of Technology

- 'Matched filter' sensors could help simplify sensor fusion
- Optomotor aVLSI chip and cricket-inspired sound localisation
- Improved approach path; robot can lock-on to sound
- Need to explore in more challenging motor control task



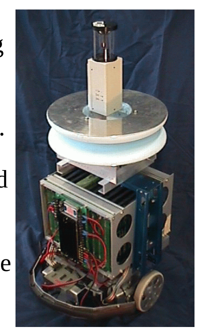
Active Video System for a Miniature Reconnaissance Robot
K. Yesin[1], B. Nelson[1], N. Papanikolopoulos[1], R. Voyles[1] and D. Krantz[2]
[1]University of Minnesota and [2]MTS Systems Corporation

- A pan-tilt video module was built for a miniature mobile reconnaissance robot.
- Severe restrictions on size, weight and power consumption.
- Available technologies for image sensing and actuation are investigated for compatibility with miniature systems.
- The module uses a single-chip CMOS video sensor and 3 mm diameter gearmotors.



Fusion of Omni-directional Sonar and Omni-directional Vision for Environment Recognition of Mobile Robots
T. Yata, A. Ohya and S. Yuta
University of Tsukuba

- New sonar can provide accurate reflecting points.
- Vision can provide edges of wall segment.
- Get environmental feature by fusing based on direction.
- Omni-directional measurement by a single measurement.

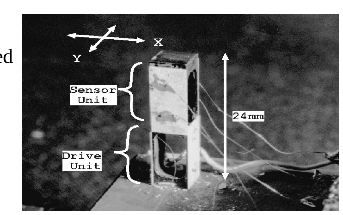


Approximating a Single Viewpoint in Panoramic Imaging Devices
Steven Derrien[1] and Kurt G. Konolige[2]
[1]IRISA and [2]SRI International

- Simple panoramic devices that approximate a single viewpoint
- Standard cameras and spherical mirrors can be used
- Real-time dewarping produces perspective images

Suppression of Mechanical Coupling for Parallel Beam Gyroscope
H. Sato[1], T. Fukuda[1], F. Arai[1], K. Itoigawa[2] and Y. Tsukahara[2]
[1]Nagoya University and [2]Tokai Rika Co.,LTD

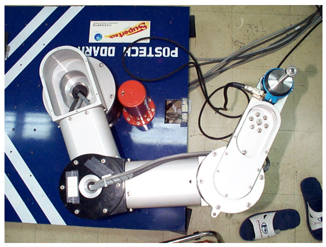
- We propose new gyroscope using parallel beam structure.
- This gyroscope can converts the Coriolis force into concentrated electric charge.
- Resonance frequency can be easily adjusted by changing the mass of the tip
- Mechanical coupling can be suppressed by applied voltage to sensor unit.



Dynamics and Optimization
Chairs: Abhinandan Jain, Beom-Hee Lee

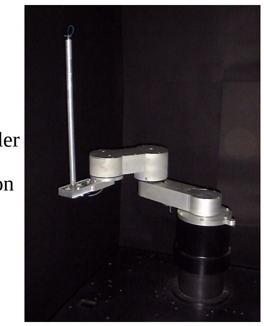
Unified Motion Specification and Control of Kinematically Redundant Manipulators
J. Park, W. K. Chung and Y. Youm
Pohang University of Science & Technology (POSTECH)

- Analysis and control of kinematically redundant manipulators in an effective and unified way
- Kinematically decoupled joint space decomposition technique to model the dynamics of self-motions and incorporate various inverse kinematic methods
- Experimental verification using a planar 3 DOF direct drive arm
- Successful specification and control of motion for redundant manipulators



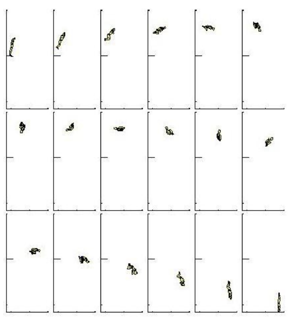
Balancing of an Inverted Pendulum with a Redundant Direct-Drive Robot
Chi Youn Chung, Jin Won Lee, Sang Moo Lee and Beom Hee Lee
Seoul National University

- Stabilizing the base-excited inverted pendulum around its upright position with a robot
- Hall-effect sensor system, Redundancy utilization, Acceleration observer/controller
- Good performance at the best configuration with a stable limit cycle
- Balancing of the 2-DOF pendulum with the 3-DOF direct-drive robot is unique.



On the Computation of Optimal High-Dives
J. V. Albro[1], G. A. Sohl[1], J. E. Bobrow[1] and F. C. Park[2]
[1]University of California, Irvine and [2] Seoul National University

- Want to generate realistic human motion, e.g. platform dives
- Solve related optimal control problem with analytic gradients
- Only had to specify 8 parameters to get successful dives
- Can get some human-like motions relatively easily this way

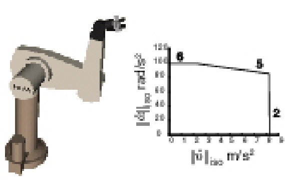


Modeling of Mechanical Systems with Lumped Elasticity
W. Khalil and M. Gautier
IRCyN - Ecole Centrale de Nantes

- - Modeling mechanical systems with lumped elasticity. For high speed machine tools and robots with elastic joints.
- - Robotics classical notations have been used, the geometric and kinematic models are directly obtained.
- - The inverse dynamic model has to be redefined and developed.
- - Applications concern the simulation and control of such systems.

Robot Acceleration Capability: The Actuation Efficiency Measure
Alan Bowling and Oussama Khatib
Stanford University

- Problem: Measure actuator oversizing for desired performance.
- Purpose: Aid in robotic manipulator design.
- Method: Analysis of dynamic model and actuator torque bounds.
- Feature: Unified study of linear and angular motions.



Reducing peak torque of third actuator yields two-fold increase in actuation efficiency without decreasing performance

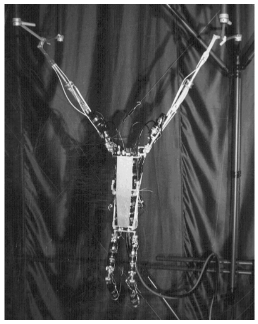
Trajectory Planning of Robots with Dynamics and Inequalities
N. Faiz and S. Agrawal
University of Delaware

Bipedal and Climbing Robots
Chairs: Toshio Fukuda, Gill A. Pratt

Behavior Coordination and its Modification on Brachiation-type Mobile Robot

Y. Hasegawa, Y. Ito and T. Fukuda
Nagoya University

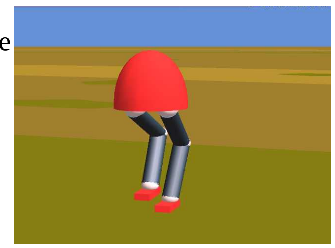
- Novel adaptation method for a behavior-based locomotion robot
- Adjusts the activation level of each behavior controller
- Apply to task changing of BrachiatorIII
- Acheive continuous locomotion behavior



A General Control Architecture for Dynamic Bipedal Walking

Chee-Meng Chew and Gill Pratt
Massachusetts Institute of Technology

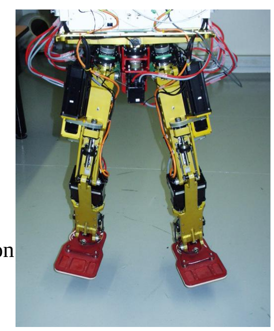
- Motivation and Objective
- Proposed Approach
- Simulation Results
- Conclusions



The Anthropomorphic Biped Robot BIP2000

B. Espiau[1] and P. Sardain[2]
[1]INRIA and LMS and [2]Laboratoire de Mecaninque des Solides

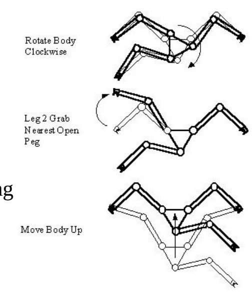
- Design of a biped robot with 15 dofs (lower part only)
- Originalities: mechanical structure, control algorithms and architecture
- Results: 2 robots built; they move.
- Testbed for further studies in locomotion and posture



Action Module Planning and its Application to an Experimental Climbing Robot

D. M. Bevly[1], S. Farritor[2] and S. Dubowsky[3]
[1]Stanford University, [2]University of Nebraska and [3]Massachusetts Institute of Technology

- A planning methodology is studied for a laboratory climbing robot
- Plans are assembled from basic actions and consider physical constraints
- An experimentally implemented climbing gate is produced
- The method produces physically realizable plans



LIBRA Action Modules

Analysis and synthesis of human motion from external measurements

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

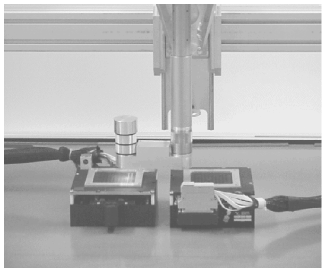
- The motivation is to develop an accurate method for estimating human joint moments from motion capture data.
- The technique is based linear quadratic optimal control theory.
- The experimental results for a five segment sagittal human model performing a lifting task are presented.
- The algorithm is robust in tracking the measured data.

Control and Applications 2
Chairs: William Hamel, Krzysztof R. Kozlowski

Robust and Efficient Motion Planning for a Planar Robot using Hybrid Control

A. E. Quaid and A. A. Rizzi
Carnegie Mellon University

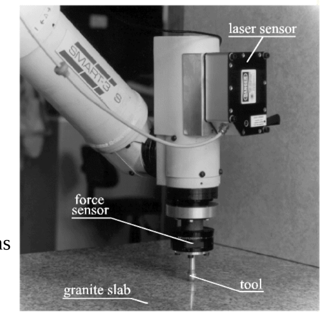
- Motivation for controller-based motion planning
- System description for planar robot
- Controller derivation
- Simulation results



Impedance Control for Industrial Robots

G. Ferretti, G. Magnani, P. Rocco, F. Cecconello and G. Rossetti
Politecnico di Milano

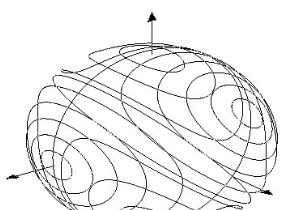
- Impedance control for an elastic joint
- The role of Coulomb friction
- An impedance controller for a multi d.o.f. manipulator
- Experimental results and conclusions



A New Class of Control Laws for Spacecraft Attitude Tracking using Switching and Trajectory Rescaling

P. Arambel[1] and V. Manikonda[2]
[1]Scientific Systems Co., Inc and [2]Intelligent Automation Inc.

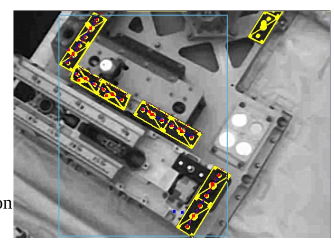
- Objective is to achieve robust attitude tracking in the presence of input constraints
- A quaternion feedback controller + switching strategy is presented to achieve globally exponentially stable tracking
- The controller overcomes problems associated with turn-around near the unstable equilibrium
- Reference trajectory rescaling is used for tracking with input constraints



On Satellite Vision-aided Robotic Experiment

Maarten Vergauwen, Marc Pollefeys, Tinne Tuytelaars and Luc Van Gool
Katholieke Universiteit Leuven

- Discussion of experiments on ETS-VII
- On-line and off-line calibration procedures
- Vision-aided robot guidance experiments
- Advanced uncalibrated computer-vision algorithms



A Value Measure for Data to Control Sensing and Motion Processes

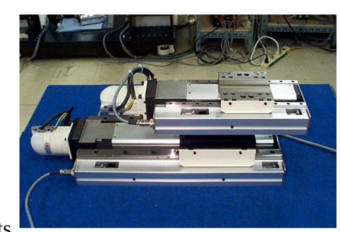
P. A. L. Silverthorne[1] and H. Stephanou[2]
[1]HelpMate Robotics, Inc. and [2]Rensselaer Polytechnic Institute

- Software Architecture for Mobile, Armed, Sensate Robot
- Data's
- Simple (autonomous) Mobile Robot example illustrated
- Extension to advanced platform, more senses/actuators

Robust and Time-Optimal Control Strategy for Coarse/Fine Dual-Stage Manipulators

S. J. Kwon, W. K. Chung and Y. Youm
Pohang University of Science & Technology (POSTECH)

- Fast and Precise Tracking adopting Coarse/Fine actuation.
- A Smooth Sliding Control Strategy.
- Null Motion Control based on Dynamic Consistency.
- Experimental Simulation Results.



Human Robot Cooperation
Chairs: Gordon Cheng, Katsushi Ikeuchi

A Robotic Co-operation System based on a Self-organization approached Human Work Model - Assembling Work Support by Vision information and Physical Interaction-

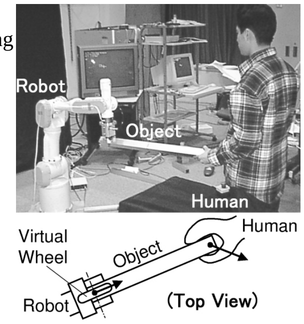
Yasuhisa Hayakawa, Tetsuya Ogata and Shigeki Sugano
Waseda University

- Robot's Support by Understanding Human Behavior
- Construction of Work Process Model by Observing Human Behavior
- Robotic Support System based on the Work Process Model
- Highly Friendly Cooperation without Sacrificing Performance

Human-Robot Cooperative Manipulation Using a Virtual Nonholonomic Constraint

Hirohiko Arai[1], Tomohito Takubo[2], Yasuo Hayashibara[3] and Kazuo Tanie[1]
[1]Mechanical Engineering Laboratory, [2]University of Tsukuba and [3]Toin University of Yokohama

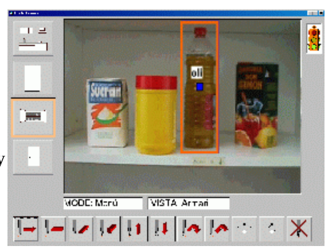
- Robotic assistance for planar handling of a long object
- Virtual nonholonomic constraint equivalent to a wheel-barrow
- No sideslip and controllability to any position/orientaiton
- Simple and intuitive maneuver for the human operator



Friendly Interface for Objects Selection in a Robotized Kitchen

A. Casals[1], X. Cufi[2], J. Freixenet[2], J. Marti[2] and X. Munoz[2]
[1]Polytechnical University of Catalonia and [2]Universitat de Girona

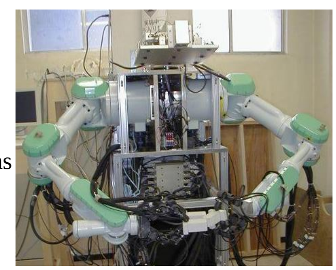
- CAPDI: A modular adapted kitchen for the disabled and elder
- A vision based friendly interface is necessary to control a robotic arm and other adapted elements
- Computer vision supports two different compatible and complementary methods for object selection
- The interface is a menu driven screen, having as input device a 4 keys keyboard



Symbolic Generation of Trajectories for Skill Generation

H. Tominaga[1], J. Takamatsu[1], H. Kimura[2] and K. Ikeuchi[1]
[1]The University of Tokyo and [2]University of Electro-Communications

- Manipulation skill
- Analyzing contact relation
- Decomposition of dimensions
- Designing sub-skills



Infant Behavior Recognition System Based on Pressure Distribution Image

T. Harada, A. Saito, T. Sato and T. Mori
The University of Tokyo

- There is increasing concern about an infant care system recently.
- We developed a novel infant behavior recognition system based on a pressure distribution image.
- Infants' status, posture and body parts positions can be recognized.
- Our system can be useful for care systems such as an automatic growth recoding system or a SIDS prevention system.

Lying infant's posture *Recognized posture*

The RoboCup-Rescue Project: A Robotic Approach to the Disaster Mitigation Problem

S. Tadokoro[1], H. Kitano[2], T. Takahashi[3], I. Noda[4], H. Matsubara[4], A. Shinjoh[5], T. Koto[6], I. Takeuchi[6], H. Takahashi[7], F. Matsuno[8], M. Hatayama[8], J. Nobe[9] and S. Shimada[10]
[1]Kobe University, [2]ERATO Kitano Symbiotic Project, [3]Chubu University, [4]Electrotechnical Laboratory, [5]International Academy of Media Arts and Sciences, [6]University of Electro Communication, [7]Port and Harbor Research Institute, [8]Tokyo Institute of Technology, [9]Mitsubishi Research Institute and [10]Chukyo University

- Robotics & AI contribution to emergency disaster response problem
- 4 projects: simulation, robotics & infrastructure, integration, and operation
- Strategic agent planning, and integration of virtual world and reality
- Grand challenge for international cooperative research