Localization

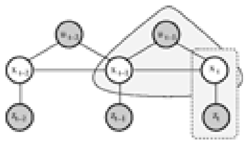
Chair *Alessandro Saffiotti, Orebro Univ.*
Co-Chair *Wan Kyun Chung, POSTECH*

08:00–08:18	FrA1.1

CRF-Filters: Discriminative Particle Filters for Sequential State Estimation

Benson Limketkai, Dieter Fox, and Lin Liao
Dept. of Computer Science & Engineering, University of Washington, USA

- Existing particle filters require extensive tuning to work in practice
- CRF-Filters learn model parameters that maximize filter performance
- Learning takes dependencies, sensor noise, and sample-based approximation into account
- CRF-Filters outperform generatively trained particle filters on laser-based robot localization task



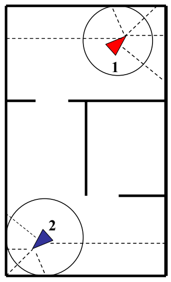
Undirected graphical model underlying CRF-Filters

08:18–08:36	FrA1.2

A Hybrid Active Global Localisation Algorithm for Mobile Robots

Andrea Gasparri, Stefano Panzieri, Federica Pascucci, Giovanni Ulivi
DIA, Università degli Studi “Roma Tre”, Rome, Italy

- An active localisation method for mobile robots without global positioning devices is proposed
- Two steps procedure:
  - Hypotheses generation using particle filter
  - Safe planning through way points and EKF tracking

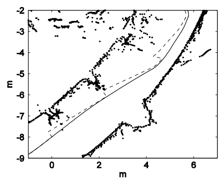


08:36–08:54	FrA1.3

Probabilistic Sonar Scan Matching For Robust Localization

Antoni Burguera, Yolanda González and Gabriel Oliver
Dept. Matemàtiques i Informàtica, Universitat de les Illes Balears, Spain

- Sonar readings are grouped to overcome their sparse nature.
- A probabilistic approach, spIC, is adopted to perform scan matching.
- The probabilistic approach accounts for noise and errors in sonar readings.
- The robot trajectory involved in the scan building is corrected.



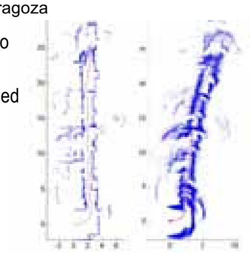
Correction of the robot trajectory

08:54–09:12	FrA1.4

Improved Data Association for ICP-based Scan Matching in Noisy and Dynamic Environments

D. Rodriguez-Losada
Universidad Politécnica de Madrid
J. Minguez
Universidad de Zaragoza

- New filtering for Scan Matching techniques to deal with noisy and dynamic scenarios
- The filter is based on a metric distance defined in sensor configuration space
- Tested in noisy and dynamic scenarios improving the results of standard scan matching under these work conditions



60 meters trajectory with 879 scans

09:12–09:30	FrA1.5

An accurate closed-form estimate of ICP’s covariance

Andrea Censi

DIS, Universita’ di Roma “La Sapienza”, Italy

- The approach is quite general, as it is based on the analysis of the error function, not on the particular algorithm used to minimize it.
- It does consider that (1) correspondences are not independent, and that (2) measurements errors can be correlated.
- It is more accurate than previous methods (also those using brute force).
- An observability analysis is performed for under-constrained situations.

** Warning: the presentation may contain formulas.*

Active Vision

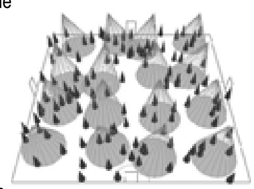
Chair *Fabio Ramos, Univ. of Sydney*
Co-Chair *Christophe Collewet, INRIA*

08:00–08:18	FrA2.1

View Planning of Multiple Active Cameras for Wide Area Surveillance

Noriko Takemura and Jun Miura
Department of Mechanical Engineering, Osaka University

- Select fixation points of cameras so that the expected number of tracked persons is maximized.
- Develop a multi-start local search (MLS)-based planning method
- Set a criterion which encourages frequent shifts of fixation points.
- Divide the cameras into mutually independent groups and determine fixation points within each group for reducing planning cost.



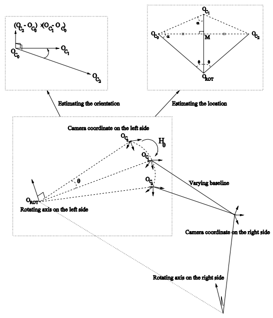
simulator of the multi-camera multi-person tracking problem

08:18–08:36	FrA2.2

A New Approach for Active Stereo Camera Calibration

Hyukseong Kwon, Johnny Park, and Avinash C. Kak
School of Electrical and Computer Engineering, Purdue University, USA

- Active stereo camera calibration by estimating the locations and the orientations of the rotating axes.
- No geometrical assumption regarding the camera's rotating motions.
- A closed form solution using the geometry of the camera's rotations.
- Improvement in the accuracy of calibration.



08:36–08:54	FrA2.3

Calibrating Pan-Tilt Cameras in Robot Hand-Eye Systems Using a Single Point

C.S. Gatla, R. Lumia, J. Wood, G. Starr
Mechanical Engineering Dept., University of New Mexico, USA

- Use single projected laser point at unknown position on distant plane for calibration
- Simplify correspondence problem since only one bright point in each image is found – no need for human intervention
- Gather data in robot configurations that detect the bright point
- Compute camera internal and external model parameters using Levenberg-Marquardt non-linear minimization

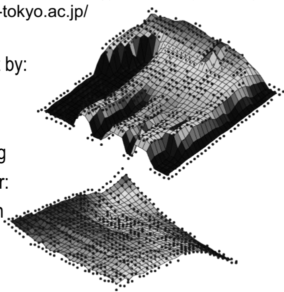
Workcell with two Staubli Robots and laser point projected on wall

08:54–09:12	FrA2.4

955-fps Real-time Shape Measurement of a Moving/Deforming Object using High-speed Vision for Numerous-point Analysis

Yoshihiro Watanabe, Takashi Komuro, and Masatoshi Ishikawa
Graduate School of Information Science and Technology, University of Tokyo
http://www.k2.t.u-tokyo.ac.jp/

- Achieve Real-time Shape Measurement by:
  - Two dimensional Pattern Projection
  - High-frame-rate Imaging
  - High-performance Image Processing
- Improve the Feasibility of Automation for:
  - Man-machine Interaction, Inspection
  - Vehicle Control, Surgery Support



09:12–09:30	FrA2.5

Uncalibrated Dynamic Visual Tracking of Manipulators

Hesheng Wang and Yun-Hui Liu
The Chinese University of Hong Kong

- Proposed a dynamic controller for visual tracking of a manipulator using an uncalibrated fixed camera.
- Developed a new adaptive algorithm to estimate the unknown camera parameters and robot parameters.
- Proved asymptotic trajectory tracking by Lyapunov method
- Verified the performance by experiments

Visual Tracking System

Biped Locomotion I

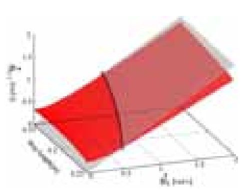
Chair *Shuuji Kajita, AIST*
Co-Chair *Rüdiger Dillmann, Univ. of Karlsruhe*

08:00–08:18 | FrA3.1

Stability Proof of Biped Walking Control based on Point-Contact

M. Doi*, Y. Hasegawa**, T. Matsuno*** and T. Fukuda*
*Dept. of Micro-Nano Systems Engineering, Nagoya University, Japan
**Dept. of of Intelligent Interaction Technologies, Univ. of Tsukuba, Japan
***Dept. of Electronics and Informatics, Toyama Prefectural Univ. Japan

- Lateral and sagittal dynamics is formulated with Passive Dynamic Autonomous Control.
- The convergency of the conserved quantity (PDAC Constant) is shown, and the convergence domain is clarified.
- The stability of sagittal motion is proved by the Liapunov Theory.
- The correctness of the proof is confirmed by numerical simulation.



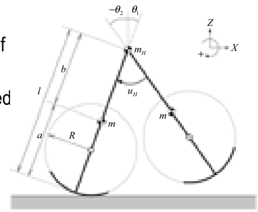
Poincare return map v.s. step-length

08:18–08:36 | FrA3.2

Dynamic Analyses of Underactuated Virtual Passive Dynamic Walking

Fumihiko Asano[1] and Zhi-Wei Luo[2,1]
1. Bio-Mimetic Control Research Center, RIKEN, Japan
2. Faculty of Engineering, Kobe University, Japan

- Underactuated virtual passive dynamic walking (UVPDW) using the rolling effect of semicircular feet is proposed
- Driving mechanism of VPDW is investigated based on generalized virtual gravity
- Relation between the rolling effect of semicircular feet and ankle-joint torque is theoretically clarified
- The importance of foot shape is discussed



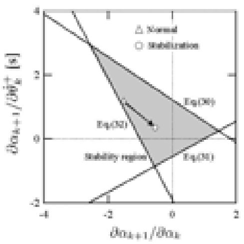
Planar compass-like biped robot with semicircular feet

08:36–08:54 | FrA3.3

Generation and Local Stabilization of Fixed Point Based on a Stability Mechanism of Passive Walking

Yoshito Ikemata, Akihito Sano, and Hideo Fujimoto
Nagoya Institute of Technology, JAPAN

- Dynamics of passive walking with knees
- Generation of fixed point of passive walking class
- Stabilization of fixed point based on a stability mechanism of passive walking
- Walking on the level ground and achieving the highest local stability

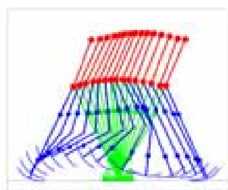


08:54–09:12 | FrA3.4

Level-Ground Walk Based on Passive Dynamic Walking for a Biped Robot with Torso

Terumasa Narukawa
Graduate School of Science and Technology, Keio University, Japan
Masaki Takahashi and Kazuo Yoshida
Department of System Design Engineering, Keio University, Japan

- Numerical simulations show that a biped robot with a torso, knees, and circular feet on level ground can walk stably and efficiently at various speeds by using a torso and swing-leg control.
- The effects of the swing-leg control and the circular feet are demonstrated.



Stick diagrams. The walking speed is 1.3m/s and the specific cost of transport is 0.09

09:12–09:30 | FrA3.5

Landing Motion Control of Articulated Legged Robot

Sanghak Sung and Youngil Youm
Mechanical Engineering Dept., POSTECH, Korea

- Human's landing strategy is applied to articulated legged robot landing motion
- Body stiffness and damping controller is developed using stiffness controller formulation
- Constant and Variable body stiffness and damping value simulation & experiment result with PBOT

Articulated legged robot, PBOT

Haptics

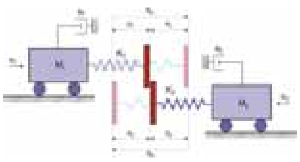
Chair *Domenico Prattichizzo, Univ. of Siena*
Co-Chair *Jaydev Desai, Univ. of Maryland*

08:00–08:18 | FrA4.1

Robust Control of Interaction with Haptic Interfaces

Dragoljub Surdilovic and Jelena Radojicic
Fraunhofer Institute IPK-Berlin, Germany

- Novel Robust Stability Criteria for Control of Interaction Between an Admittance Display and Passive/Active Environments.
- Advanced Admittance Displays for Material Handling and Assembly (Power-Assist Manipulators).
- Experiments with Very Stiff Virtual Environments.

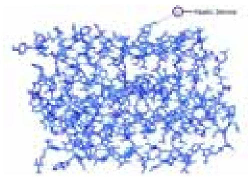


08:18–08:36 | FrA4.2

A Force-Feedback Algorithm for Adaptive Articulated-Body Dynamics Simulation

Sandy Morin and Stephane Redon
INRIA Rhone-Alpes, France

- We present a force-feedback algorithm for complex articulated bodies
- The articulated body is simulated using adaptive dynamics
- Our force-feedback algorithm has a logarithmic complexity
- The force applied to the user is computed within a few microseconds
- We demonstrate our algorithm on articulated-body models of proteins



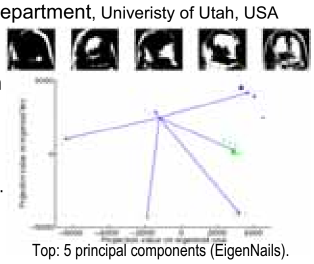
Haptic interaction with an articulated-body model of the bacteriorhodopsin membrane protein (857 degrees of freedom).

08:36–08:54 | FrA4.3

EigenNail for Finger Force Direction Recognition

Yu Sun, John M. Hollerbach,
School of Computing, University of Utah, USA
Stephen A. Mascaro
Mechanical Engineering Department, Univeristy of Utah, USA

- 6 directions of fingertip force are classified based on the coloration patterns in the fingernail and surrounding skin.
- Features termed EigenNails are automatically extracted with PCA.
- Results show that 98% of 960 fingernail images of 8 different subjects are correctly classified with resolution as low as 10-by-10.



Top: 5 principal components (EigenNails). Bottom: Images of the fingernail for different directions of force projected to 2- EigenNail space. They are well separable.

08:54–09:12 | FrA4.4

Performance Issues in Collaborative Haptic Training

Behzad Khademian and Keyvan Hashtrudi-Zaad
Electrical and Computer Engineering Dept., Queen's University, Canada

- A new position-based multilateral shared control architecture for a dual-user collaborative haptic training system is proposed.
- The controller allows users to have variable interact with each other and with the slave.
- Transparency (impedance reflection) in such collaborative system is evaluated and analyzed.
- A performance index is defined to quantify users' skills and to identify the maximum allowable dominance of the trainee over the trainer.

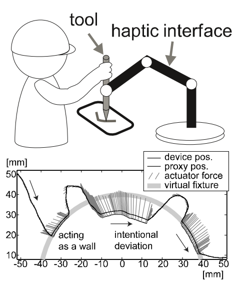
Collaborative haptic training experimental setup, consisting of two Planar Twin-pantograph haptic devices.

09:12–09:30 | FrA4.5

Passive Virtual Fixtures Based on Simulated Position-Dependent Anisotropic Plasticity

Ryo Kikuuwe, Naoyuki Takesue, and Hideo Fujimoto
Nagoya Institute of Technology, Japan

- Virtual fixtures are computer-generated fixtures for assisting/guiding human manipulation through haptic interfaces.
- The control framework for always-passive, plasticity-based virtual fixtures is presented.
- A plasticity-based virtual fixture acts as a hard wall when the user's force is small.
- It can be deviated by intentionally producing a force larger than a predetermined level.
- It can be used with both admittance-type and impedance-type haptic interfaces.



Sensor Networks I

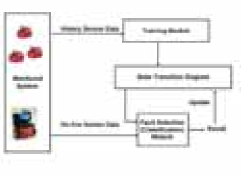
Chair *John M. Dolan, Carnegie Mellon Univ.*
Co-Chair *Sanjiv singh, Carnegie Mellon Univ.*

08:00–08:18	FrA5.1

Sensor Analysis for Fault Detection in Tightly-Coupled Multi-Robot Team Tasks

Xingyan Li and Lynne E. Parker
Dept. of Computer Science, University of Tennessee, Knoxville, USA

- Objective is to monitor for faults in tightly-coupled multi-robot tasks based on sensor data, without use of motion models.
- Approach builds probabilistic state transition model from sensory data using fuzzy clustering to identify states
- SAFDetection approach validated on physical robots performing a cooperative box pushing task.



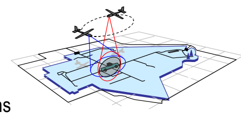
SAFDetection approach

08:18–08:36	FrA5.2

Cooperative Standoff Tracking of Uncertain Moving Targets using Active Robot Networks

Eric W. Frew
Aerospace Engineering Sciences Dept., University of Colorado, Boulder, USA

- Cooperative sensing optimized at minimum allowable distance and 90 degree phasing
- Following elliptical contours ensures standoff guaranteed for uncertain target
- Solution modifies guidance vector fields designed for circular orbits to elliptical patterns
- Coordinate splay state using differential speed commands



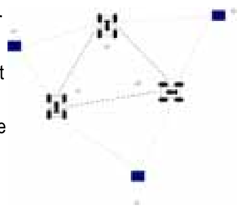
Cooperative standoff tracking of a moving target by two unmanned aircraft

08:36–08:54	FrA5.3

Triangulation Based Multi Target Tracking with Mobile Sensor Networks

Seema Kamath, Eric Meisner, and Volkan Isler
Dept. of Computer Science, Rensselaer Polytechnic Institute, USA

- We study a typical application of mobile sensor networks:tracking multiple targets
- Sensor Nodes must collaborate to obtain target position estimates
- We present a distributed framework to compute sensor assignment and motion strategies

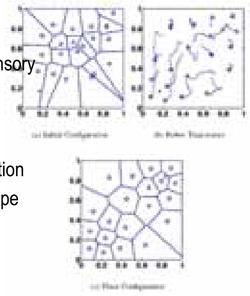


08:54–09:12	FrA5.4

Decentralized, Adaptive Control for Coverage with Networked Robots

Mac Schwager, Jean-Jacques Slotine, Daniela Rus
MIT, USA

- Networked robots cover a region optimally without knowledge of the distribution of sensory information
- The control law estimates the sensory distribution from measurements
- The control law requires only local information
- Convergence is proven with a Lyapunov-type proof

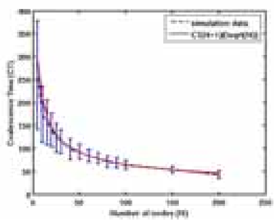


09:12–09:30	FrA5.5

Latency Analysis of Coalescence for Robot Groups

Sameera Poduri and Gaurav S. Sukhatme
Univ. of Southern California, USA

- A group of isolated robots search for peers and coalesce to form large connected components
- No knowledge of environment or robot locations is assumed.
- Probabilistic analysis based on independent random walks is presented and validated using simulations.



Coalescence Time is $O(1/\sqrt{N})$ for *N* robots

Sampling-based Motion Planning

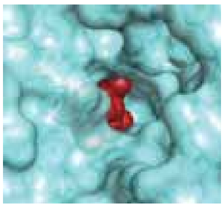
Chair *Elzbieta Roszkowska, Wroclaw Univ. of Tech.*
Co-Chair *Davide Brugali, Univ. of Bergamo*

08:00–08:18	FrA6.1

Molecular Disassembly with RRT-Like Algorithms

Juan Cortés, Léonard Jaillet, and Thierry Siméon
LAAS-CNRS, Toulouse, France

- Mechanistic problem formulation: Disassembly path planning for objects with articulated parts
- Difficulty: Cluttered environments with hundreds of potential degrees of freedom
- The ML-RRT algorithm: Decoupling object motions and automatically identifying mobile parts involved in the disassembly path



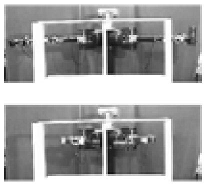
Molecular disassembly problem: Who to extract the ligand from the protein active site ?

08:18–08:36	FrA6.2

Single-Query Motion Planning with Utility-Guided Random Trees

Brendan Burns and Oliver Brock
Computer Science Department, University of Massachusetts Amherst, USA

- Generalization of random tree algorithms
- Adaptive tree expansion based on utility
- Improved efficiency and robustness
- Experiments on a real-world humanoid platform



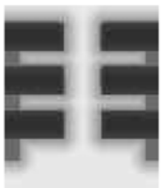
Planner executing on the UMass humanoid torso

08:36–08:54	FrA6.3

Sampling-Based Motion Planning with Sensing Uncertainty

Brendan Burns and Oliver Brock
Computer Science Department, University of Massachusetts Amherst. USA

- Extend motion planning to unknown environments
- Model error in real-world sensing
- Additional sensing as needed, guided by planning
- Robust plans despite errors and uncertainty



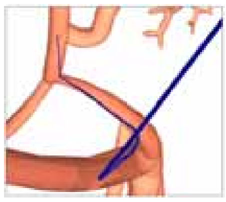
Uncertain perception of an office environment (black is more certain)

08:54–09:12	FrA6.4

Efficient Motion Planning of Highly Articulated Chains using Physics-based Sampling

Russell Gayle, Avneesh Sud, Ming C. Lin, and Dinesh Manocha
Dept. of Computer Science, University of North Carolina at Chapel Hill, USA
Stephane Redon
INRIA Rhone-Alpes, France

- Generates physically-based motion which satisfies geometric, kinematic and dynamic constraints
- Adaptive reduction of state space dimensionality for improved performance
- Constraint forces bias the search and sampling direction
- Can be used as a motion planning algorithm, or as local planner for PRM or RRT



Motion planning of a 2,500-DOF articulated chain as a catheter in a network of arteries

09:12–09:30	FrA6.5

Manipulation Planning Among Movable Obstacles

Mike Stilman†, Jan-Ullrich Schamburek†‡,
James Kuffner†, Tamim Asfour‡
†The Robotics Institute, Carnegie Mellon University, USA
‡Institute of Computer Science and Engineering, University of Karlsruhe, Germany

- RSC is a novel planner that identifies and removes obstacles to make space for manipulation
- Rapidly generates motion for articulated robots in nonlinear search spaces of exponential dimension
- Uses reverse-time search that samples future actions to constrain prior displacements
- Autonomously selects objects, samples surfaces for valid placements and handles task space constraints

Multirobot Task Allocation

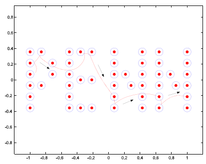
Chair *Georg Klein, Univ. of Oxford*
Co-Chair *Alcherio Martinoli, EPFL*

08:00–08:18 FrA7.1

Sensor-Based Dynamic Assignment in Distributed Motion Planning

Michael M. Zavlanos and George J. Pappas
GRASP Laboratory, Electrical and Systems Engineering Dept.,
University of Pennsylvania, USA

- Distributed control framework for multi-agent assignment problems, based on exploring available destinations.
- Hybrid controllers for the agents combine local sensing and distributed navigation.
- Worst case polynomial complexity, despite the exponential growth of the number of possible assignments with respect to the number of agents.



An agent's path until it is assigned to a destination.

08:18–08:36 FrA7.2

SET: An Algorithm for distributed multirobot task allocation with dynamic negotiation based on task subsets

Antidio Viguria
Georgia Institute of Technology, USA
Ivan Maza, and Anibal Ollero
Robotics, Vision and Control Group, University of Seville, Spain

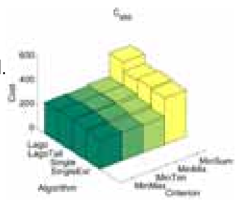
- Two market-based algorithms for the distributed solution of the MRTA problem are presented: SIT-MASR and SET-MASR.
- Robots consider their local plans when bidding and multiple tasks can be allocated to a single robot during the negotiation.
- The SET algorithm is based on the negotiation of subset of tasks and can be considered as a generalization of the SIT algorithm, which only negotiates single tasks.
- Both algorithms have been tested with multiple missions consisting in visiting waypoints with promising results.

08:36–08:54 FrA7.3

Comparative experiments on optimization criteria and algorithms for auction based multi-robot task allocation

Alejandro R. Mosteo and Luis Montano
DIIS - I3A, University of Zaragoza, Spain

- Simulations in random graphs and in large model of a real building.
- Three auction algorithm families are compared.
- Mission time, total resource usage and combined criteria are used.
- Combined criteria reveal as a very competitive option in all tests.



08:54–09:12 FrA7.4

A Complete Methodology for Generating Multi-Robot Task Solutions using ASyMTRe-D and Market-Based Task Allocation

Fang Tang[1] and Lynne E. Parker[2]
[1]Computer Sci. Dept., California State Polytechnic University, Pomona, USA
[2]Dept. of Computer Science, University of Tennessee, Knoxville, USA

- Unique contribution: enabling formation of both strongly-cooperative and weakly-cooperative task solutions in same application
- Coalitions to achieve lowest-level multi-robot tasks formed using our ASyMTRe-D approach
- Higher-level task allocation makes use of market-based task allocation algorithm
- Approach validated in simulation and on physical robots performing a site preparation task

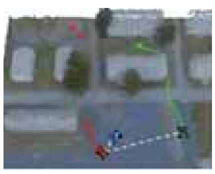
Robots performing site preparation using proposed approach

09:12–09:30 FrA7.5

A Generalized Framework for Solving Tightly-coupled Multirobot Planning Problems

Nidhi Kalra,
RAND
Dave Ferguson,
Intel
and Anthongy Stentz
Carnegie Mellon

- Problem: Tight coordination and long-term planning
- Approach: an adaptive coordination framework
- Approach: novel market-based techniques
- Simulation results: superior solutions
- Fieldable: tested on large outdoor robots



Medical Microrobots

Chair *Sergej Fatikow, Univ. of Oldenburg*
Co-Chair *Jake Abbott, ETH Zurich*

08:00–08:18	FrA8.1

Trajectory Planning for Functional Wrist Movements in an ADL-Oriented, Robot-Assisted Therapy Environment

Kimberly J. Wisneski, MS and Michelle J. Johnson, PhD
Biomedical Engineering Dept., Marquette University, Milwaukee USA, Physical Medicine and Rehabilitation, Medical College of Wisconsin, USA, Rehabilitation Robotics Research and Design Lab, Clement J. Zablocki VA, USA

- Robot-assisted therapy devices are being used more frequently in stroke rehabilitation.
- Carryover of motor gains after robot training may be improved with the use of training activities focused on activities of daily living (ADLs).
- New trajectory models are need to support robot-based functional training using ADLs.
- We evaluate the utility of minimum-jerk trajectory models with and without curvature considerations for planning robot-based movements during functional ADLs tasks such as drinking.

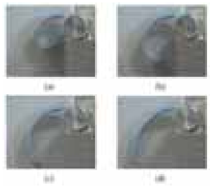
Activities of Daily Living Exercise Robot (ADLER) for Functional Robot Assisted Therapy

08:18–08:36	FrA8.2

Electrolytic Silicone Bourdon Tube Microactuator for Reconfigurable Surgical Robots

Nicola Ng Pak, Arianna Menciassi, and Paolo Dario
CRIM Lab, Scuola Superiore Sant'Anna, Italy
Robert J. Webster
Mechanical Engineering Dept., Johns Hopkins University, USA

- Development of a microactuator designed for use in robots for endoluminal surgery
- The miniaturizable design proposed harnesses the Bourdon effect to convert electrolytic pressure into mechanical motion
- Large displacement (>400%)
- Low power consumption (< 0.5W at 5V)



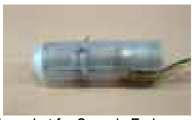
Images of the SBT changing shape as it is pressurized via electrolysis.

08:36–08:54	FrA8.3

Paddling based Microrobot for Capsule Endoscopes

Hyunjun Park, Sungjin Park, and Euisung Yoon
Korea Institute of Science and Technology, KOREA
Byungkyu Kim
Hankuk Aviation Univ. KOREA
Jongoh Park and Sukho Park
Chonnam National Univ. KOREA

- Paddling based locomotive mechanism is proposed and designed.
- Proposed multi-legs microrobot is fabricated and the control setup is also constructed.
- Kinematic and dynamic parameters are optimized by preliminary experiments.
- Through in-vitro and in-vivo experiments, the locomotive performances are tested.



Microrobot for Capsule Endoscopes

In-vivo Test

08:54–09:12	FrA8.4

Design and Calibration of an Optical Micro Motion Sensing System for Micromanipulation Tasks

Tun Latt Win, U-Xuan Tan, Shee Cheng Yap and Wei Tech Ang
School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore

- Position Sensitive Detectors (PSD) are used as sensing devices.
- Neural network calibration is performed to eliminate nonlinearity of PSDs and lenses.
- After calibration, percentage RMS error and noise are about 0.16% and 0.7 micrometer respectively. The sampling rate of the system is 250 Hz.
- The system can be used as an evaluation tool in micromanipulation tasks

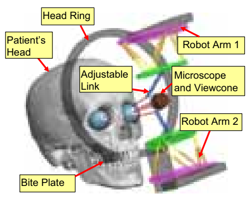
Micro Motion Sensing System

09:12–09:30	FrA8.5

Design and Theoretical Evaluation of Micro-Surgical Manipulators for Orbital Manipulation and Intraocular Dexterity

Wei Wei[1], Roger Goldman[1], Nabil Simaan[1], Howard Fine[2] and Stanley Chang[2]
[1] Advanced Robotics and Mechanism Applications Lab, Columbia University
[2] Dept. of Ophthalmology, Columbia University, USA

- Analysis and dexterity evaluation for a 16 DoF robot for ophthalmic surgery
- Robot offers both orbital manipulation and intraocular dexterity
- This hybrid robot is composed from parallel robots and an intraocular distal dexterity device
- Quantification of kinematic performance of the system with intraocular dexterity



CAD Model of the Proposed Two-Armed Robotic System

Detection of Dynamic Objects

Chair *Yasushi Nakauchi, Univ. of Tsukuba*
Co-Chair *Carlos Balaguer, Univ. Carlos III de Madrid*

08:00–08:18 FrA9.1

A data fusion architecture for the dynamic follow-up of vehicles

Arnaud CLERENTIN, Eric BRASSART, Laurent DELAHOCHE, Bruno MARHIC, Sonia IZRI
LTI, IUT Amiens, France

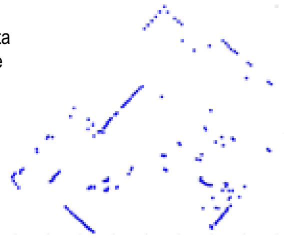
- Computation of a danger level about the vehicle surrounding
- Management and propagation of uncertainties from low level data to a global danger estimate
- Key tool : the TBM of Smets, a variant of the Dempster Shafer theory

08:18–08:36 FrA9.2

Using Boosted Features for the Detection of People in 2D Range Data

Kai O. Arras, Oscar Martinez Mozos, Wolfram Burgard
Dept. of Computer Science, University of Freiburg, Germany

- Where are the people? Range data contain little information on people
- We classify groups of adjacent beams from legs
- Using AdaBoost to learn a robust classifier
- Classification rates over 90% in cluttered environments

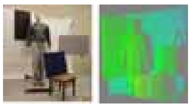


08:36–08:54 FrA9.3

Training and optimization of operating parameters for flash LADAR cameras

Michael Price[1], Jacqueline Kenney[2], Roger D. Eastman[2], Tsai Hong[3]
EECS Department, MIT[1] - CS Department, Loyola College in Maryland[2] - Intelligent Systems Division, NIST[3]

- Objective: set parameters for flash LADAR range camera to optimize range data quality
- Implementation: non-linear offline training that creates look-up table for real-time online use
- Result: preliminary tests show promise in reducing range variance



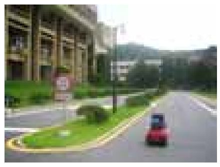
Scene with range data collected using optimal parameters

08:54–09:12 FrA9.4

Outdoor Navigation of a Mobile Robot Using Differential GPS and Curb Detection

Seung-Hun Kim, Chi-Won Roh, and Sungchul Kang
Intelligent Robotics Research Center, Korea Institute of Science and Technology, Seoul, Korea
Min-Yong Park
Electrical and Electronic Engineering Dept., Yonsei University, Seoul, Korea

- Localization by fusing differential GPS and odometry data of a mobile robot using extended Kalman filter.
- An algorithm to detect curbs using a laser range finder
- Hybrid navigation strategy for a reliable mobile robot system



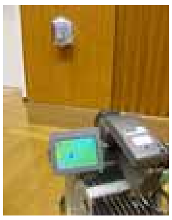
The mobile robot driving along the road

09:12–09:30 FrA9.5

Property Modifiable Discreet Active Landmarks

Tetsuo Tomizawa
Ubiquitous Functions Research Group, AIST, Japan
Yoichi Morales Saiki, Akihisa Ohya, Shin'ichi Yuta
Intelligent Robot Lab, Univ. of Tsukuba, Japan

- We developed Active Landmark devices which are able of changing their own properties
- Active landmarks can be easily detected by a robot system and its information can be used for tracking and localization applications
- These devices are not visible for humans
- We introduce an alterable thermo landmark system and some of its applications



An alterable thermo landmark and a mobile robot with IR camera.

Flexible Arms I

Chair *Alin Albu-Schäffer, DLR - German Aeorspace Center*
Co-Chair *Masaru Uchiyama, Tohoku Univ.*

08:00–08:18 FrA10.1

A Vision-Based Endpoint Trajectory and Vibration Control for Flexible Manipulators

Xin Jiang, Atsushi Konno, and Masaru Uchiyama
Department of Aerospace Engineering, Tohoku University, Japan

- Trajectory following achieved by tracking interpolated image features
- A vision-based vibration suppression control
- A position control solution for flexible manipulators utilizing only visual information

08:18–08:36 FrA10.2

Numerical Implementation and Comparison Between the Viscous, Fractional and Hysteretic Damping Models of a Rigid-Flexible Planar Manipulator

Jorge M. Martins, Alexandre N. Paris, and José M. Sá da Costa
Instituto Superior Técnico - IDMEC, Technical University of Lisbon, Portugal

- Dynamics modeling of a flexible manipulator with structural damping
- Treatment of viscous, fractional and hysteretic structural damping approaches
- Identification of the minimum set of dynamic parameters
- Identification of the damping model parameters
- Experimental validation

The IST planar Rigid-Flexible Manipulator

08:36–08:54 FrA10.3

A DAE approach to Feedforward Control of Flexible Manipulators

Stig Moberg
Division of Automatic Control, Linköpings Universitet, Sweden
Sven Hanssen
Dept. of Solid Mechanics, Royal Institute of Technology, Stockholm, Sweden

- A General Elastic Model Structure for Flexible Industrial Robot Structures
- A Feedforward Control Approach based on solution of DAE's
- Simulation Example included

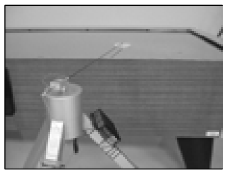
IRB6600ID from ABB Robotics

08:54–09:12 FrA10.4

Fast Identification Method to Control a Flexible Manipulator with Parameter Uncertainties

Jonathan Becedas, Juan Ramón Trapero, Vicente Feliu
Universidad de Castilla-La Mancha, Spain
Hebertt Sira-Ramírez
Cinvestav IPN, Mexico

- On-line closed loop identification method combined with Generalized Proportional Integral controller.
- The identification method estimates the unknown system parameter and update the controller.
- Experimental results validate the theoretical analysis.



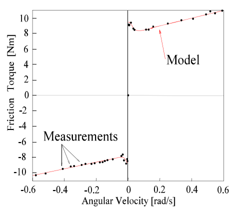
Flexible Robot Prototype

09:12–09:30 FrA10.5

Control of Harmonic Drive Motor Actuated Flexible Linkages

J.-P. Hauschild
Electrical Engineering,Technical University of Hamburg-Harburg, Germany
G. R. Heppler
Dept. of Systems Design Engineering, University of Waterloo, Canada

- Friction compensation for harmonic drive motors is investigated and implemented
- Experimental results are presented
- An inner friction compensation control loop allows the use of controllers designed for flexible links with direct drive motors
- Experimental and simulation results for a two flexible link system are reported.



Distributed Target Tracking

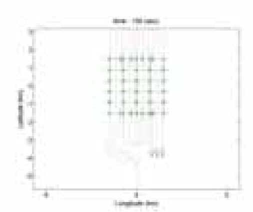
Chair *Daniel Clouse, Jet Propulsion Lab.*
Co-Chair *Jorge Dias, Univ. of Coimbra*

08:00–08:18	FrA11.1

Switched UAV-UGV Cooperation Scheme for Target Detection

Herbert G. Tanner
Mechanical Engineering Dept.,
The University of New Mexico, USA

- UAV and UGV teams cooperate to locate a possibly moving target within a given area
- Ground vehicles first partition the area and guard the boundaries
- Aerial vehicles sweep the regions in search of the target
- Closed loop group behaviors are asymptotically stable
- Search terminates in finite time



08:18–08:36	FrA11.2

A Dynamic Target Tracking of Car-Like Wheeled Robot in a Sensor-Network Environment via Fuzzy Decentralized Sliding-Mode Grey Prediction Control

Chih-Lyang Hwang, Tsai-Hsiang Wang, Ching-Chang Wong
Electrical Engineering of Tamkang University, Taiwan, R.O.C.

(I) Introduction

(II) System Description

(III) Fuzzy Sliding-Mode Grey Prediction Control

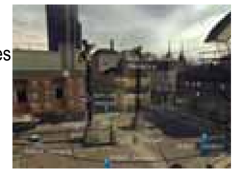
(IV) Experimental Result

08:36–08:54	FrA11.3

Switched Video Feedback for Sensor Deployment and Target Tracking in a Surveillance Network

Amit Goradia*, Zhiwei Cen**, Clayton Haffner**
Ning Xi*, Matt Mutka**
*Dept. of Electrical and Computer Engineering
**Dept. of Computer Science and Engineering
Michigan State University, East Lansing, MI, USA

- Defined the problem of optimal sensor deployment in a surveillance network
- Developed metrics and used Monte Carlo method to obtain optimal deployment strategies
- Developed a dynamic programming based approach to o generate the optimal switching strategy to minimize switching time

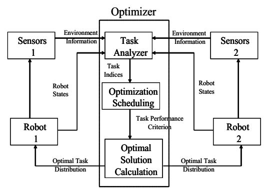


08:54–09:12	FrA11.4

Optimality Framework for Hausdorff Tracking using Mutational Dynamics and Physical Programming

Amit Goradia, Clayton Haffner, Ning Xi, Matt Mutka
Department of Electrical and Computer Engineering,
Department of Computer Science and Engineering,
Michigan State University, USA

- Modeling multiple target tracking with a single camera using Hausdorff tracking
- Exploit the motion redundancy for accomplishing the tracking task using a dynamic optimality framework
- Propose to use physical programming for solving the dynamic optimization problem
- Experimental results compare weighted sum approach and physical programming approach for dynamic optimization.



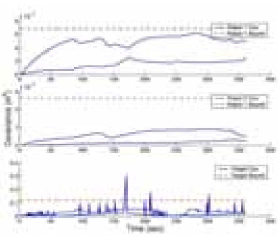
09:12–09:30	FrA11.5

On the Performance of Multi-robot Tracking

Faraz Mirzaei, Anastasios Mourikis, and Stergios Roumeliotis
Dept. of Computer Science and Engineering, University of Minnesota, USA

Objective:
- Analysis of accuracy during cooperative localization and target tracking

Results:
- Upper bounds on:
  - Worst-case positioning uncertainty
  - Average positioning accuracy
- Bounds analytical functions of
  - sensors' characteristics
  - sensing graph
- Investigation of asymptotic behavior



Networked Teleoperation

Chair *Michel Kinnaert, Univ. Libre de Bruxelles*
Co-Chair *Zbigniew Wasik, Toyota Motor Europe*

08:00–08:18	FrA12.1

Bilateral Delayed Teleoperation: The Effects of a Passivated Channel Model and Force Sensing

A. Aziminejad, M. Tavakoli, R.V. Patel, and M. Moallem
Electrical and Computer Engineering, University of Western Ontario (UWO), Canada
Canadian Surgical Technologies & Advanced Robotics (CSTAR)

- Based on a passivity framework, admittance-type and hybrid-type delay-compensated communication channel models are introduced.
- Using direct force measurements does not necessarily render a delayed teleoperation system unstable.
- Slave-side force measurements significantly improve transparency compared to position error-based approaches.

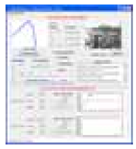

Setup for telemanipulated tissue palpation

08:18–08:36	FrA12.2

Automatic Regulation of the Information Flow in the Control Loops of a Web Teleoperated Robot

J.A. Fernandez-Madrigal, C. Galindo, E. Cruz-Martin, A. Cruz-Martin, and J. Gonzalez
Dept. of System Engineering and Automation
University of Malaga, Spain

- A web interfaced robot is considered as a set of control loops.
- We propose and implement a hysteresis algorithm for regulating the flow of information through the loops as a method to satisfy system time requirements.
- Real experiments have been conducted on a real robot.

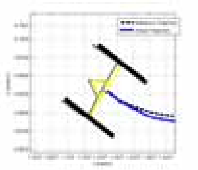


08:36–08:54	FrA12.3

Remote Low Frequency State Feedback Kinematic Motion Control for Mobile Robot Trajectory Tracking

Daniel Montrallo Flickinger and Mark A. Minor
Department of Mechanical Engineering, University of Utah, USA

- Teleoperation with all motion control completely remote from the robots
- Medium scale mobile robots used as couriers for wireless networking experiments
- Trajectory tracking control of mobile robots over an uncontrolled wireless network
- Controller stability at very low state feedback sampling frequencies

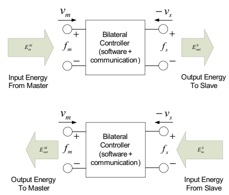

Trajectory Tracking Demonstration: From Experimental Data

08:54–09:12	FrA12.4

Stable Bilateral Control of Teleoperators Under Time-varying Communication Delay: Time Domain Passivity Approach

Jee-Hwan Ryu
School of Mechanical Engineering,
Korea University of Technology and Education, R. of Korea
Carsten Preusche
Institute of Robotics and Mechatronics, DLR, Germany

- Modified two-port time-domain passivity approach is proposed for time-varying delay
- Input and output energy at each port of a bilateral controller is separated.
- Output energy at one port should be less than the input energy at the other port.
- Teleoperation experiment with about 120(msec) time delay each way is performed



09:12–09:30	FrA12.5

Control of a teleoperated nanomanipulator with time delay under direct vision feedback

Oliver Tonet[1,2], Martina Marinelli[1], Giuseppe Megali[1,2], Arne Sieber[3], Pietro Valdastri[1], Arianna Menciassi[1], Paolo Dario[1,2]
[1] CRIM Lab, Scuola Superiore Sant'Anna, Pisa, Italy
[2] EndoCAS Center for Computer-Assisted Surgery, University of Pisa, Italy
[3] ARC Seibersdorf Research GmbH, Seibersdorf, Austria

- Time-delayed teleoperation forces users to adopt move-and-wait control strategies
- We compare 3 control strategies for driving a nanomanipulation system in a Fitts' task
- The fastest strategy also allows movements of size across several orders of magnitude
- The strategies can be used in general for vision-guided time-delayed teleoperation


Nanomanipulator and Fitts' 2-D precision pointing task

Localization Concepts

Chair *Xiaoping Yun, Naval Postgraduate School*
Co-Chair *Wes Huang, Applied Perception*

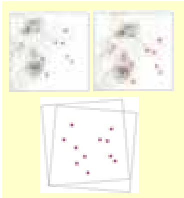
10:50–11:08 FrB1.1

Map Matching Scheme for Position Estimation of Planetary Explorer in Natural Terrain

Takashi Kubota, Klaus G.Moesl, Ichiro Nakatani

Institute of Space and Astronautical Science, JAXA, JAPAN

- New scheme is proposed to perform position estimation for planetary explorer
- Feature points on rough terrain are extracted
- Map matching techniques are introduced
- Simulation and experimental results show the effectiveness of the proposed method

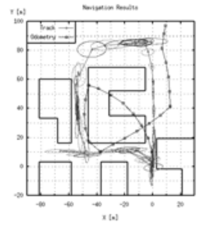


11:08–11:26 FrB1.2

Multi-Hypothesis Outdoor Localization using Multiple Visual Features with a Rough Map

Jooseop Yun and Jun Miura
Department of Mechanical Engineering, Osaka University, Japan

- A Localization Method using Stereo Vision in an Outdoor Urban Environment.
- Use of a Rough 2D Map with Pose and Shape Uncertainties.
- Multi-Feature EKF-based Hypothesis Generation using the Coupling, the Ordering and the Priority Constraints of Features.
- A Novel Hypothesis Management Strategy of Tracking, Pruning and Merging.



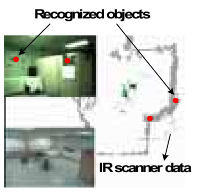
The longest track and odometry-alone results for localization

11:26–11:44 FrB1.3

Mobile Robot Localization Using Fusion of Object Recognition and Range Information

Byung-Doo Yim, Yong-Ju Lee, Jae-Bok Song and Woojin Chung
Dept. of Mechanical Engineering, Korea University, Korea

- Localization based on fusion of an IR scanner and a mono camera.
- Range sensor-based localization results in frequent update of sample probability.
- Vision sensor-based localization leads to robust pose estimation by object recognition.
- Good performance in various types of real environments.



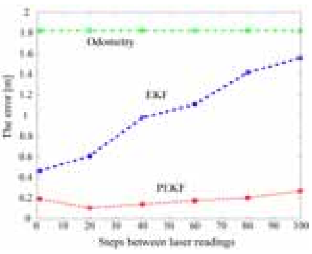
Sensor fusion based localization

11:44–12:02 FrB1.4

Mobile Robot Localization based on a Polynomial Approach

C. Manes[1], A. Martinelli[2,3], F. Martinelli[4] and P. Palumbo[5]
1.Univaq Italy 2.ETHZ Switzerland 3.INRIA France 4.Tor Vergata Italy
5.CNR Italy

- A new analytical algorithm (PEKF) to localize a mobile robot is introduced.
- The algorithm has well defined optimal properties (it is the best affine estimator of the robot configuration).
- It does not require any linear approximation.
- It significantly outperforms the standard EKF as shown through many simulations.



12:02–12:20 FrB1.5

An Indoor Localization Aid for the Visually Impaired

Joel A. Hesh and Stergios I. Roumeliotis
University of Minnesota

- **Objective**: Estimate the position of a person inside a building using sensors mounted on a white cane
- **Sensors**: Laser scanner, gyroscope, pedometer
- **Estimator**: 3D attitude, 2D position
- **Positioning error**: less than 0.16m
- **Advantages**:
  - Lightweight (550g)
  - Allows use of white cane
  - Unobtrusive

Vision and Estimation

Chair *Ezio Malis, INRIA*
Co-Chair *Vincenzo Lippiello, Univ. degli Studi di Napoli Federico II*

10:50–11:08 FrB2.1

Particle Filtering on the Euclidean Group

Junghyun Kwon, Minseok Choi, and F. C. Park
School of Mechanical & Aerospace Engineering, Seoul National University,Korea
Changmook Chun
Intelligent Robotics Research Center, KIST, Korea

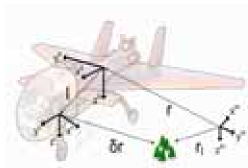
- We generalize the particle filter to stochastic nonlinear systems evolving on SE(3) for simultaneously estimating the state and covariance evolving on P(n), the space of symmetric positive definite matrices.
- The filter is constructed in a coordinate-invariant way, and explicitly takes into account the geometry of SE(3) and P(n).
- An experimental study involving vision-based robot end-effector pose estimation is presented.

11:08–11:26 FrB2.2

Inertial Navigation Aided by Monocular Camera Observations of Unknown Features

Michael George and Salah Sukkarieh
School of Aerospace, Mechanical and Mechatronic Engineering
The University of Sydney, Australia

- Unknown ground based features are tracked using monocular images to constrain drift in inertial navigation sensors
- Point based features are added to an unscented estimation process in camera coordinates
- Results demonstrate promising application in environments without GPS



11:26–11:44 FrB2.3

A Multi-state Constraint Kalman Filter for Vision-aided Inertial Navigation

Anastasios I. Mourikis and Stergios I. Roumeliotis
University of Minnesota

- M-SC-KF algorithm for fusing IMU and monocular camera measurements
- Key advantages:
  - Complexity **linear** in number of locally visible features
  - Estimates **optimal** up to linearization errors
  - **Real-time** performance, demonstrated in large-scale experiment in urban setting

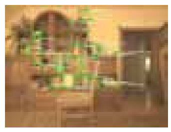
Experimental results: 10m position error after 3.2km trajectory in urban environment

11:44–12:02 FrB2.4

Visual Odometry Based on Gabor Filters and Sparse Bundle Adjustment

Bogdan Kwolek
Rzeszow University of Technology, Poland

- Corner and SIFT features.
- Inter frame correspondences: SVD, proximity, crosscorrelation and Gabor filter.
- Initial pose estimate: SVD, quaternions.
- Refined estimate of pose: RANSAC and SBA.
- Produces pose estimates even if overlap between images is small.



SVD-based inter-frame feature matching using proximity, crosscorrelation and Gabor filter.

12:02–12:20 FrB2.5

A Model-free Vision-based Robot Control for Minimally Invasive Surgery using ESM Tracking and Pixels Color Selection

F. Bourger, C. Doignon, P. Zanne and M. de Mathelin
Laboratoire des Sciences de l'Image, de l'Informatique et de la Télédétection,
University of Strasbourg, France

- Automatic selection of contributed areas of the region-of-interest in the image.
- Model-free ESM tracking and servoing with a joint hue-saturation color attribute.
- 4 DOF Robot control with motion constraint.

Biped Locomotion II

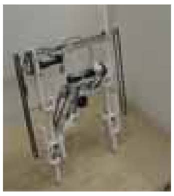
Chair *Yoshihiko Nakamura, Univ. of Tokyo*
Co-Chair *Arto Visala, Helsinki Univ. of Tech.*

10:50–11:08 FrB3.1

Differentially Flat Design of Bipeds Ensuring Limit-Cycles

Vivek Sangwan and Sunil K. Agrawal
Mechanical Systems Lab, Mechanical Engineering Dept.
University of Delaware, USA

- **Biped** robots can be **under-actuated** at the ground contact or may have phases of such under-actuation.
- **Differential Flatness** can facilitate planning and control of periodic motion (limit cycles) for such under-actuated systems.
- A class of ***differentially flat*** planar **biped** designs has been identified.
- Planning and Control simulations along with a fabricated prototype has been presented.



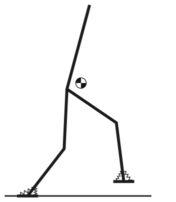
A four link biped with shank and thigh in each leg. The knee joint has a stopper to avoid hyper-extension and latches to lock the joint.

11:08–11:26 FrB3.2

Energetic Effects of Adding Springs at the Passive Ankles of a Walking Biped Robot

K. D. Farrell†, C. Chevallereau‡, and E. R. Westervelt†
†Mechanical Engineering Department, The Ohio State University, USA
‡IRCCyN, Ecole Centrale de Nantes, FRANCE

- Springs added at passive ankles of a model of a 5-link biped, RABBIT
- The addition of springs enabled the reduction of total power consumed when walking
- Methodical approach to choosing the feet and spring size is presented



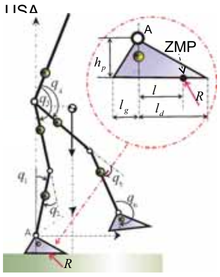
Underactuated 5-link planar biped with feet and springs at ankles.

11:26–11:44 FrB3.3

A Path-Following Approach to Stable Bipedal Walking and Zero Moment Point Regulation

Dalila DJOUDI*, Christine CHEVALLEREAU*, and J.W GRIZZLE**
* IRCCyN, CNRS, Ecole Centrale de Nantes, France
** University of Michigan, USA

- Simultaneously regulation of the position of the ZMP and of the joints of the biped.
- Only the kinematic evolution of the robot's state is regulated, but not its temporal evolution.
- Robot temporal evolution defined through a one degree of freedom subsystem of the closed-loop model.
- Analytical stability study of the control law.



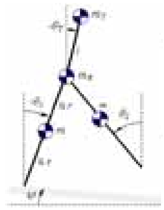
Planar biped

11:44–12:02 FrB3.4

Time-Scaling Trajectories of Passive-Dynamic Bipedal Robots

Jonathan K. Holm*, Dongjun Lee**, and Mark W. Spong*
*CSL, University of Illinois at Urbana-Champaign, USA
**MA&BE, University of Tennessee, Knoxville, TN, USA

- Constant and variable time-scaling of limit cycle trajectories
- Allows walking at arbitrary speeds
- Allows transitions between any two walking speeds in arbitrary time
- Applicable to any continuous dynamical system and a class of hybrid dynamical systems

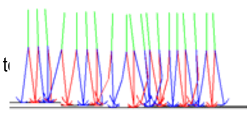


12:02–12:20 FrB3.5

A Reinforcement Learning Based Dynamic Walking Control

Yong Mao, Jiaxin Wang, Peifa Jia, Shi Li, Zhen Qiu, Le Zhang and Zhuo Han
Computer Science and Technology Dept., Tsinghua University, China

- A quasi-passive dynamic walking robot is built.
- A Q-learning based method is proposed to learn the robot's nominal gait.
- A fuzzy advantage learning algorithm is used to control the robot's walking on uneven floor
- Effectiveness of the method is verified by simulation results



Walking on uneven floor

Physical Human-Robot Interaction I

Chair *Rachid Alami, CNRS*
Co-Chair *Leonardo Lanari, Univ. di Roma La Sapienza*

10:50–11:08 FrB4.1

Replicating Human-Human Physical Interaction

Kyle B. Reed and Michael Peshkin
Mechanical Engineering Dept. (LIMS), Northwestern University, USA
James Patton
Rehabilitation Institute of Chicago, USA

- Can human-human interaction guide human-robot interaction?
- We did the simplest experiment that could reveal emergent behaviors in human-human haptic interaction.
- Result: Task performance changed when subjects perceived the robotic partner to be a robot or a human agent.
- Result: A robotic partner providing a force profile similar to that which a human partner provides, surprisingly did not elicit specialization in the human subjects.

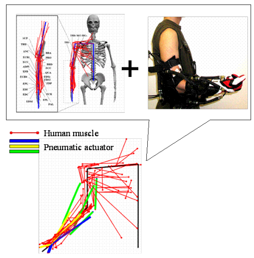
Two people working together on a task. One is then replaced by a motor.

11:08–11:26 FrB4.2

Pinpointed Control of Muscles by using Power-Assisting Device

Jun Ueda, Ming Ding, Masayuki Matsugashita, Reishi Oya, Tsukasa Ogasawara
Robotics Laboratory, Nara Institute of Science and Technology, Japan

- Pinpointed muscle control approach to modify the load force of selected muscles
- A musculoskeletal-exoskeletal integrated human model
- A prototype power-assisting system using pneumatic rubber actuators
- The feasibility of the muscle force control is analyzed from a view point of nonlinear programming.

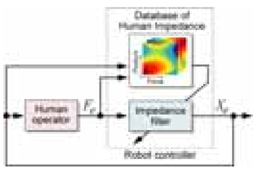


11:26–11:44 FrB4.3

Analysis and Modeling of Human Impedance Properties for Designing a Human-Machine Control System

Yoshiyuki TANAKA, Teruyuki ONISHI, Toshio TSUJI,
Dept. of Articitial Complex Systems Engineering, Hiroshima University, Japan
Naoki YAMADA, Yuusaku TAKEDA, and Ichiro MASAMORI
Mazda Motor Corporation, Japan

- The integration of human impedance properties into a human-machine system is discussed.
- The human-machine system manipulated by the lower limbs is focused on.
- Human leg impedance is analyzed according to leg posture and foot force.
- The prototype control structure with the database of human leg impedance is designed and evaluated.



11:44–12:02 FrB4.4

Environment Feedback for Robotic Walking Support System Control

Oscar Chuy Jr., Yasuhisa Hirata, and Kazuhiro Kosuge
Department of Bioengineering and Robotics,
Tohoku University, Sendai, Japan.

- This paper proposes a control approach for an active (motorized) robotic walking support system based on environment feedback.
- Environment information is included in the motion control algorithm but will not cause any motion without user's intention.
- This approach leads to a passive behavior for an active type of walking support system.

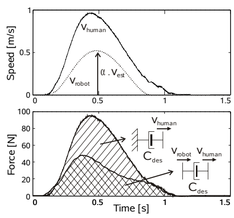
Robotic Walking Support System

12:02–12:20 FrB4.5

Human-inspired robot assistant for fast point-to-point movements

B. Corteville, E. Aertbelien, H. Bruyninckx, J. De Schutter and H. Van Brussel
Dept. of Mechanical Engineering, University of Leuven, Belgium

- The robot controller contains an admittance controller which gives the robot a damping behavior (C_{des}). During interaction with the human, the forces are uncomfortably high.
- The robot estimates the intended human motion (v_{human}) based on the minimal jerk criterion. Based on this estimation, the robot assists the human by moving along (v_{robot}).
- This assistance reduces the interaction forces, can be scaled and feels natural to the human.



Speed and interaction forces during human-robot cooperation

Sensor Networks II

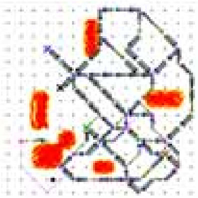
Chair *Thomas C. Henderson, Univ. of Utah*
Co-Chair *Federica Pascucci, Univ. degli Studi*

10:50–11:08 FrB5.1

Adaptive Embedded Roadmaps For Sensor Networks

Gazihan Alankus, Nuzhet Atay, Chenyang Lu, and O. Burchan Bayazit
Washington University in St. Louis, USA

- Robot navigation with the help of sensor network using a distributed roadmap
- Adaptive embedded roadmap contains possible safe paths and directions to goals
- Reduces the workload of the sensor network and increases navigation safety
- Successful in the presence of static and dynamic obstacles



AER simulation running with fire simulation

11:08–11:26 FrB5.2

Energy Saving Target Tracking Using Mobile Sensor Networks

Yingying Li, Yun-hui Liu
Mechanical Engineering and Automation Dept.,
Chinese University of Hong Kong, Hong Kong, China

- Minimizing the energy consumption of target tracking using mobile sensor networks is proved to be NP-complete.
- An approximately optimal solution named breadth-first leader-follower strategy is presented.
- Simulation has been conducted to demonstrate the performance of the algorithm in different situations.

11:26–11:44 FrB5.3

Leveraging RSSI for Robotic Repair of Disconnected Wireless Sensor Networks

Kyle A. Luthy and Edward Grant
ECE Dept., North Carolina State University, Raleigh, NC 27695, USA
Thomas C. Henderson
Computer Science Dept., University of Utah, Salt Lake City, UT 84112, USA

- Evaluates large scale network disconnectivity for distributed sensor networks.
- Examines low cost and adaptive method for robotic network repair.
- Uses received signal strength (RSSI) for mobile robot navigation and placement.

Time-lapse Photograph of RSSI Navigation

11:44–12:02 FrB5.4

Detecting and Tracking Level Sets of Scalar Fields using a Robotic Sensor Network

Karthik Dantu and Gaurav S. Sukhatme
Computer Science Dept., University of Southern California, USA

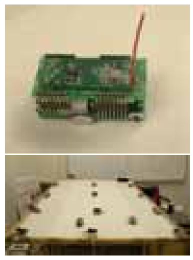
- Present algorithm to detect and track level sets using a robotic sensor network
- Control law uses local sensing and performs gradient descent

$$\dot{x} = \alpha \, \mathrm{Null}(\nabla G(x)) + \beta (\nabla G(x))^{\dagger} G(x)$$

where $(\nabla G(x))^{\dagger} = (\nabla G(x))^T (\nabla G(x) (\nabla G(x))^T)^{-1}$

$G(x) = [d_1(x) - d_2(x)]$ and

$\nabla G(x) = [(\nabla d_1(x) - \nabla d_2(x))^T]$



Robomote and the Testbed

12:02–12:20 FrB5.5

Adaptive Sampling for Estimating a Scalar Field using a Robotic Boat and a Sensor Network

Bin Zhang and Gaurav S. Sukhatme
Robotic Embedded System Laboratory,
Computer Science Dept., University of Southern California, USA

- An adaptive sampling algorithm based on local linear regression for estimating scalar field is proposed
- The estimation errors of local linear regression depend on the Hessian matrix of the scalar field
- Static sensor nodes are used to estimate the Hessian matrix
- The optimal path for the robotic boat is then computed

Robotic Boat of NAMOS

Reasoning for Robots

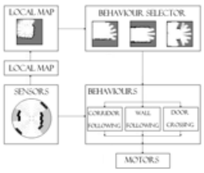
Chair *Hideki Hashimoto, Univ. of Tokyo*
Co-Chair *Markus Vincze, Tech. Univ. Wien*

10:50–11:08 FrB6.1

A CBR approach to Behaviour-Based Navigation for an Autonomous Mobile Robot

Alberto Poncela, Cristina Urdiales and Francisco Sandoval
Departamento de Tecnología Electrónica, Universidad de Málaga, Spain

- CBR-based Navigation scheme relying on 3 behaviours: Wall Following, Corridor Following, Door Crossing.
- Behaviour Selector: switching among competitive behaviours.
- Behaviour implementation through CBR: learning by observation and by own experience (adaptation).
- Performance tests in real environments with a Pioneer robot equipped with sonar sensors.



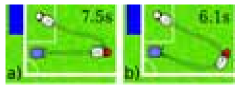
Behaviour-Based Navigation System

11:08–11:26 FrB6.2

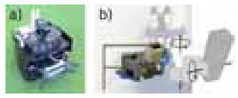
Seamless Execution of Action Sequences

Freek Stulp, Wolfram Koska, Alexis Maldonado, Michael Beetz
Intelligent Autonomous Systems Group
Technische Universität München, Munich, Germany

- Problem: Gap between action abstraction and execution.
- Solution: *Subgoal Refinement*
  - takes free action parameters
  - optimizes them wrt. duration
  - duration predicted with learned action models
- Result: faster execution and emergence of smooth motion in three robotic domains



greedy optimized



application domains

11:26–11:44 FrB6.3

Semantic Knowledge-Based Execution Monitoring for Mobile Robots

A. Bouguerra, L. Karlsson and A. Saffiotti
Mobile Robotics Lab.
Örebro University, Örebro 70182, Sweden

- Robots need to monitor the execution of their plans
- Implicit expectations of correct execution are derived from semantic knowledge
- Perceptual information is used to check the expectations
- Experiments on a real robot in a house environment (rooms and furniture)

11:44–12:02 FrB6.4

Reflection and Reasoning Mechanisms for Failure Detection and Recovery in a Distributed Robotic Architecture for Complex Robots

Matthias Scheutz and James Kramer
Artificial Intelligence and Robotics Lab, Dept. Of Computer Science and Eng.
University of Notre Dame, Notre Dame, IN 46556, USA

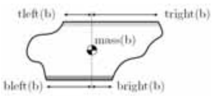
- Present DIARC architecture for human-robot interaction implemented in multi-agent system middle-ware
- Demonstrate efficient automatic online error detection and recovery of faulty using introspection and reasoning
- Components in distributed robotic architecture are recovered during task performance in HRI interaction task

12:02–12:20 FrB6.5

Using Constrained Intuitionistic Linear Logic for Hybrid Robotic Planning Problems

Uluc Saranli
Dept. of Computer Engineering, Bilkent University, Turkey
Frank Pfenning
Dept. of Computer Science, Carnegie Mellon University, USA

- Planning for robotic systems must consider both physical and algorithmic properties
- Linear logic can efficiently deal with algorithmic aspects but not good for continuous reasoning
- Adding continuous constraints into linear logic yields an expressive and efficient unified framework
- A Balanced Blocks World example with dynamic constraints is used for illustration



$$\Psi_c \mid (\Gamma_f, \Gamma_a); \Delta_0 \Longrightarrow G$$

$$\frac{\Psi \models D \quad \Psi \mid \Gamma; \Delta, A \Longrightarrow C}{\Psi \mid \Gamma; \Delta, D \supset_c A \Longrightarrow C} \supset_c L$$

$$\frac{\Psi \models D \quad \Psi \mid \Gamma; \Delta \Longrightarrow A}{\Psi \mid \Gamma; \Delta \Longrightarrow D \wedge_c A} \wedge_c R$$

Software Architectures for Multirobot Systems

Chair *Aude Billard, EPFL*
Co-Chair *Michael Wang, Chinese Univ. of Hong Kong*

10:50–11:08 FrB7.1

OOPS for Motion Planning: An Online, Open-source Programming System

Erion Plaku, Kostas E. Bekris, and Lydia E. Kavraki
Department of Computer Science, Rice University
Houston, Texas, USA

OOPS$_{MP}$ aims to aid researchers in the development, experimental validation, and comparison of motion planners

OOPS$_{MP}$ Offers:

- Open-source
- Online plug-and-play functionality
- Customization and extendibility
- Utility and core modules
- State-of-the-art motion planners
- Benchmarks and general functionality for experiments

11:08–11:26 FrB7.2

A Multi-Vehicle Framework for the Development of Robotic Games: The Marco Polo Case

Brent Perteet, James McClintock, and Rafael Fierro
MARHES Laboratory
School of Electrical and Computer Engineering
Oklahoma State University, USA

- A robotic framework is developed for education and research.
- Games encourage students towards science, technology, engineering, and mathematics.
- The robotic pursuit-evasion game, Marco Polo, is formally introduced and implemented in the framework.

The Robotic Games Framework

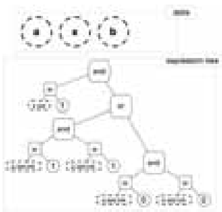
11:26–11:44 FrB7.3

Distributed Watchpoints: Debugging Large Multi-Robot Systems

Michael De Rosa, Seth Goldstein, and Peter Lee
School of Computer Science, Carnegie Mellon University, USA

Jason Campbell, Padmanabhan Pillai, and Todd Mowry
Intel Research Pittsburgh, USA

- A simple language for representing distributed error conditions
- Centralized and distributed detection algorithms for multi-robot errors
- Low runtime overhead



11:44–12:02 FrB7.4

A Practical Implementation of Random Peer-to-Peer Communication for a Multiple-Robot System

Chris A. C. Parker and Hong Zhang
Department of Computing Science,
University of Alberta, Canada

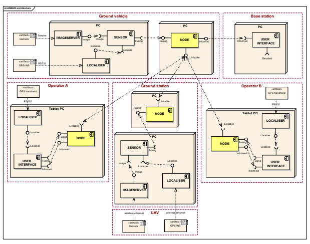
- An effective communication scheme for decentralized multiple-robot systems (MRS) is experimentally evaluated.
- Results with 802.11B networks demonstrate the viability of this scheme.
- The scheme takes advantage of the stochastic nature of decentralized MRS.
- It requires no specialized hardware and could be applied to many existing MRS.

12:02–12:20 FrB7.5

Building a Software Architecture for a Human-Robot Team Using The Orca Framework

Tobias Kaupp, Alex Brooks, Ben Upcroft and Alexei Makarenko
ACFR, The University of Sydney, Australia

- Human-robot team performing **information fusion**
- Architecture constrained by requirement of **decentralization**
- **Component-Based Software Engineering (CBSE)** can address constraints
- **Orca** is more flexible for deploying distributed systems than other frameworks



Rehabilitation Systems

Chair *Eugenio Guglielmelli, Univ. Campus Bio-Medico*
Co-Chair *Philippe Fraisse, Univ. Montpellier 2*

10:50–11:08	FrB8.1

Upper body posture estimation for standing function

Gaël Pages, Nacim Ramdani, Philippe Fraisse and David Guiraud
LIRMM UMR 5506 CNRS Univ. Montpellier 2, France

- Contribution in paralegia standing rehabilitation via functional electrical stimulation (FES).
- Investigating how intact upper body may cooperate with stimulated lower limbs.
- Preliminary study : posture estimation through forces exerted on handles in presence of bounded uncertainty.
- Experimental study with paraplegic patients.

11:08–11:26	FrB8.2

A Gas-Actuated Anthropomorphic Transhumeral Prosthesis

Kevin Fite, Thomas Withrow, Keith Wait, and Michael Goldfarb
Department of Mechanical Engineering, Vanderbilt University, USA

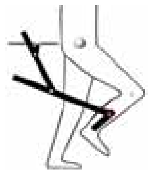
- This paper presents the design of an anthropomorphic 21 degree-of-freedom, 9 degree-of-actuation arm prosthesis
- The design leverages the power density of pneumatic actuation with the energy density of liquid propellants
- The prosthesis is expected to approach the dexterity of an anatomical arm and is projected to deliver half of the force and power output of an average human arm

11:26–11:44	FrB8.3

Gravity Balancing of a Human Leg using an External Orthosis

Abbas Fattah, and Sunil K. Agrawal
Department of Mechanical Engineering, University of Delaware, USA

- We present a new design to remove gravity load on the joints of a human leg during walking.
- This orthosis is connected to the human leg on the shank and its other end is fixed to a walking frame.
- This design avoids issues with the existing exoskeletons, such as joint and segment misalignment.



11:44–12:02	FrB8.4

Passive Swing Assistive Exoskeletons for Motor-Incomplete Spinal Cord Injury Patients

Kalyan K. Mankala, Sai K. Banala, Graduate Students
Sunil K. Agrawal, Professor
Mechanical Systems Laboratory, University of Delaware, Newark, DE 19716

- Passive elements charged by treadmill in stance phase and in swing phase while discharging, helps in assisting human leg.
- Usage of system dynamics in optimization of parameters.
- Exoskeleton was constructed and experiments on a healthy subject were performed.
- Experimental results and effectiveness of the device discussed.

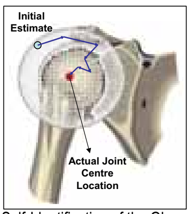
Swing Assist Device with a human subject

12:02–12:20	FrB8.5

Self-Identification of the Joint Centre of a Cable-Driven Shoulder Rehabilitator

Shabbir Kurbanhusen Mustafa[1,2], Guilin Yang[2], Song Huat Yeo[1] and Wei Lin[2]
[1] School of Mechanical & Aerospace Engineering, Nanyang Technological University, Singapore.
[2] Mechatronics Group, Singapore Institute of Manufacturing Technology, Singapore.

- A cable-driven shoulder rehabilitator is presented with a user dependent joint centre location.
- Identification of this joint centre is critical for positioning accuracy and motion planning tasks.
- A self-identification model is proposed using the differential change in cable end-point distance.
- Based on simulation studies, joint centre was accurately identified from initial estimates with deviations of $\pm 50mm$.



Self-Identification of the Gleno-humeral joint centre

Recognition of Dynamic Objects

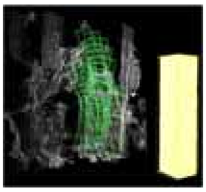
Chair *Patrick Bouthemy, IRISA / INRIA*
Co-Chair *Alfredo de Oliveira Martins Martins, Inst. Superior de Engenharia do Porto*

10:50–11:08	FrB9.1

Robust Recognition and Pose Estimation of 3D Objects Based on Evidence Fusion in a Sequence of Images

Sukhan Lee, Seongsoo Lee, Jeihun Lee and Dongju Moon, Eunyoung Kim and Jeonghyun Seo
ISRC, School of Information and Communication Engineering, Sungkyunkwan Univ., South Korea
{lsh,lss0703}@ece.skku.ac.kr

- Using particle filtering framework for object recognition, not only robust recognition but pose estimation
- Sequence of image in time-domain as a particles
- Evidence(feature) selection and collection for recognition
- Real-time recognition : avg. 2Hz



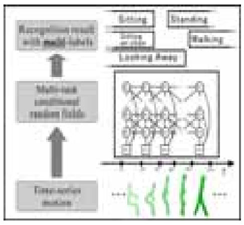
Recognition using particle filter framework in sequence of image

11:08–11:26	FrB9.2

Robust Action Recognition and Segmentation with Multi-Task Conditional Random Fields

Masamichi Shimosaka, Taketoshi Mori and Tomomasa Sato
Graduate School of Information Science and Technology, University of Tokyo, JAPAN

- A novel chunking (annotation and segmentation) method for action recognition
- Multi-task conditional random fields (MT-CRFs) assign input motion to sequence of multi-labels of action
- Mathematically, MT-CRFs are kinds of graphical models and offer several advantages over traditional recognition methods with dynamic Bayesian nets



11:26–11:44	FrB9.3

Real-time keypoints matching: application to visual servoing

Thi Thanh Hai Tran, Eric Marchand
IRISA-INRIA Rennes, Lagadic team, Rennes, France

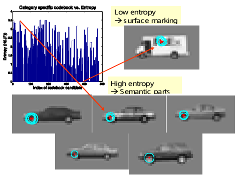
- Tracking by matching
- Near real-time tracking algorithm
- Fast keypoints detection
- PCA based keypoint description
- Keypoint matching using ANN algorithms
- Validation on visual servoing experiments

11:44–12:02	FrB9.4

Visual Categorization Robust to Large Intra-Class Variations using Entropy-guided Codebook

Sungho Kim, and In So Kweon
School of EECS, KAIST, Korea
Chil-Woo Lee
School of ECE, Chonnam Nat'l Univ., Korea

- Visual categorization robust to large intra-class variations using the entropy-guided codebook selection in bag-of-visual words method.
- High entropy codebook within a category can remove surface markings.
- Low entropy codebook of inter-category can enhance the category discrimination.

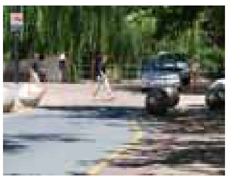


12:02–12:20	FrB9.5

Improved Response Modelling on Weak Classifiers for Boosting

Gary Overett
RSISE, Australian National University, Australia
Lars Petersson
National ICT Australia

- Improved discriminating power of weak classifiers
- Counteracts overfitting of training data
- Improved pedestrian detection results
- May be trained on one tenth the training data without loss of accuracy



Flexible Arms II

Chair *Imin Kao, SUNY at Stony Brook*
Co-Chair *Paolo Rocco, Pol. di Milano*

10:50–11:08 FrB10.1

Robust Control using Recursive Design Method for Flexible Joint Robot Manipulator

Jong-Guk Yim, Je Sung Yeon, and Jong Hyeon Park
Mechatronics Lab., Hanyang Univ., Seoul, Korea
Sang-Hun Lee and Jong-Sung Hur
Electro-Mechanical Research Institute Hyundai Heavy Industries Co.,Korea

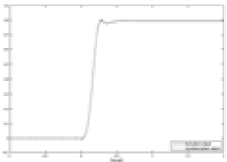
- For flexible manipulators, we propose the robust controller using a recursive design method.
- As the fictitious control, a nonlinear H-infinity control is designed in the sense of L2-gain attenuation.
- The real robust control is designed recursively by using a Lyapunov's second method.

11:08–11:26 FrB10.2

Minimum-time control of flexible joints with input and output constraints

Luca Consolini, Oscar Gerelli,
Corrado Guarino Lo Bianco and Aurelio Piazzi
Dipartimento di Ingegneria dell'Informazione, Università di Parma, Italy

- Linear programming approach to feedforward minimum-time control
- Successfully applied to the feed-forward rest-to-rest transition of a flexible joint
- Compared to previous optimal approach based on "transition polynomials"



Expected system output y and measured plant output for a $\pi/2$ rest-to-rest transition

11:26–11:44 FrB10.3

An Acceleration-based State Observer for Robot Manipulators with Elastic Joints

Alessandro De Luca
DIS, Universita' di Roma "La Sapienza", Italy
Dierk Schröder
LEA, Technische Universität München, Germany
Michael Thümmel
RM, DLR Oberpfaffenhofen, Germany

- A new observer based on the use of accelerometers mounted on the links
- No knowledge of the link dynamics is needed
- A linear and decoupled observation error is obtained when link acceleration is available
- Observer tuning is made easy by its decentralized structure

11:44–12:02 FrB10.4

MIMO State Feedback Controller for a Flexible Joint Robot with Strong Joint Coupling

Luc Le Tien, Alin Albu Schaeffer, and Gerd Hirzinger
German Aerospace Center (DLR)

- Modeling and control of a robot with flexible joints
- Multi-input-multi-output (MIMO) design for the strongly coupled joints in modal coordinates
- Asymptotic stability is shown for the MIMO controller
- Experimental results with the DLR medical robot are presented

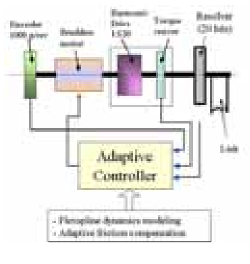
DLR medical robot

12:02–12:20 FrB10.5

Precision Control of Robots with Harmonic Drives

Wen-Hong Zhu
Canadian Space Agency

- Adaptive joint torque controller compensating harmonic drive frictions, while incorporating flexspline dynamics
- *Virtual decomposition* based motion controller
- Precision motion control of a 7-DOF robot at both moderate and ultra-low speeds
- Encoder-resolution accuracy at a joint speed of 0.001 (rad/s)
- No stick-slip behaviour



Sensor Fusion Based on Particle Filtering

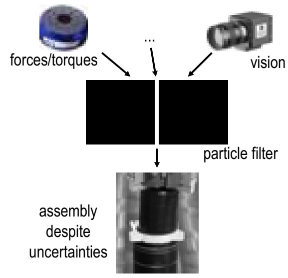
Chair *Roger, D. Quinn, Case Western Res. Univ.*
Co-Chair *Daniela Rus, MIT*

10:50–11:08 FrB11.1

Multi Sensor Fusion in Robot Assembly Using Particle Filters

U. Thomas, S. Molkenstruck, R. Iser, and F. M. Wahl
Institute for Robotics and Process Control, TU Braunschweig, Germany

- Sensor fusion in robot assembly, based on particle filter
- Evaluation of particles through forces/torques and vision
- Modeling of expected contact forces from CAD data, sampled and stored in Force Torque Maps

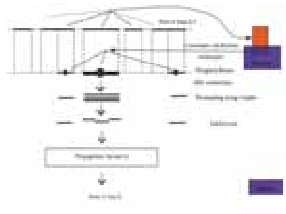


11:08–11:26 FrB11.2

A new estimation method for multisensor fusion by using interval analysis and particle filtering

Amadou Gning, Fahed Abdallah, Philippe Bonnifait
Heudiasyc UMR 6599 CNRS Université de Technologie de Compiègne

- *Box particles filtering* is a state observation method
- Measurements errors are supposed to be only bounded (not described by *pdf*)
- In comparison with particle filtering, the number of particles is divided by 100
- Vehicle pose is estimated by fusing dead-reckoning sensors and GPS measurements in a loosely coupled scheme



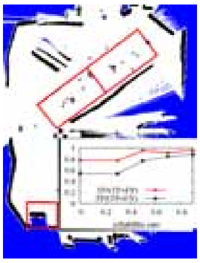
Box Particle Filter

11:26–11:44 FrB11.3

Heterogeneous Feature State Estimation with Rao-Blackwellized Particle Filters

G. D. Tipaldi, A. Farinelli, L. Iocchi, D. Nardi
Dipartimento di Informatica e Sistemistica
Sapienza Universita' di Roma, Italy

- Formal Framework for Data Association with sensor Reliability
- Suitable for tracking complex and heterogeneous (multi-class) features
- Robust to feature classification errors
- Use of Reliability in the estimation process enhances system performance

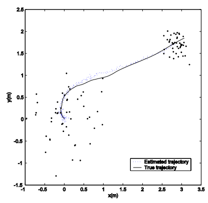


11:44–12:02 FrB11.4

Distributed Particle Filter for Target Tracking

Dongbing Gu
Department of Computer Science
University of Essex, UK

- This paper investigates target tracking using a distributed particle filter over sensor networks
- Gaussian mixture model (GMM) is adopted to approximate the posterior distribution of weighted particles
- An EM algorithm is developed to estimate the GMM
- Each node can obtain the GMM through an average consensus filter

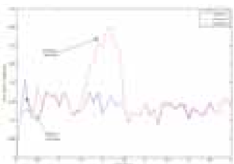


12:02–12:20 FrB11.5

Rao-Blackwellized Particle Filtering for Mapping Dynamic Environments

Isaac Miller and Mark Campbell
Dept. of Mechanical and Aerospace Engineering, Cornell University, USA

- Bayesian factorization decomposes mapping into data association and target tracking
- Small particle filter used to represent distribution over history of data associations
- Algorithm stores multiple association histories and is robust to association mistakes
- Automatically determines number of obstacles using the Bayesian framework
- Validated with simulation and roadside LIDAR



Multiple association histories within particles yields robustness to mistaken obstacle identity.

Search and Rescue Robotics

Chair *Robin Murphy, Univ. of South Florida*
Co-Chair *Keiji Nagatani, Tohoku Univ.*

10:50–11:08 FrB12.1

Probabilistic Strategies for Pursuit in Cluttered Environments with Multiple Robots

Geoffrey Hollinger and Sanjiv Singh
Robotics Institute, Carnegie Mellon University, Pittsburgh, USA
Athanasios Kehagias
Division of Mathematics, University of Thessaloniki, Greece

- Development of algorithms to search for targets in large, complex environments with cycles
- Heuristic graph search solution minimizes *expected time to capture*
- Approach generalizes to mobile and stationary targets and scales well with multiple robots
- Computationally efficient in environments beyond the scope of methods in the literature

11:08–11:26 FrB12.2

Development of an unit type robot "KOHGA2" with stuck avoidance ability

Hitoshi Miyanaka[1], Norihiko Wada[1], Tetsushi Kamegawa[2], Noritaka Sato[1],
Shingo Tsukui[3], Hiroki Igarashi[4] and Fumitoshi Matsuno[1]
[1]The University of Electro-Communications, Tokyo, Japan
[2]Okayama University, Okayama, Japan
[3]TOPY Industries, Ltd, Aichi, Japan [4]SGI Japan, Tokyo, Japan

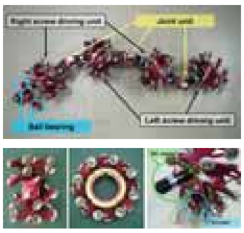
- We developed an unit assembled robot "KOHGA2"
- KOHGA2 has crawler-arms and the structure of the robot can be rearranged
- The stuck avoidance strategies using the swinging motion of the crawler-arms are described
- We examine the improvement of the mobility by rearranging the robot configuration

11:26–11:44 FrB12.3

Control of a Snake-like Robot Using the Screw Drive Mechanism

Masaya Hara[1], Shogo Satomura[1], Hiroaki Fukushima[1], Tetsushi Kamegawa[2], Hiroki Igarashi[3] and Fumitoshi Matsuno[1]
[1]The University of Electro-Communications, Tokyo, Japan
[2]Okayama University, Okayama, Japan [3]SGI Japan, Tokyo, Japan

- Develop a prototype of a new snake-like robot using the screw drive mechanism.
- Design a control system based on the derived kinematic model.
- Simulations and experiments show the validity of the derived model and the effectiveness of the proposed control method.

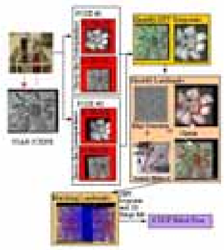


11:44–12:02 FrB12.4

Finding Disaster Victims: A Sensory System For Robot-Assisted 3D Mapping of Urban Search and Rescue Environments

Zhe Zhang, Hong Guo, Goldie Nejat, and Peisen Huang
Department of Mechanical Engineering
State University of New York (SUNY) at Stony Brook, USA

- This paper presents a major effort in developing a compact 3D sensory system for robotic search and rescue operations in unknown chaotic environments.
- The proposed unique sensor can directly map rubble in 3D and in real-time at a frame rate of up to 60 fps.
- A novel 3D Visual SLAM method is utilized incorporating both 2D and 3D images for robust/reliable landmark identification, mapping and localization.



Sensory System Architecture

12:02–12:20 FrB12.5

Development of Three-legged Modular Robots and Demonstration of Collaborative Task Execution

M.OHIRA[1],R.CHATTERJEE[2],T.KAMEGAWA[3] and F.MATSUNO[1,2]
[1]Department of Mechanical Engineering and Intelligent Systems, The University of Electro-Communications, Tokyo, Japan.
[2]International Rescue System Institute, Kawasaki, Japan
[3]Okayama University Graduate School of Natural Science and Technology, Okayama, Japan

- Three-legged modular robots which can be Interconnected to cooperatively achieve multiple Locomotion modes
- The robots collaboratively perform tasks that cannot be done by a single module
- We report the development of experimental modular robots and experimentations with their cooperative activities

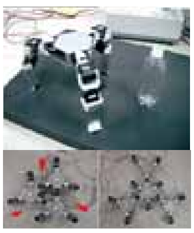


Image-based Localization

Chair *Nak Young Chong, Japan Advanced Inst. of Science and Tech.*
Co-Chair *Martin Adams, Nanyang Tech. Univ.*

13:50–14:08 FrC1.1

SURF features for efficient robot localization with omnidirectional images

A. C. Murillo, J. J. Guerrero, and C. Sagüés
DIIS - I3A, University of Zaragoza, Spain

- Efficient vision-based global localization:
  SURF (Speeded up robust features)
  +
  Hierarchical localization (Topological & Metric results)
- Localization experiments with 2data sets using SURF,SIFT and Radial Lines:
  SURF had the best compromise between efficiency and accuracy

Robust SURF matches after estimation of a 1D trifocal tensor

14:08–14:26 FrC1.2

High Precision Relative Localization Using a Single Camera

Munir Zaman
School of Electronics and Physical Sciences
Surrey University, UK.

- **Objective:** Kinematic independent method for high resolution relative localization
- **Sensor**: *Single* downward-pointing camera
- **Concept**: High precision planar transformations between image frames correspond to change in robot pose
- **Advantages**: high resolution, no kinematic modelling, computationally simple (FFT based)

Implementation of Visiodometry

14:26–14:44 FrC1.3

A Comparison of Two Approaches to Vision and Self-Localization on a Mobile Robot

Daniel Stronger and Peter Stone
Department of Computer Science
University of Texas at Austin

- Problem: On mobile robot with camera, use image to deduce own location
- Approach A: Object recognition, then Monte-Carlo Localization
- Approach B: Image edges are detected and matched to those in 3D model of environment
- Empirical comparison of approaches on Sony Aibo-ERS7, discussion of relative advantages

Approach B matches a model of the field to the observed image

14:44–15:02 FrC1.4

A visual bag of words method for interactive qualitative localization and mapping

David FILLIAT
ENSTA - PARIS - FRANCE

- A system for small personal robots inspired by image categorization methods that learns to recognize rooms
- Incremental training with simple user interaction
- Active localization strategy makes it robust to wide range of positions and to people passing by
- Validated on Sony Aibo and image database

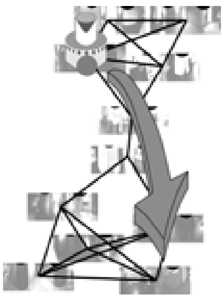
Robot and environment used in validation

15:02–15:20 FrC1.5

Navigation using an appearance based topological map

O. Booij, B. Terwijn, Z. Zivkovic, B. Kröse
Informatics Institute, Faculty of Science, University of Amterdam

- A visual navigation system is presented that uses an appearance based representation of the environment without any metric information.
- While driving the robot searches for the best path in a dynamic environment given all the available images.
- Experiments are conducted in a dynamic environment with people walking near the robot.



Computer Vision Systems

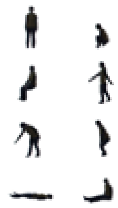
Chair *Nicolas Chaillet, UMR CNRS 6596 ENSMM UFC*
Co-Chair *Emanuele Menegatti, The Univ. of Padua*

13:50–14:08 FrC2.1

3-D Human Posture Recognition System Using 2-D Shape Features

Jwu-Sheng Hu, Tzung-Min Su, and Pei-Ching Lin
Electrical and Control Engineering Dept., National Chiao-Tung University, HsinChu, Taiwan, R.O.C.

- An integrated framework for recognizing 3-D human posture from 2-D images is proposed in this work.
- Fourier descriptors of the sampled points on the posture contour are calculated as the main and assistant feature.
- A modified particle filter is applied to improve the robustness of human posture recognition for continuous monitoring.
- The proposed framework is efficient in both human posture recognition and human behavior analysis.



Eight 3-D human postures in the database

14:08–14:26 FrC2.2

Calibration of Catadioptric Sensors by Polarization Imaging

Olivier Morel, David Fofi
Laboratoire Le2i UMR CNRS 5158, Le Creusot, France

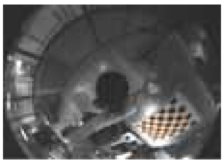
- New way of calibrating catadioptric sensors
- An optical apparatus -that may be embedded- automatically calibrates the sensor (orthographic camera is required)
- Calibration is performed by means of the general camera model developped by Sturm and Ramalingam

14:26–14:44 FrC2.3

Single View Point Omnidirectional Camera Calibration from Planar Grids

Christopher Mei and Patrick Rives
INRIA Sophia Antipolis, ICRA Project-team

- OpenSource Matlab calibration toolbox with C/C++ projection functions
- Shown to be valid theoretically for all central catadioptric sensors and fisheye lenses
- Approach validated experimentally on parabolic, hyperbolic, folded mirror, wide-angle and spherical sensors
- Simple calibration steps using images of a planar grid



14:44–15:02 FrC2.4

Stereo-based Markerless Human Motion Capture for Humanoid Robot Systems

Pedram Azad[1], Ales Ude[2], Tamim Asfour[1], and Rüdiger Dillmann[1]
[1]Institute for Computer Science and Engineering, University of Karlsruhe, Germany
[2]Jozef Stefan Institute, Ljubljana, Slowenia

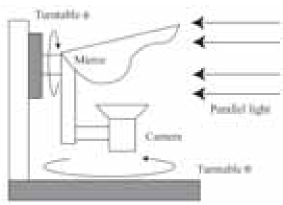
- A stereo-based markerless human motion capture system is presented
- Within a particle filter framework stereo-vision, edge-based calculations, and hand/head tracking are fused
- The system can process 320×240 stereo color input images at 15 Hz on a 3 GHz CPU

15:02–15:20 FrC2.5

Mirror Localization for a Catadioptric Imaging System by Projecting Parallel Lights

Ryusuke Sagawa[1], Nobuya Aoki[1], Yasuhiro Mukaigawa[1], Tomio Echigo[2], Yasushi Yagi[1]
1. Osaka University, Osaka, Japan
2. Osaka Electro-Communication University, Osaka, Japan

- Focus on the localization of the mirror
- Can be applied to non-single viewpoint system
- Use parallel lights to simplify the projection
- The parameters to be estimated is reduced by projecting parallel lights
- Accuracy is improved by reducing the number of parameters



Calibration system using parallel lights

Biped Locomotion III

Chair *Philippe Wenger, Ec. Centrale de NAntes*
Co-Chair *Eiichi Yoshida, National Inst. of Advanced Industrial Science andTechnology (AIST)*

13:50–14:08	FrC3.1

ZMP-based Biped Running Enhanced by Toe Springs

Shuuji KAJITA, Kenji KANEKO, Mitsuharu MORISAWA
Shinichiro NAKAOKA and Hirohisa HIRUKAWA
AIST, Japan

- HRP-2LT: a biped robot of 1.27m height, twelve active DOFs and two passive DOFs at its springy toes
- Compression and release phase of toe springs are carefully planned based on ZMP scheme
- Simulated 3km/h running and a jump experiment with both feet are shown

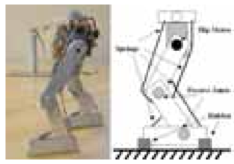
Jump of 0.1s, 3cm

14:08–14:26	FrC3.2

Bipedal Walking and Running with Compliant Legs

Fumiya Iida, Jürgen Rummel, and André Seyfarth
CSAIL, Massachusetts Institute of Technology, USA, and
Locomotion Laboratory, University of Jena, Germany

- A biped robot model with passive compliant legs for walking and running behavior
- Analysis of locomotion dynamics in simulation and a real-world robot
- Minimalistic control of forward locomotion speed and gait patterns



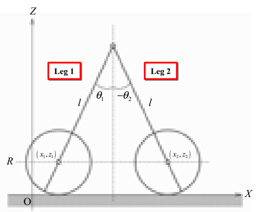
Biped Robot: Jena Walker

14:26–14:44	FrC3.3

The Effect of Semicircular Feet on Energy Dissipation by Heel-strike in Dynamic Bipedal Walking

Fumihiko Asano[1] and Zhi-Wei Luo[2,1]
1. Bio-Mimetic Control Research Center, RIKEN, Japan
2. Faculty of Engineering, Kobe University, Japan

- The effect of semicircular feet on energy-dissipation by heel-strike is investigated
- Dissipated mechanical energy by heel-strike is derived and its feature is analyzed
- Shock-absorbing effect of semicircular feet is theoretically clarified
- Feature of energy dissipation is analyzed based on singular values



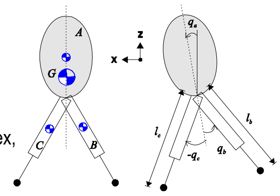
Configuration at instant of transition

14:44–15:02	FrC3.4

A Physical Model and Control Strategy for Biped Running

Muhammad E. Abdallah, Kenneth J. Waldron
Mechanical Engineering Dept.
Stanford University, USA

- Characterizes the mechanics of biped running with a tractable model and principles.
- Presents a simple, heuristic control strategy that achieves stable running.
- Introduces the Equilibrium Running Index, capturing the physical parameters effecting running speed.

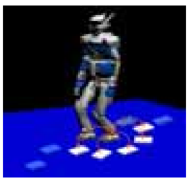


15:02–15:20	FrC3.5

Experimentation of Humanoid Walking Allowing Immediate Modification of Foot Place Based on Analytical Approach

Mitsuharu Morisawa, Kensuke Harada, Shuuji Kajita,
Shin'ichiro Nakaoka, Kiyoshi Fujiwara, Fumio Kanehiro,
Kenji Kaneko, and Hirohisa Hirukawa
National Institute of Advanced Industrial
Science and Technology(AIST), JAPAN

- The modification of foot place at every step was proven by using an actual human-size humanoid robot HRP-2.
- Using analytical solution of the COG, the walking pattern was generated in real-time.
- Two methods of suppression of the ZMP fluctuation were achieved by changing a single support phase and mixing the opposite phase of ZMP trajectory.



Physical Human-Robot Interaction II

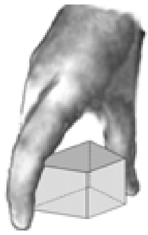
Chair *Masakatsu G. Fujie, Waseda Univ.*
Co-Chair *Herman Bruyninckx, Katholieke Univ. Leuven*

13:50–14:08	FrC4.1

Conveying virtual tactile feedback via augmented kinesthetic stimulation

Alessandro Formaglio and Domenico Prattichizzo
Department of Information Engineering, University of Siena, Italy
Gabriel Baud-Bovy
Psychology Faculty, at Vita-Salute San-Raffaele University, Milan, Italy

- Haptic perception of tactile feedback in virtual grasping using single-contact-point devices
- A new contact model featuring anisotropic compliance in the nighborhood of contact
- Ellipsoidal force force field with maximum stiffness along surface normal direction
- Results: virtual shape perception is possible even without vision and voluntary explorations

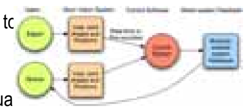


14:08–14:26	FrC4.2

Development of a Wearable Vibrotactile Feed-back Suit for Accelerated Human Motor Learning

Jeff Lieberman and Cynthia Breazeal
Media Arts and Sciences, MIT, USA

- •Tactile feedback in [sports, rehab, etc] training can help novices learn skills deeper and faster.
- •Tracking gauges user performance, comparing tc a teacher. Errors are fed back as vibrations.
- •This augments visual and aural feedback methods, and improves techniques such as virtua reality environments.
- •Reduction in errors by 20%, accelerated learning by 7% in initial study of 40 users [$p < 0.01$].



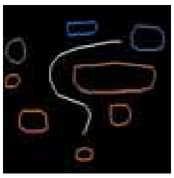
Tactile Feedback system for Kinesthetic Learning

14:26–14:44	FrC4.3

Scene Matching between a Map and a Hand Drawn Sketch Using Spatial Relations

Gaurav Parekh, Marjorie Skubic, James M. Keller
Electrical and Computer Engineering Dept., University of Missouri - Columbia, USA
Ozy Sjahputera
Center for Geospatial Intelligence, University of Missouri - Columbia, USA

- Scene matching between a map that has been drawn to scale and a hand drawn sketch.
- Force histogram method used to capture the spatial relations between objects.
- Ability to perform scene matching makes the robot sketch interface robust and easier to use.
- Approach evaluated using several hand drawn sketches that were collected in a user study.



A user drawn sketch of the environment.

14:44–15:02	FrC4.4

Assisting to Sketch Unskilled People with Fixed and Interactive Virtual Templates

C.A. Avizzano, O. Portillo-Rodriguez and M. Bergamasco
Perceptual Robotics Laboratory. Scuola Superiore Sant'Anna Pisa Italy.

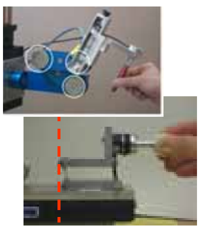
- This work presents a study where unskilled people is assisted when drawn using a haptic interface
- A first application has been developed to extract fixed templates from image files
- With a second application, the user can generate interactive templates indicating where he/she desires to put a geometrical template inside the haptic interface's workplace

15:02–15:20	FrC4.5

Virtual Fixture Control for Compliant Human-Machine Interfaces

Panadda Marayong*, Hye Sun Na+, and Allison M. Okamura*
*Mechanical Engineering Department, Johns Hopkins University, USA
+Biomedical Engineering Department, University of Texas at Austin, USA

- Virtual Fixtures provide motion guidance in human-machine cooperative manipulation.
- Position errors due to robot compliance and hand dynamics degrade virtual fixture performance.
- Newly developed ***Dynamically-Defined Virtual Fixtures*** consider joint compliance and human hand dynamics.
- Two user experiments demonstrate significant performance improvement with this method.



JHU Steady-Hand Robot and 1-DOF Compliant Human-Machine Testbed

Sensor Modelling and Uncertainty

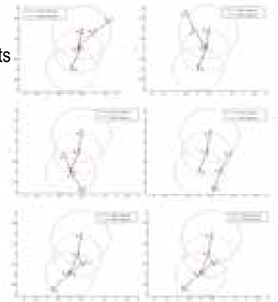
Chair *Kurt Konolige, SRI International*
Co-Chair *José Sá da Costa, Tech. Univ. of Lisbon, Inst. Superior Técnico*

13:50–14:08 FrC5.1

Determining the Robot-to-Robot Relative Pose Using Range-only Measurements

Xun S. Zhou and Stergios I. Roumeliotis
University of Minnesota

- Goal: Estimate the 3 d.o.f. robot-to-robot transformation using range measurements
- Key findings:
  - At most 6 solutions given 3 distances
  - At most 4 solutions given 4 distances
  - Unique solution given 5 distances
- Derived algorithms for computing all possible solutions that are
  - efficient (non-iterative)
  - robust to numerical errors

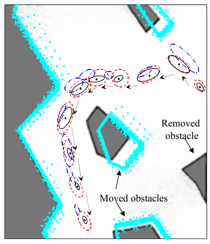

Example of 6 solutions

14:08–14:26 FrC5.2

A Consensus-based Approach for Estimating the Observation Likelihood of Accurate Range Sensors

J.L. Blanco, J. Gonzalez, J.A. Fernández-Madrigal
Dept. of System Engineering and Automation
University of Malaga, Spain

- Probabilistic localization and SLAM require an observation likelihood function. We propose a novel approach, the range scan likelihood consensus (RSLC), for computing the likelihood of accurate laser range scans.
- The artificial uncertainty inflation is avoided by means of a Consensus Theoretic fusion rule.
- Experimental results for synthetic and real data show a great improvement in robustness for localization within dynamic environments.

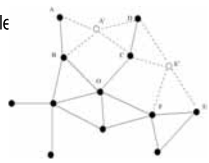


14:26–14:44 FrC5.3

Mobile Sensor Networks Self Localization based on Multi-dimensional Scaling

Chang-Hua Wu
Science and Mathematics Dept., Kettering University, USA
Weihua Sheng
Electrical and Computer Engineering Dept., Oklahoma State University, USA
Ying Zhang
Palo Alto Research Center, USA

- Mobile self-location problem for sparse mobile sensor networks
- Mobility Assisted MDS-MAP(P), based on Multi-dimensional Scaling
- Virtual nodes added via node movement for additional constraints

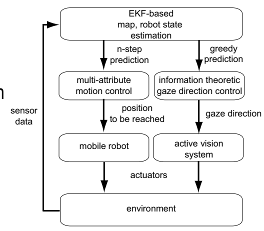

A sparse sensor network with virtual nodes shown as unfilled circles

14:44–15:02 FrC5.4

Combined Trajectory Planning and Gaze Direction Control for Robotic Exploration

Georgios Lidoris, Kolja Kühnlenz, Dirk Wollherr and Martin Buss
Institute of Automatic Control Engineering (LSR),
Technische Universität München, Germany

- Mobile robot exploration by autonomously solving a Simultaneous Localization and Mapping problem
- Robot trajectory planning is combined with gaze direction control
- Information theoretic criteria are used
- Estimation errors are kept low despite the assumption of very inaccurate robot and sensor models



Proposed motion and gaze direction control scheme

15:02–15:20 FrC5.5

Spatial Uncertainty Management for Simultaneous Localization and Mapping

Piotr Skrzypczynski
Institute of Control and Information Engineering,
Poznan University of Technology, Poznan, Poland

- New approach to spatial uncertainty management for **SLAM** is proposed.
- It merges two types of maps, **grid** and **feature based**, and two uncertainty representations, **probabilistic** and **fuzzy**.
- Line segments extraction assisted by the **FSG** map, that filters out artifacts.
- Odometry corrected by incremental **scan matching**.


Example of the Fuzzy Support Grid (FSG) map

Robot Design and Performance Evaluation I

Chair *William Singhose, Georgia Tech.*
Co-Chair *Surya Singh, Univ. of Western Australia*

13:50–14:08	FrC6.1

Using COTS to Construct a High Performance Robot Arm

Christian Smith and Henrik I. Christensen
Centre for Autonomous Systems, Royal Institute of Technology

- A detailed study of the construction of an articulated robotic manipulator using commercially available products.
- Fast dynamic performance – used for ball-catching experiments.
- End effector velocities up to 7 m/s, accelerations up to 140 m/s².

14:08–14:26	FrC6.2

A pick-and-place hand mechanism without any actuators and sensors

Satoru Sakai, Yashuhide Nakamura, Kenzo Nonami
Department of Electrical and Mechanical Engineering,
Chiba University

A passive placing mechanism for passive closure grippers:
- No actuators
- No sensors
- No springs
- No payload stress !!!

14:26–14:44	FrC6.3

Shady3D: a Robot that Climbs 3D Trusses

Yeoreum Yoon, Daniela Rus
MIT

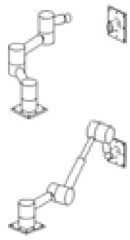
- Minimalist truss-climbing robot design
- 3 DOFs, 2 compliant grippers
- Truss planning with minimal plane transitions
- Hardware Experiments

14:44–15:02	FrC6.4

Configuration Control and Recalibration of a New Reconfigurable Robot

Farhad Aghili and Kourosh Parsa
Spacecraft Engineering,
Canadian Space Agency
Saint-Hubert, Quebec J3Y 8Y9, Canada

- Reconfiguration using cylindrical passive joints
- As dexterous as a hyper-redundant robot with less actuators and sensors
- Suitable for space applications: cost-effective, compact, and versatile
- Otherwise locked, the passive joints become controllable when the robot forms a closed kinematic chain

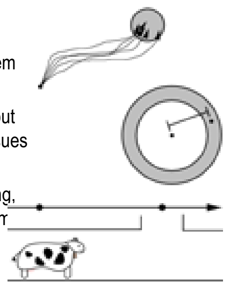


15:02–15:20	FrC6.5

Sloppy motors, flaky sensors, and virtual dirt: Comparing imperfect ill-informed robots

Jason M. O'Kane and Steven M. LaValle
Department of Computer Science
University of Illinois

- Are some robot systems provably “more powerful” than others?
- Definition of dominance of one robot system over another.
- Similar in spirit to theory of computation, but accounting for sensing and uncertainty issues unique to robotics.
- Extensions for errors in motion and sensing, unknown environments, and continuous tim



Visual SLAM

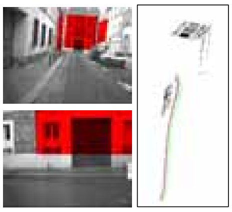
Chair *Christian LAUGIER, INRIA Rhône-Alpes*
Co-Chair *Jorge Pomares, Univ. of Alicante*

13:50–14:08 FrC7.1

An Efficient Direct Method for Improving visual SLAM

G. Silveira, E. Malis, P. Rives
INRIA Sophia-Antipolis, France & CenPRA Research Center, Brazil

- New approach to recover 3D motion, structure and illumination changes *directly* from intensity discrepancies
- Suitable parameterizations and enforcement of scene rigidity and cheirality constraints
- New solution to the visual SLAM initialization
- Comparisons with existing methods show significant performance improvements



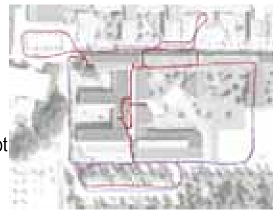
Left: first and last image of the sequence. Right: both pose and scene being incrementally reconstructed

14:08–14:26 FrC7.2

Mini-SLAM: Minimalistic Visual SLAM in Large-Scale Environments Based on a New Interpretation of Image Similarity

Henrik Andreasson[1], Tom Duckett[2], and Achim Lilienthal[1]
[1]AASS, Dept. of Technology, Örebro University, Sweden
[2]Dept. of Computing and Informatics, University of Lincoln, UK

- Vision based SLAM using Omni-directional images and odometry
- Minimalistic with regards to computation and hardware requirements
- Estimation of visual landmark positions not needed
- Consistent maps in a large environment (path length: 1.4 km) with indoor and outdoor passages



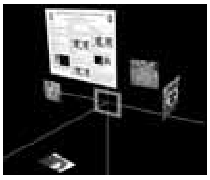
Aerial image together with the estimated path

14:26–14:44 FrC7.3

Towards simultaneous recognition, localization and mapping for hand-held and wearable cameras

Robert Castle, Darren Gawley, Georg Klein and David Murray
Department of Engineering Science, University of Oxford, UK

- Wearables need to be able to recognize objects to benefit a user.
- Planar objects are detected using SIFT and localized in 3D.
- Addition of localized objects to monocular SLAM makes it more robust.
- The map becomes human readable, and the camera view can be augmented with the objects.



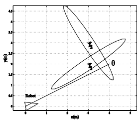
A 3D view of a SLAM map with identified objects

14:44–15:02 FrC7.4

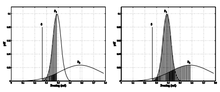
Data Association in Bearing-Only SLAM using a Cost Function-based Approach

N. M. Kwok[(1)], Q. P. Ha[(1)] and G. Fang[(2)]
[(1)]ARC Centre of Excellence for Autonomous Systems
Faculty of Engineering, University of Technology, Sydney, Australia
[(2)]School of Engineering, University of Western Sydney, Australia

- Associate between measurement and registered features in EKF-based SLAM
- Mahalanobis distance metric tests only power of association decision
- Cost function-based association accounts for test of significance – interference from other measurements/features
- Mitigates association ambiguities – improves bearing-only SLAM performance



Data association scenario



Feature f_1 lower cost Feature f_2 higher cost

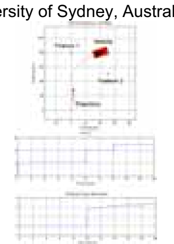
15:02–15:20 FrC7.5

On the Observability of Bearing-only SLAM

Teresa Vidal-Calleja[1], Mitch Bryson[2], Salah Sukkarieh[2], Alberto Sanfeliu[1], and Juan Andrade-Cetto[1]
[1]Institut de Robòtica i Informàtica Industrial, UPC-CSIC, Spain
[2]Centre of Excellence for Autonomous System, University of Sydney, Australia

- We present an **observability analysis** for planar vehicles performing SLAM with bearing-only observations.
- The analysis is performed modelling the system as piecewise constant using the Stripped Observability Matrix method.
- The characterised instantaneous unobservable modes indicate the directions in the state space for which no information is being added.

a) b) c)



a) Trajectory, b) Information Matrix Rank, c) Heading Information.

Rehabilitation Devices

Chair *Maria Chiara Carrozza, Scuola Superiore Sant'Anna*
Co-Chair *Toshio Fukuda, Nagoya Univ.*

13:50–14:08	FrC8.1

ARMin II - 7 DoF rehabilitation robot: mechanics and kinematics

Matjaž Mihelj
Faculty of Electrical Engineering, University of Ljubljana, Slovenia
Tobias Nef and Robert Riener
ETH Zurich and University Zurich, Switzerland

- Upper extremity rehabilitation robot with seven active degrees of freedom for shoulder, elbow and wrist.
- Semi-exoskeleton configuration; all robot axes correspond to human anatomical axes.
- Rehabilitation is based on patient cooperative control strategies supported by a multimodal display.


Subject exercising in the ARMin II robot

14:08–14:26	FrC8.2

Design, Control and Human Testing of an Active Knee Rehabilitation Orthotic Device

Weinberg B., Nikitczuk J., Mavroidis C.
Mechanical & Industrial Engineering Dept., Northeastern University, USA
Patel S., Patritti B., Bonato P.
Spaulding Rehabilitation Hospital, Boston, MA, USA
Canavan P., Physical Therapy Dept., Northeastern University, USA

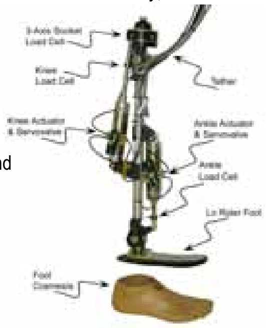
- Portable knee rehabilitation device for stroke patient gait retraining
- Electro-Rheological Fluid (ERF) based brakes for controllable resistance
- Advanced closed loop torque control of ERF brakes and AKROD
- Preliminary human tests

14:26–14:44	FrC8.3

Design and Control of a Powered Knee and Ankle Prosthesis

Frank Sup, Amit Bohara, and Michael Goldfarb
Mechanical Engineering Department, Vanderbilt University, USA

- Design details of the prosthesis prototype that is a first step towards a self-contained version with on-board control and hot gas actuation
- Impedance-based control approach that coordinates the motion of the prosthesis and user for the control of level walking.
- Experimental results and video are shown that indicate the effectiveness of the active prosthesis and control approach.



14:44–15:02	FrC8.4

A Powered Leg Orthosis for Gait Rehabilitation of Motor-Impaired Patients

Sai K. Banala, Alexander Kulpe, Graduate Students,
Sunil K. Agrawal, Professor
Mechanical Systems Laboratory, University of Delaware, Newark, DE 19716

- Controllers described (1) Trajectory tracking PD controller (2) Set-point PD controller (3) Force-Field controller
- Force-Field controller simulates "tunnel" around foot.
- Simulation results and experimental results with a dummy leg.
- Set-point PD controller and Force-field controller suitable for rehabilitation.

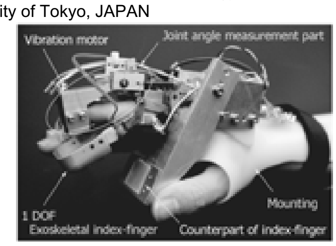

Powered leg orthosis with a human subject

15:02–15:20	FrC8.5

A Prototype of Index-Finger PIP Joint Motion Amplifier for Assisting Patients with Impaired Hand Mobility

Keisuke Watanabe, Hiroshi Morishita, Taketoshi Mori and Tomomasa Sato
Graduate School of Infomation Science and Technology,
The University of Tokyo, JAPAN

- **Joint Motion Amplifier:** a novel device which compensates joint's limited passive range of motion
- The device's fingertip
  - amplifies user's finger motion
  - moves separately from the user's finger
- A prototype for index-finger's proximal interphalangeal(PIP) joint was constructed



Overview of the index-finger PIP joint motion amplifier

Mapping: Features and Modelling

Chair *Daniele Nardi, Uni. Roma*

Co-Chair *Ashley Desmond Tews, CSIRO*

13:50–14:08	FrC9.1

Sonar Feature Map Building for a Mobile Robot

Hong-Ming Wang, Zeng-Guang Hou, Jia Ma, Yun-Chu Zhang, Yong-Qian Zhang and Min Tan
Key Laboratory of Complex Systems and Intelligence Science
Institute of Automation, Chinese Academy of Sciences
Beijing 100080, China.

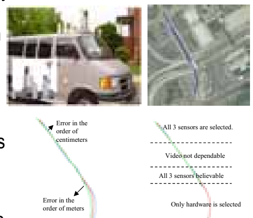
- Introduction of Sonar Mapping
- Data-level Fusion Model for Feature Identification
- Estimating Parameters of Identified Features
- Feature-level Fusions for Map Updating
- Experimental Results

14:08–14:26	FrC9.2

Sensor Selection Using Information Complexity for Multi-sensor Mobile Robot Localization

Sreenivas Sukumar[1], Hamparsum Bozdogan[2], David Page[1], Andreas Koschan[1] and Mongi Abidi[1]
[1]Imaging, Robotics and Intelligent Systems Lab, University of Tennessee, USA
[2] Department of Statistics, University of Tennessee, USA

- Topic: Deals with uncertainty minimization in multi-sensor systems for global localization.
- Method: Information theoretic definitions of sensor belief and sensor validity.
- Mathematical tool used: Statistical definitions of information complexity.
- Application: Unmanned vehicles in large scale environments, small robots in buildings.



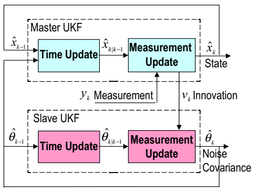
Sensor selection for unmanned vehicles in urban environments

14:26–14:44	FrC9.3

Noise Covariance Identification-Based Adaptive UKF with Application to Mobile Robot System

Q. Song, Z. Jiang and J.D. Han
Shenyang Institute of Automation, Chinese Academy of Sciences, China

- An Adaptive Unscented Kalman Filter (AUKF) with master-slave structure is introduced.
- The master UKF estimates the states.
- The slave UKF estimates the noise covariance for the master UKF.
- The proposed method intends to compensate the performance degradation due to changing noise.



Structure of the AUKF

14:44–15:02	FrC9.4

On achievable accuracy for range-finder localization

Andrea Censi
DIS, Universita' di Roma "La Sapienza", Italy

How accurate can YOUR localization method be?

Find it out here.

15:02–15:20	FrC9.5

Good Experimental Methodologies for Robotic Mapping: A Proposal

Francesco Amigoni and Simone Gasparini
Dipartimento di Elettronica e Informazione, Politecnico di Milano, Italy
Maria Gini
Dept. of Computer Science and Engineering, University of Minnesota, USA

- We propose a methodology for experimental research in segment-based mapping systems and apply it to our own mapping system.
- Our methodology requires to use publicly available data, to show all parameter values, and to include, among other things, sensitivity analysis and cases where results are not as expected.

Force Control

Chair *Luigi Villani, Univ. di Napoli Federico II*
Co-Chair *Dragoljub Surdilovic, Fraunhofer Inst. for Production Systems and DesignTechnology*

13:50–14:08 FrC10.1

Impedance Behaviors for Two-handed Manipulation: Design and Experiments

Thomas Wimböck, Christian Ott, and Gerd Hirzinger
Institute of Robotics and Mechatronics, German Aerospace Center (DLR)

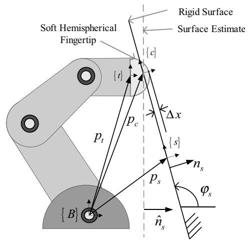

- Intuitive high-level control of a humanoid upper body enabling fast application development.
- Based on the compliance control law potentials are superimposed to generate impedance behaviors that map onto all joints.
- Experimental verification of hand-arm coordination and two-handed manipulation using DLR's Justin.

14:08–14:26 FrC10.2

Force/Position Tracking of a Robot in Compliant Contact with Unknown Stiffness and Surface Kinematics

Zoe Doulgeri and Yiannis Karayiannidis
Electrical and Computer Engineering Dept.,
Aristotle University of Thessaloniki, 54124 GREECE

- A robotic finger with soft tip of uncertain compliance in contact with a surface of unknown position and slope is considered
- An adaptive control law is proposed that achieves:
  - •Force and position tracking
  - •Surface slope identification

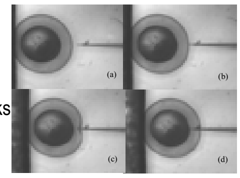


14:26–14:44 FrC10.3

Visual-based Impedance Force Control of Three-dimensional Cell Injection System

Haibo Huang*, Dong Sun*, James K. Mills** and Wen J. Li***
* City University of Hong Kong, Hong Kong
** University of Toronto, Canada
*** Chinese University of Hong Kong, Hong Kong

- Propose a new methodology to use planar visual feedback to estimate 3D cell deformation and injection force.
- Propose an automatic motion planning methodology designed for cell injection tasks
- Propose to use an impedance force control algorithm to regulate the injection force during the cell injection.



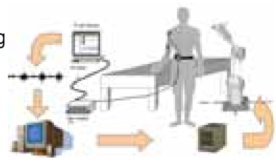
Microinjection experiment on zebrafish embryos

14:44–15:02 FrC10.4

Motion Tasks and Force Control for Robot Manipulators on Embedded 2-D Manifolds

Xanthi Papageorgiou, and Kostas J. Kyriakopoulos
Mechanical Engineering Dept., National Technical University of Athens, Greece
Savvas G. Loizou
Grasp Lab., University of Pennsylvania, Philadelphia, USA

- Driving and stabilization on 2-D manifolds of an articulated robot manipulator moving in 3-D workspaces.
- Provably correct compliant dynamic controller performing motion planning for articulated robot manipulators.
- Novel theoretically guaranteed compliant dynamic trajectory tracking controller, achieving obstacle avoidance for articulated robot manipulators.



Compliant robot manipulator's motion, interfacing with the neural system and obstacle avoidance.

15:02–15:20 FrC10.5

Force Estimation Based Compliance Control of Harmonically Driven Manipulators

Leon Aksman†, Craig Carignan‡, and David Akin†
† - Aerospace Engineering Dept., University of Maryland, USA
‡ - Dept. of Radiology, Georgetown University, USA

- Estimation of external forces exerted on a harmonically driven manipulator.
- Estimation based on adaptation of modeled dynamics and online learning of unmodeled friction.
- Compliance control implemented using force estimates.
- Force-torque sensor used as a baseline for comparison to force estimates.

Pose Estimation

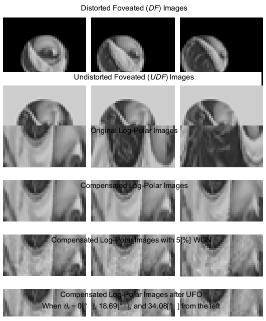
Chair *Hugh Durrant-Whyte, Univ. of Sydney*
Co-Chair *Kohtaro Ohba, AIST*

13:50–14:08 FrC11.1

Eccentricity Compensator for Log-Polar Sensor

Sota Shimizu and Joel W. Burdick
California Institute of Technology

- Proposed eccentricity compensator corrects deformation using log-polar geometry.
- Proposed Unreliable Feature Omission (UFO) increases quality of a space-variant image like a log-polar image using Discrete Wavelet Transform.
  - by removing resolution-based unreliable coefficients
  - even if the space-variant resolution is not isotropic

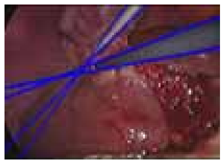


14:08–14:26 FrC11.2

A Degenerate Conic-Based Method for a Direct Fitting and 3-D Pose of Cylinders with a Single Perspective View

C. Doignon and M. de Mathelin
Laboratoire des Sciences de l'Image, de l'Informatique et de la Télédétection, University of Strasbourg, France

- 3-D positioning and tracking of surgical laparoscopic instruments in the human abdomen.
- A new representation of circular cylinders based on the symmetry axis and its image.
- A robust fitting of the overall apparent contour.

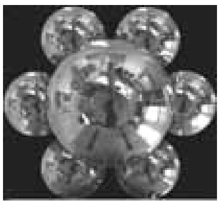


14:26–14:44 FrC11.3

Robust and Real-time Rotation Estimation of Compound Omnidirectional Sensor

Trung Ngo Thanh, Hajime Nagahara, Ryusuke Sagawa, Yasuhiro Mukaigawa, Masahiko Yachida, Yasushi Yagi
Osaka University, Japan

- We uses only distant feature points for estimating rotation of sensor
- The distant points are detected by using small baselines of the compound omni-directional sensor
- RANSAC based estimation helps the approach more robust
- Fast computation is derived by at least 2 pairs of feature correspondence on consecutive frames



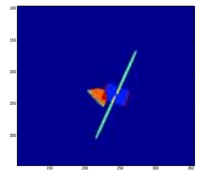
Input image of compound omnidirectional sensor

14:44–15:02 FrC11.4

Nearly Analytical Pose Estimation

John McInroy
University of Wyoming

- A nearly analytical, two step process for pose estimation from a single camera is developed.
- Step 1: Solution of a least squares matrix problem, followed by projection onto the nearest scaled subunitary matrix.
- Step 2: Solution of a least squares vector problem, followed by projection onto SO(3)
- For the same level of accuracy, only 1.27 iterations are required, vs. 37.4 for a popular method



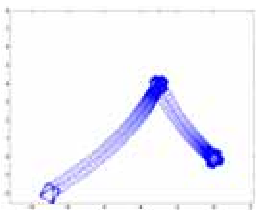
The method is tested on simulated images of a satellite.

15:02–15:20 FrC11.5

Switched Homography-Based Visual Control of Differential Drive Vehicles with Field-of-View Constraints

G. López-Nicolás*, S. Bhattacharya**, J.J. Guerrero*, C. Sagüés* and S. Hutchinson**
*DIIS – I3A, Universidad de Zaragoza, Spain
**Electrical and Computer Engineering Dept., University of Illinois, USA

- Switched control law based directly on the homography elements
- Navigation along optimal paths
- Differential drive motion constraints
- Field-of-view constraints of the monocular system



Robot trajectory

Marine Robotics: Planning and Navigation

Chair *Kimon Valavanis, Univ. of South Florida*
Co-Chair *Sauro Longhi, Univ. Pol. delle Marche*

13:50–14:08	FrC12.1

Behavior Based Adaptive Control for Autonomous Oceanographic Sampling

Donald Eickstedt and Michael Benjamin
NAVSEA Division Newport, Newport RI, USA
Ding Wang and Joseph Curcio and Henrik Schmidt
Massachusetts Institute of Technology, USA

- Autonomous Oceanographic Sampling for Rapid Environmental Assessment
- Sensor Platform Control is Behavior Based with Multiple Objective Functions
- Mission Oriented Operating System Autonomy Architecture
- Adaptive Sampling of the Ocean Thermal Gradient in Monterey Bay, CA


An autonomous kayak performing adaptive sampling in Monterey Bay, CA

14:08–14:26	FrC12.2

Model-Based Nonlinear Observers for Underwater Vehicle Navigation: Theory and Preliminary Experiments

James C. Kinsey and Louis L. Whitcomb
The Johns Hopkins University, USA

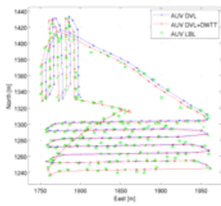
- Reports the analytical development and preliminary experimental evaluation of an exact dynamic model-based nonlinear observer for underwater vehicle navigation.
- Observer exploits exact knowledge of the vehicle's nonlinear dynamics, the forces and moments acting on the vehicle, and disparate position and velocity measurements.
- Asymptotic stability of the observer is proven using Lyapunov techniques and the KYP Lemma.
- Observer is experimentally implemented on a laboratory ROV.
- Position estimates possess lower error than 12kHz LBL systems and are comparable to estimates from the Extended Kalman Filter.

14:26–14:44	FrC12.3

Experimental Results in Synchronous-Clock One-Way-Travel-Time Acoustic Navigation for Autonomous Underwater Vehicles

Ryan Eustice[y], Louis Whitcomb[z], Hanumant Singh[¤] and Matthew Grund[¤]
[y]Dept Naval Architecture & Marine Engineering, University of Michigan, USA
[z]Dept Mechanical Engineering, Johns Hopkins University, USA
[¤]Dept Applied Ocean Physics & Engineering, Woods Hole Oceanographic Institution, USA

- This talk presents a scalable, bounded-error, multi-AUV navigation methodology for large-area surveys (i.e., O(100 km))
- Navigation is derived from one-way-travel-time (OWTT) ranges fused with Doppler odometry
- Results for two field experiments conducted using an AUV and surface ship are presented

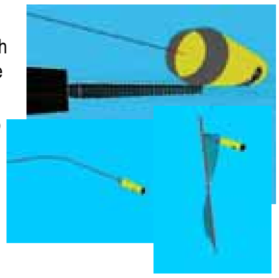

Field results for an AUV survey

14:44–15:02	FrC12.4

Optimal AUV path planning for extended missions in complex, fast-flowing estuarine environments.

Dov Kruger, Rustam Stolkin, Aaron Blum, Joseph Briganti
Center for Maritime Systems
Stevens Institute of Technology, USA

- Automatic planning of AUV paths which best exploit complex current data while avoiding obstacles.
- Novel AUV missions – ride currents up and down a fast flowing tidal estuary.
- Path parameterizations, cost functions and efficient optimization strategies.
- Simulations for the Hudson River.



15:02–15:20	FrC12.5

Global Robust and Adaptive Output Feedback Dynamic Positioning of Surface Ships

K. D. Do
School of Mechanical Engineering, The University of Western Australia
35 Stirling Highway, Crawley, WA 6009, Australia

- Constructive method to design robust adaptive output feedback for DP of ships.
- Environmental disturbances are included.
- No rate measurements are required.
- Ship parameters are not required to be known.

Localization: Learning and Clustering

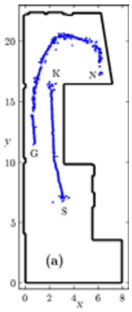
Chair *Stergios Roumeliotis, Univ. of Minnesota*
Co-Chair *Goldie Nejat, State Univ. of New York at Stony Brook*

15:28–15:46 FrD1.1

A Spatially Structured Genetic Algorithm Over Complex Networks for Mobile Robot Localisation

Andrea Gasparri, Stefano Panzieri, Federica Pascucci, Giovanni Ulivi
DIA, Università degli Studi "Roma Tre", Rome, Italy

- A spatially structured genetic algorithm for mobile robotic localisation is proposed
- Complex Network Theory is applied to deploy the population and find optimal solutions
- Spatial structures are used to create evolutionary niches and carry on multi-hypotheses



15:46–16:04 FrD1.2

Incremental Spectral Clustering and Its Application To Topological Mapping

Christoffer Valgren and Achim Lilienthal
Dept. Of Technology, Örebro University, Sweden
Tom Duckett
Dept. of Computing and Informatics, University of Lincoln, UK

- General purpose clustering algorithm: an extension of spectral clustering
- Example application: appearance-based topological mapping
- The entire affinity matrix does not have to be computed
- Incremental, but supports node merging and splitting

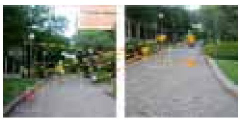

Part of topological map, generated by the algorithm.

16:04–16:22 FrD1.3

Outdoor Landmark-view Recognition Based on Bipartite-graph Matching and Logistic Regression

Eduardo Todt
Faculty of Engineering, PUCRS, Porto Alegre, Brazil
Carme Torras
Institut de Robòtica i Informàtica Industrial, CSIC-UPC, Barcelona, Spain

- Extraction of visual landmarks from outdoor images for mobile robot applications, based on visual saliency.
- Co-occurrence, spatial and saliency relationships between landmarks are added to landmark color descriptors.
- An enhanced view-matching model is developed using logistic regression.

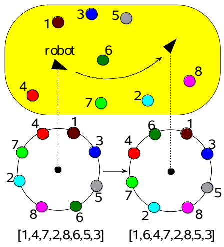

Landmark matching at similar views. The arrows indicate the solution of the weighted bipartite matching

16:22–16:40 FrD1.4

Learning Combinatorial Information from Alignments of Landmarks

Luigi Freda
DIS, Università di Roma "La Sapienza", Italy
Benjamín Tovar, Steve M. LaValle
DCS, University of Illinois, USA

- The information space of a robot moving in the plane with limited sensing is characterized
- Only the circular order of landmarks around the robot is sensed. No metric information available
- The navigation and mapping capabilities using this minimal sensing model are described
- An algorithm for building a topological representation of the environment is presented



Circular order of landmarks sensed by the robot

Telepresence

Chair *Yasuyoshi Yokokohji, Kyoto Univ.*
Co-Chair *Mark Minor, Univ. of Utah*

15:28–15:46	FrD2.1

Quantitative evaluation of delay of head movement for an acoustical telepresence robot: *TeleHead*

Iwaki Toshima[1)2)], and Shigeaki Aoki[1)]
1)NTT CS Lab., NTT Corp. 2)Tokyo Intsitute of Technology

- *TeleHead* is an acoustical telepresence robot.
- *TeleHead* has a user-like dummy head synchronized with user's head movement in real time.
- We evaluated relationships between head movement delay and sense of incongruity.
- Head movement control should have a dead time shorter than 27 ms.

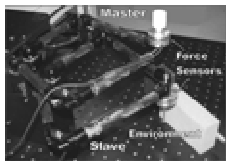
An acoustical telepresence robot: *TeleHead* and its inside.

15:46–16:04	FrD2.2

Stable Non-linear Force/Position Mapping for Enhanced Telemanipulation of Soft Environments

Pawel Malysz and Shahin Sirouspour
Electrical and Computer Engineering Dept., McMaster University, Canada

- Enforces monotic non-linear mappings of position/force for enhanced tissue manipulation
- Lyapunov-based adaptive controllers
- Stability analyzed using off-axis circle criterion and Nyquist envelope of interval plant systems
- Validated experimentally on two-axis teleoperation system

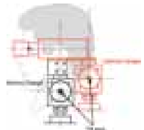


16:04–16:22	FrD2.3

Design and Evaluation of a Tele-presence Vision System for Manipulation Tasks

K. Shiratsuchi, K. Kawata, E. Vander Poorten and Y. Yokokohji
Dept. of Mechanical Engineering & Science., Kyoto University, JAPAN

- "Permissible errors" were defined.
- A camera system with the minimum DOF for a set of tasks was designed based on the idea of "permissible visual errors".
- Verification is done with our unified hand/arm teleoperation platform
- The proposed design framework breaks away from design by simply mimicking human appearance.

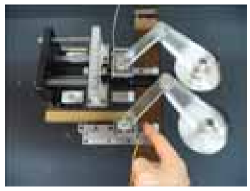


16:22–16:40	FrD2.4

A Transparent Bilateral Controller for Teleoperation Considering the Transition of Motion

Heng Wang and K. H. Low
School of Mechanical & Aerospace Eng., Nanyang Technological Univ., Singapore
Michael Yu Wang
Mechanical & Automation Eng. Dept., The Chinese Univ. of Hong Kong, Hong Kong, China

- Two-channel bilateral controller
- Perfect transparency can be achieved in theory
- Consider the transition between the free space motion and the constrained motion
- No control mode switch is required during the transition of motion



Quadrupeds

Chair *molfino Rezia Molfino, Univ. of Genova*
Co-Chair *Jadran Lenarcic, Jozef Stefan Inst.*

15:28–15:46 FrD3.1

Towards Realization of Adaptive Running of a Quadruped Robot Using Delayed Feedback Control

Zu Guang Zhang
The University of Tokyo, JAPAN
Toshiki Masuda, Hiroshi Kimura, and Kunikatsu Takase
The University of Electro-Communications, JAPAN

- The quadruped robot **Rush** is a kneed machine with only one actuator per compliant leg.
- A rhythm generator and a torque generator are used to construct a **novel control system**.
- The states of both generators are modulated by **DFC** using adequate sensor information.
- The designed mechanical and control systems are required to autonomously adapt to not only **flat** also **rough** terrain.

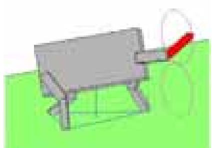
The prototype of a quadruped running robot, **Rush**

15:46–16:04 FrD3.2

Inverse Kinematics for a Point-Foot Quadruped Robot with Dynamic Redundancy Resolution

Alexander Shkolnik, Russ Tedrake
Electrical Engingeering and Computer Science, MIT, USA

- Developed controller based on whole-body Jacobians to control Center of Mass and foot movement
- Inverse kinematics redundancy resolution plays a large role in stability!
- Redundancy resolution using partial inverse-kinematics solutions minimizes twisting
- More aggressive dynamic movements can be executed even while only considering static stability

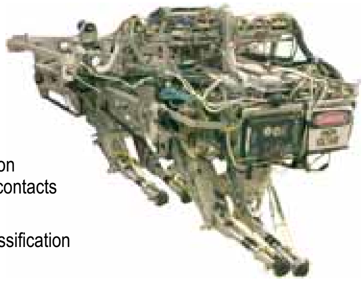


16:04–16:22 FrD3.3

A Hybrid Motion Model for Aiding State Estimation in Dynamic Quadrupedal Locomotion

Surya P. N. Singh[1] and Kenneth J. Waldron[2]
[1] Mech. Eng., Univ. of Western Australia,
[2]Locomotion Lab., Stanford Univ.

- Fast Trot & Gallop Model
- Shown on KOLT Robot Trotting experiments
- Switches contexts based on dynamic state – not foot contacts
- Method also does gait classification

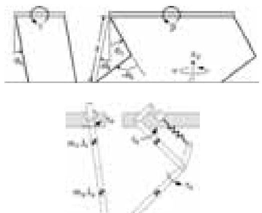


16:22–16:40 FrD3.4

Force Redistribution in a Quadruped Running Trot

L. R. Palmer III and D. E. Orin
Department of Electrical and Computer Engineering
The Ohio State University, USA

- Force redistribution based upon the articulated-body dynamics algorithm for multi-body systems.
- Passive SLIP (spring-loaded inverted pendulum) dynamics are preserved.
- 3D trot control up to 4.75 *m/s* and 20 *deg/s*.



Physical Human-Robot Interaction Devices and Their Control

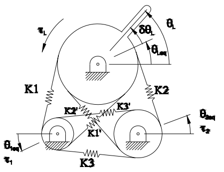
Chair *Khatib Oussama, Stanford Univ.*
Co-Chair *Carlo Alberto Avizzano, Scuola Superiore S.Anna*

15:28–15:46	FrD4.1

A Comparative Dependability Analysis of Antagonistic Actuation Arrangements for Enhanced Robotic Safety

Roberto Filippini, Soumen Sen, Giovanni Tonietti, and Antonio Bicchi
Interdepartmental Research Center “E. Piaggio”,
Faculty of Engineering, University’ of Pisa, Italy

- A detailed comparative dependability analysis is conducted for Variable Impedance Actuation using antagonistic actuation of a single joint
- Three variants of a general arrangements are considered
- Results provide guidelines for design of safe and dependable actuators for physical human-robot interaction



General arrangement for an antagonistic actuation system

15:46–16:04	FrD4.2

Proxy-Based Sliding Mode Control of a Manipulator Actuated by Pleated Pneumatic Artificial Muscles

M. Van Damme, B. Vanderborght, R. Van Ham, B. Verrelst, F. Daerden, D. Lefeber
Vrije Universiteit Brussel, Department of Mechanical Engineering
Multibody Mechanics Research Group
michael.vandamme@vub.ac.be

- Lightweight manipulator actuated by Pleated Pneumatic Artificial Muscles
- Adaptable compliance and high power to weight ratio
- Safety is of primary importance
- Proxy-Based Sliding mode control: improved performance and safety

16:04–16:22	FrD4.3

Position and Force Control Based on Mathematical Models of Pneumatic Artificial Muscles Reinforced by Straight Glass Fibers

Taro Nakamura and Hitomi Shinohara
Dept. of Precision Mechanics, Chuo University, Japan

- Contraction ratio and force of a Straight Fibers Type are **much larger** than those of a conventional McKibben Type !
- However, It has high nonlinear characteristics. Its gain has high compliance
- Feed-forward compensation based on **Mathematical models** is applied to the artificial muscle
- Accuracy position and force control is realized !

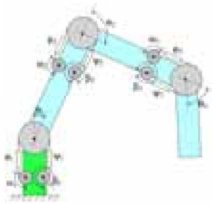
An artificial muscle manipulator

16:22–16:40	FrD4.4

Feedback linearization and simultaneous stiffness-position control of robots with antagonistic actuated joints

G. Palli and C. Melchiorri
DEIS - University of Bologna – Italy
T. Wimböck, M. Grebenstein and G. Hirzinger
DLR - Institute of Robotics and Mechatronics - Germany

- The dynamic model of a robotic manipulator with antagonistic actuated joints is presented.
- Joint positions and stiffnesses can be simultaneously adjusted by using nonlinear transmission elements.
- Full feedback linearization and stiffness-position control of the antagonistic actuated robot is achieved.
- Simulation results are reported.



A robotic arm with 3 antagonistic actuated joints

Fuzzy, Neural and Probabilistic Control

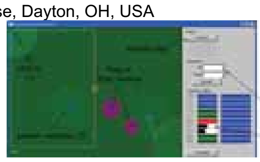
Chair *Helge-Bjoern Kuntze, Fraunhofer-Inst. for Information and Data ProcessingIITB*
Co-Chair *Raffaella Mattone, Univ. di Roma*

15:28–15:46	FrD5.1

Towards Probabilistic Operator-Multiple Robot Decision Models

Mark Campbell, Frédéric Bourgault and David Schneider
Sibley School of Mechanical and Aerospace Engineering,
Cornell University, Ithaca, NY, USA
Scott Galster
Human Effectiveness Directorate,
Wright-Patterson Air Force Base, Dayton, OH, USA

- Coupled operator-multiple robot systems are modeled in a unified framework using probabilistic graphs (i.e. Bayesian Networks)
- Human operator decision data from a series of tests performed by AFRL on Cornell's RoboFlag simulator are being analyzed with this framework
- Human decision prediction, adaptive autonomy, interactive decision aids, and interface optimization are long term goals

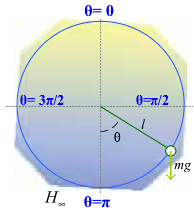

Multi-vehicle search-and-identify game in RoboFlag simulator

15:46–16:04	FrD5.2

Fuzzy Control of Inverted Robot Arm with Perturbed Time-Delay Affine Takagi-Sugeno Fuzzy Model

Wen-Jer Chang, Wei-Han Huang and Wei Chang
Dept. of Marine Engineering, National Taiwan Ocean University, R.O.C.

- An Affine T-S fuzzy model of the time-delay perturbed inverted robot arm system was constructed.
- The analysis and synthesis for the controller design problem was solved by the T-S fuzzy control theory.
- An ILMI algorithm was developed to find suitable fuzzy control gains for the closed-loop stability conditions.



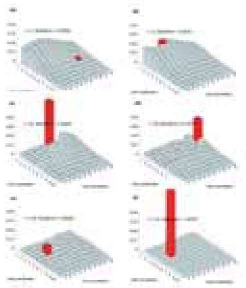
Inverted robot arm system

16:04–16:22	FrD5.3

A Decision-Making Framework for Control Strategies in Probabilistic Search

Timothy H. Chung and Joel W. Burdick
Engineering and Applied Sciences,
California Institute of Technology, USA

- Formulated probabilistic search problem as a decision and compared different control strategies
- Derived analytic expressions for decision evolution, useful for insights & implementation
- Proposed two novel control strategies which have applications to visual search and behavioral modeling


Belief Evolution in Time

16:22–16:40	FrD5.4

On-line Evolutionary Head Pose Measurement by Feedforward Stereo Model Matching

Wei Song, Mamoru Minami and Yasushi Mae
Graduate School of Engineering, University of Fukui, Japan
Seiji Aoyagi
Faculty of Engineering, Kansai University, ☐ Japan

- We present a method to estimate the 3D head pose using stereo cameras.
- The proposed method uses genetic algorithm (GA) and a stereo model matching.
- A motion-feedforward method is proposed for hand-eye system to improve the dynamics of recognition.
- The effectiveness of the proposed method is confirmed by the experiments.


Experimental system: Recognition under given motion of the end-effector

Robot Design and Performance Evaluation II

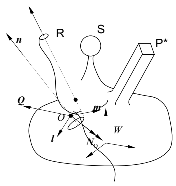
Chair *John Morrell, Yale Univ.*
Co-Chair *Takahiro Suzuki, Univ. of Tokyo*

15:28–15:46	FrD6.1

Statics as a Means to Assess the Sensitivity of a Manipulator to Kinematic Parameter Deviations

Carlo Innocenti
DIMeC, University of Modena and Reggio Emilia, Italy

- How the end-effector pose depend on the geometric inaccuracies of the links?
- The answer is provided, at any manipulator configuration, by six static analyses.
- The complexity of the kinematic model is kept to a minimum.
- The method is applicable to any statically determinate manipulator with rigid links.

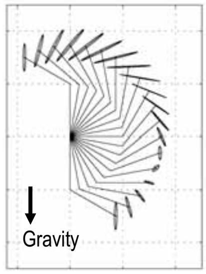


15:46–16:04	FrD6.2

Effect of Gravity on Manipulation Performance of Robotic Arm

Tasuku Yamawaki, and Masahito Yashima
Dept. of Mechanical Systems Engineering,
National Defense Academy of Japan, JAPAN

- This paper reveals how gravity effects on the manipulation performance with respect to the control accuracy and the mechanical efficiency
- An ellipsoid given by the output controllability matrix is applied to the evaluation (see figure)
- Computer simulations demonstrate a trajectory planning as an application example of the evaluation

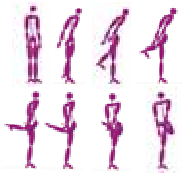


16:04–16:22	FrD6.3

Progressive Clamping

Daniel Raunhardt and Ronan Boulic
Ecole Polytechnique Fédérale de Lausanne, Switzerland

- Modeling kinematic anisotropy of joint limits for virtual mannequins or robots
- Damps only the part of the motion by adding highest priority constraints that brings a joint towards its limit
- Integration into a Prioritized Inverse Kinematics solver



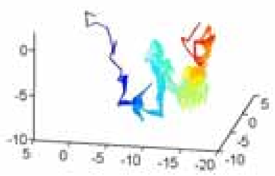
Example where the convergence to the final state is faster with progressive clamping compared to clamping

16:22–16:40	FrD6.4

A Unified Geometric Approach for Inverse Kinematics of a Spatial Chain with Spherical Joints

Li Han and Lee Rudolph
Dept. of Mathematics and Computer Science, Clark University, USA

- Three types of inverse kinematics (IK) problems solved in a **unified** geometric approach
- The set of IK solutions completely **parameterized** and proven to be piecewise practically **convex**
- Loop closure constraints formulated exactly as **linear inequalities** in the *anchored triangle parameters*
- **Singular** configurations properly parameterized



A Few IK Solutions for a Chain with Hundreds of Links

Coordination and Deployment

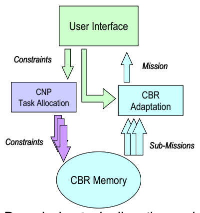
Chair *Udo Frese, Univ. Bremen*
Co-Chair *Denny Oetomo, INRIA Sophia Antipolis*

15:28–15:46 FrD7.1

Integrated Mission Specification and Task Allocation for Robot Teams – Design and Implementation

Patrick Ulam, Yoichiro Endo, Alan Wagner, Ronald Arkin
College of Computing, Georgia Institute of Technology, USA

- Describes the implementation of two integrated mission specification and task allocation architectures
- Mission specification occurs via case-based reasoning planner
- Task allocation occurs through contract net protocol based negotiation
- Examines tradeoffs that occur when combining these tools into an integrated architecture



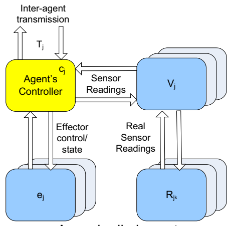
Pre-mission task allocation and mission specification architecture

15:46–16:04 FrD7.2

Job-agents: How to coordinate them?

Niak Wu Koh and Marcelo H. Ang, Jr.
National University of Singapore
Cezary Zieliński
Warsaw University of Technology, Poland
Ser Yong Lim
Singapore Institute of Manufacturing Technology

- Generic robot programming framework
- Transition-function based formalism for robot controllers
- Job-agent coordination
- Matrix-based supervisory controller



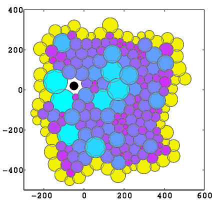
An embodied agent

16:04–16:22 FrD7.3

Heterogeneous Sensor Network Deployment using Circle Packings

Miu-Ling Lam and Yun-Hui Liu
Dept. of Mechanical and Automation Engineering
The Chinese University of Hong Kong, Hong Kong, China

- Sensor ranges of nodes modeled as circles of different radii
- Circle packing and overlap packing techniques employed to obtain node positions and sensing ranges
- Wide coverage area and obstacle avoidance
- Efficient and scalable



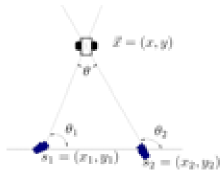
Sensor network deployment using overlap circle packing

16:22–16:40 FrD7.4

Sensor Placement Algorithms for Triangulation Based Localization

Onur Tekdas and Volkan Isler
Computer Science Dept., Rensselaer Polytechnic Institute, USA

- Robots can localize themselves in a workspace by querying nodes of a sensor-network.
- This paper addresses the problem of placing a minimum number of sensors so that the localization uncertainty at every location in a workspace is less than a given threshold.
- We present a general solution framework and an approximation algorithm for a geometric instance.



Actuators

Chair *Jun Ueda, Nara Inst. of science and Tech.*
Co-Chair *Vincent Hayward, McGill Univ.*

15:28–15:46 FrD8.1

Accurate Force Control and Motion Disturbance Rejection for Shape Memory Alloy Actuators

Yee Harn Teh and Roy Featherstone
Dept. of Information Engineering, RSISE, The Australian National University, Canberra, ACT 0200 Australia

- Small-signal frequency response analysis on SMA wires with force response of up to 100Hz
- Model extracted from frequency response data useful for simulation and control design
- Step response – excellent setpoint accuracy, force error of 0.001N, no limit cycles
- Sine response – tracks 2Hz force command, force error of 0.003N
- Good rejection of large motion disturbances – force error of 0.005N.

15:46–16:04 FrD8.2

Loosely Coupled Joint Driven by SMA Coil Actuators

Mizuho Shibata, Takahiro Yoshimura, and Shinichi Hirai
Dept. of Robotics, Ritsumeikan University, Japan

- Robotic joint that has a soft object and actuators instead of the cartilage and muscles
- The cartilage causes the rotational center o the link to shift, allowing the smooth motion
- The motion of the joint is highly robust against disturbances because it is highly compliant

Loosely coupled joint driven by SMA Coils

16:04–16:22 FrD8.3

Development of a Spherical Ultrasonic Motor with an Attitude Sensing System using Optical Fibers

Tomoaki Mashimo, Kosuke Awaga, and Shigeki Toyama
Dept. of Mechanical System Engineering,
Tokyo University of Agriculture and Technology, Japan

- A vew Spherical Ultrasonic Motor (SUSM) was developed.
- The Attitude sensing system using optical fibers for the SUSM.
- Position errors of the sensing system are less than 0.5 deg (equals to 0.087 mm).

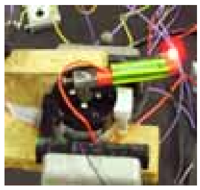
Spherical Ultrasonic Motor

16:22–16:40 FrD8.4

High Speed Visual Servoing with Ultrasonic Motors

Andrea Ranftl, and Jos Vander Sloten
Dept. Mech. Eng., Katholieke Universiteit Leuven, Belgium
Loïc Cuvillon, and Jacques Gangloff
LSIIT, Universite I Strasbourg, France

- Goal: maximize bandwidth of visual loop for high speed visual servoing systems
- Proposition of a new dynamical model for vision sensor: **averaging filter**
- Identification with rotational ultrasonic motor and high speed camera
- Validation with ultrasonic motors and high speed camera using deadbeat and RST controllers



Rotational US motor used for identification and validation experiments

Novel Robot Control Techniques

Chair *Kostas Kyriakopoulos, National Tech. Univ. of Athens*
Co-Chair *Harry Asada, MIT*

15:28–15:46 FrD9.1

Revising the robust control design for rigid robot manipulators

Luca Bascetta and Paolo Rocco
Dip. Elettronica e Informazione, Politecnico di Milano, Italy

- Robust controllers ensure stability of the position control loop even if only partial knowledge of the dynamic model of the robot is available
- Existing robust control laws present an undesired interaction between the gains of the controller of the nominal system and the robust control term
- Introducing a structured representation of model uncertainty, a different robust control law that overcomes these limitations can be introduced
- A case study is discussed to show the benefits of the proposed control approach

15:46–16:04 FrD9.2

A Global Asymptotic Stable Output Feedback PID Regulator for Robot Manipulators

Yuxin Su
School of Electro-Mechanical Engineering, Xidian University, Xi'an, China
Peter C. Müller
School of Safety Control Engineering, University of Wuppertal, Germany
Chunhong Zheng
School of Electronic Engineering, Xidian University, Xi'an, China

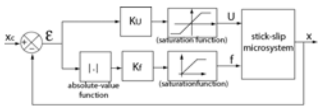
- A simple output PID controller is developed for global asymptotic positioning of uncertain robot manipulators.

16:04–16:22 FrD9.3

High-Stroke Motion Modelling and Voltage/Frequency Proportional Control of a Stick-Slip Microsystem

Micky Rakotondrabe, Yassine Haddab and Philippe Lutz
Laboratoire d'Automatique de Besançon (LAB) - CNRS
ENSMM – Université de Franche-Comté
Besançon - FRANCE

- High stroke motion of stick-slip microsystems
- Modelling and closed-loop control
- Voltage/Frequency proportional control
- Increasing the resolution



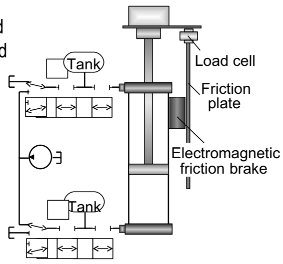
Principle scheme of the U/f proportional control

16:22–16:40 FrD9.4

Application of Passive Dynamic Control to Pneumatic Cylinders

Y. Minamiyama, T. Kiyota and T. Sasaki
The University of Kitakyushu
N. Sugimoto Nagaoka University of Technology

- New mechanical system control method "Passive Dynamic Control (PDC)" based on inherently safe design has been proposed.
- Method of applying the PDC to the positioning of the pneumatic cylinder is described.
- The continuous positioning with high safety, good energy saving and high rigidity can be realized.



Redundant Robots

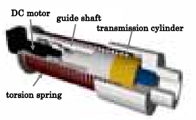
Chair *Carlos Luck, Univ. of Southern Maine*
Co-Chair *Giuseppe Oriolo, Univ. di Roma "La Sapienza"*

15:28–15:46 FrD10.1

Posture control of redundant manipulators based on the task oriented stiffness regulation

Koichi Koganezawa
Dep. of Mechanical Engineering, Tokai University, Japan

- A new theory for determining the posture of redundant manipulators is presented.
- All joints are assumed to be stiffness adjustabl by the antagonistic joint actuation.
- Actuator with non-linear elastic system(ANLES was developed.
- The simulations reveals that manipulators take a desired posture for doing a specified task by the proposed theory.



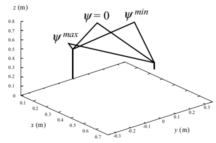
Actuator with non-linear elastic system (ANLES)

15:46–16:04 FrD10.2

A Practical Redundancy Resolution for 7 DOF Redundant Manipulators with Joint Limits

Masayuki Shimizu, Woo-Keun Yoon, and Kosei Kitagaki
Intelligent Systems Research Institute
National Institute of Advanced Industrial Science and Technology (AIST)
JAPAN

- Redundancy resolution in global configuration space for S-R-S manipulators with joint limits is presented.
- Inverse kinematics is analytically solved.
- How to identify feasible inverse kinematic solutions under joint limits is discussed.
- Analytical redundancy resolution method for avoiding joint limits is developed.



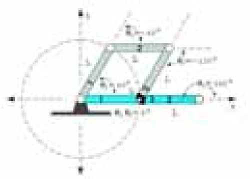
Feasible region of self-motion under joint limits

16:04–16:22 FrD10.3

Identifying the Failure-Tolerant Workspace Boundaries of a Kinematically Redundant Manipulator

Rodney G. Roberts
Florida A&M-Florida State University, USA
Rodrigo S. Jamisola, Jr. and Anthony A. Maciejewski
Colorado State University, USA

- A redundant manipulator can be rendered useless by a joint failure if the manipulator is poorly designed or controlled.
- Design of fault-tolerant workspaces by imposing a set of artificial joint limits prior to a failure.
- Novel conditions for identifying the boundaries of the failure-tolerant workspace.
- Optimized failure-tolerant workspaces for a planar robot are presented.

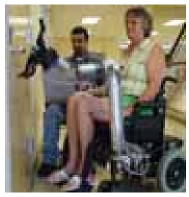

A fault-tolerant configuration and a fault-intolerant configuration

16:22–16:40 FrD10.4

Combined Mobility and Manipulation Control of a Newly Developed 9-DoF Wheelchair-Mounted Robotic Arm System

Redwan Alqasemi and Rajiv Dubey
Department of Mechanical Engineering, University of South Florida, USA

- A Wheelchair-Mounted Robotic Arm (WMRA) was designed and built on a power wheelchair.
- Wheelchair controller is modified to be controlled using the arm controller.
- Controller software combines wheelchair mobility and arm manipulation to control the 9-DoF system using several optimization methods.
- Different user interfaces are used for teleoperation and autonomous motion with preset Activities of Daily Living (ADL) tasks.


New 9-DoF WMRA System with Space-Ball User Interface

Oscillation/Vibration Control

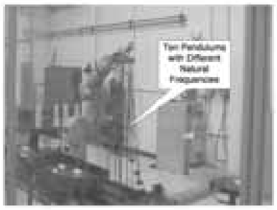
Chair *Mike Tao Zhang, Intel Corp.*
Co-Chair *Gianantonio Magnani, Pol. di Milano*

15:28–15:46	FrD11.1

Wideband Suppression of Motion-Induced Vibration

David Bowling, Gregory Starr, John Wood, Ron Lumia
Dept. of Mechanical Engineering, University of New Mexico, USA

- Rate-limited Boxcar-Aliased IFIR trajectories.
- Arbitrary number of continuous derivatives.
- Vibration suppression over very wide band of frequencies.
- Several examples of use.



Experimental setup to illustrate non-excitation of multiple frequencies

15:46–16:04	FrD11.2

Curvilinear Transport of Suspended Payloads

Christine Williams, Gregory Starr, John Wood, Ron Lumia
Dept. of Mechanical Engineering, University of New Mexico, USA

- Transport of freely suspended objects over curvilinear paths.
- Dynamic Programming used to develop parametric optimal trajectory path for robots.
- Actual experimentation, along with simulations in MATLAB and MSC.ADAMS, show virtually non-existent residual oscillations.

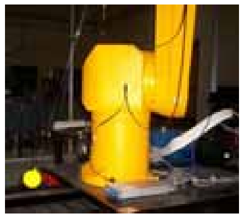


Photo of suspended payload in motion

16:04–16:22	FrD11.3

A Control Lyapunov Approach for Feedback Control of Cable-Suspended Robots

So-Ryeok Oh and Sunil K. Agrawal
Mechanical Engineering Dept, University of Delaware, USA

- CLF based positive controller for a broad class of cable robots with a multi-input is presented
- Proposal for a CLF candidate for a cable robot
- Secondary controller is implemented to address the limitation of CLF controller
- Asymptotic stability and positivity of multiple inputs are guaranteed for cable robots.

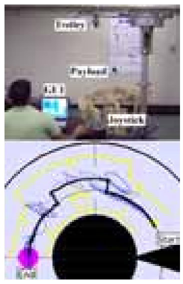
A cable-suspended robot designed and built at University of Delaware

16:22–16:40	FrD11.4

Manipulation with Tower Cranes Exhibiting Double-Pendulum Oscillations

William Singhose, and Dooroo Kim
Woodruff School of Mechanical Engineering,
Georgia Institute of Technology, USA
Singhose@gatech.edu

- Double-pendulum tower crane dynamics
- Command shaping reduces oscillations, improves throughput, and reduces collisions
- Human-operator performance testing
- Tele-operation with uncertain time delay



Remote Operation of Tower Crane

Marine Robotics: Sensing and Control

Chair *Gianluca Antonelli, Univ. degli Studi di Cassino*
Co-Chair *Andrea Caiti, Univ. of Pisa*

15:28–15:46 FrD12.1

Experiments with Underwater Robot Localization and Tracking

Peter Corke, Matthew Dunbabin
CSIRO ICT Centre, Australia
Carrick Detweiler, Daniela Rus, Iuliu Vasilescu
Massachusetts Institute of Technology, USA
Michael Hamilton
James San Jacinto Mountains Reserve, USA

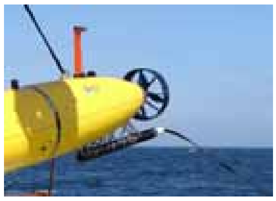
- Novel self-localizing underwater acoustic sensor network system
- Can localize one or more underwater robots
- Experimental comparison of acoustic localization with GPS for surface transects
- Comparison with visual odometry for sea-floor transects

15:46–16:04 FrD12.2

Autonomous Control of an Autonomous Underwater Vehicle Towing a Vector Sensor Array

Michael Benjamin
NAVSEA - Newport RI, MIT Dept. of Mechanical Engineering
David Battle, Don Eickstedt, Henrik Schmidt, Arjuna Balasuriya
MIT Department of Mechanical Engineering

- Autonomous Control Architecture for an AUV with special modules for towing a 100-meter vector sensor array.
- Behavior-based architecture with multi-objective optimization for behavior conflict resolution.
- Results reported from Field Exercises in Monterey Bay California in August 2006.



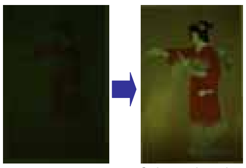
The MIT vehicle with the towed vector sensor array

16:04–16:22 FrD12.3

Color Registration of Underwater Images for Underwater Sensing with Consideration of Light Attenuation

Atsushi Yamashita[1),2)], Megumi Fujii[1)], and Toru Kaneko[1)]
[1)] Dept. of Mechanical Engineering, Shizuoka University, Japan
[2)] Dept. of Mechanical Engineering, California Institute of Technology, USA

- Colors of objects observed in underwater environments are different from those in air because of light attenuation
- We propose a color registration method of underwater images with consideration of light attenuation
- Colors can be estimated not only when the imaging geometry is known, but also when it is even unknown by using more than two underwater images.



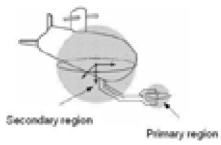
Original underwater image — Color registration result

16:22–16:40 FrD12.4

A Region Reaching Control Scheme for Underwater Vehicle-Manipulator Systems

Y.C. Sun and C.C. Cheah
School of Electrical and Electronic Engineering,
Nanyang Technological University, Singapore

- A region reaching control scheme is proposed for Underwater Vehicle-Manipulator Systems
- The desired objective can be specified as a region instead of a point
- Lyapunov-like function is proposed for the stability analysis
- Simulation studies are presented to demonstrate the effectiveness of the proposed controller



Localization: Motion Estimation and RFID

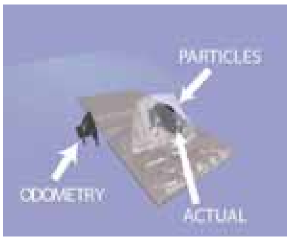
Chair *Marilena Vendittelli, Univ. di Roma "La Sapienza"*
Co-Chair *Tetsuro Yabuta, Yokohama National Univ.*

17:00–17:18	FrE1.1

Proprioceptive localization for a quadrupedal robot on known terrain

Sachin Chitta, Paul Vernaza, Roman Geykhman, Daniel D. Lee
GRASP Lab, University of Pennsylvania, USA

- Global localization achieved for a legged robot on known terrain via proprioceptive data
- No exteroceptive sensors necessary
- Efficient particle-filter based implementation
- Experiments show marked improvement over dead-reckoning



17:18–17:36	FrE1.2

Automated Robot Docking Using Direction Sensing RFID

Myungsik Kim, Hyung Wook Kim, and Nak Young Chong
School of Information Science, JAIST, Japan

- Development of DOA guided self-navigation and docking robot system.
- A reliable, self-contained RFID module for radio direction finding.
- DOA is estimated using the signal strength ratio received by a dual directional antenna.
- Enabled the robot to navigate through a cluttered and changing environment.

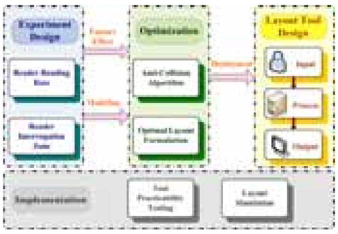
Developed RFID-enabled self-navigation and docking mobile robot system

17:36–17:54	FrE1.3

Robust Design for RFID System Testing and Applications

Han-Pang Huang and Ying-Ting Chang
Department Mechanical Engineering
Graduate Institute of Industrial Engineering
National Taiwan University, Taiwan

- RFID Interrogation Zone Measurement
- Experiments for RFID Reading Rate
- RFID Interrogation Range Experiment
- Optimal Layout and Deployment Planning Tool

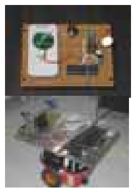


17:54–18:12	FrE1.4

Laser-activated RFID-based Indoor Localization System for Mobile Robots

Yu Zhou, Wenfei Liu, and Peisen Huang
Mechanical Engineering Department
State University of New York at Stony Brook, USA

- A novel idea of indoor mobile robot localization is proposed based on RFID technology.
- A novel type of RFID tag is designed to be activated individually when hit by a laser beam.
- The laser-activated RFID tag is used as a landmark with a known position.
- The system functions like an indoor GPS.

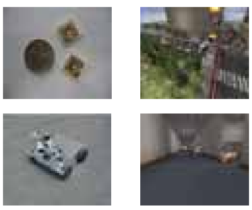


18:12–18:30	FrE1.5

RFId-Based Exploration for Large Robot Teams

V. A. Ziparo, A. Kleiner, and B. Nebel
Dept. of Computer Science, University of Freiburg, Germany
D. Nardi
DIS, Universita' di Roma "Sapienza", Italy

- Efficient local exploration and path-planning with indirect communication via RFID Technology.
- Efficient global task assignment and path planning in time-space on RFID graphs
- Local exploration won the first place in the Virtual Rescue Robots competition at Robocup 2006



Probabilistic Approaches to Visual Tracking

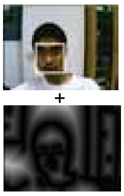
Chair *Gianmarco Veruggio, Scuola di Robotica*
Co-Chair *Urbano Nunes, Univ. of Coimbra*

17:00–17:18 FrE2.1

A Robust Multiple Cues Fusion based Bayesian Tracker

Xiaoqin Zhang, Zhiyong Liu, and Hong Qiao
Institute of Automation, Chinese Academy of Sciences, China

- A robust multiple cues fusion based Bayesian tracker is present.
- A selective updating technique is employed to accommodate for appearance and illumination changes.
- Mean shift algorithm is embedded into the Bayesian framework to give a heuristic prediction process.



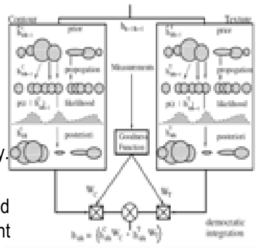
MOG based appearance model + Chamfer matching based shape model

17:18–17:36 FrE2.2

Combining Texture and Edge Planar Trackers based on a local Quality Metric

A.H. Abdul Hafez
Computer Science & Engg. Dept., Osmania University, Hyderabad, India
Visesh Chari and C.V. Jawahar
CVIT, International Institute of Information Technology, Hyderabad, India

- A new probabilistic tracking framework for integrating visual cues is presented here.
- The framework allows selection of "good" features for each cue, along with factors of their important "goodness" factors.
- Two particle filter trackers run independently. Using either texture or edge cues.
- The output of the master tracker is computed by democratic integration using the important factors.

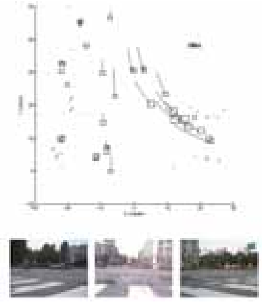


17:36–17:54 FrE2.3

Interacting Object Tracking in Crowded Urban Areas

Chieh-Chih Wang, Tzu-Chien Lo, and Shao-Wen Yang
Department of Computer Science and Information Engineering
National Taiwan University, Taipei, Taiwan

- High crowdedness causes challenging data association problems in tracking.
- A scene interaction model and a neighboring object interaction model are proposed.
- Long-term and short-term interactions are taken into account.
- Anomalous activity recognition is accomplished.

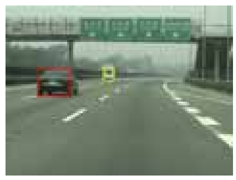


17:54–18:12 FrE2.4

Symmetry-Aided Particle Filter for Vehicle Tracking

Huaping Liu, Fuchun Sun, and Kezhong He
Department of Computer Science and Technology, Tsinghua University, China
State Key Laboratory of Intelligent Technology and Systems, China

- Introduction and related works
- Brief review of particle filters
- Observation model
  - Color histogram
  - **Symmetry**
- Experimental results



18:12–18:30 FrE2.5

Multiple Objects Tracking Circuit using Particle Filters with Multiple Features

Jung Uk Cho, Seung Hun Jin, Xuan Dai Pham, and Jae Wook Jeon
School of Information and Communication Engineering,
Sungkyunkwan University, Korea

- Real-time multiple objects tracking circuit using particle filters with multiple features
- Designed using VHDL and implemented in an FPGA
- Acquire images from camera and display tracking images and output trajectory data
- Apply to a wide range of applications such as intelligent robot, surveillance, and HCI

Multiple Objects Tracking System and Result

Stability and Control of Dynamic Walking and Running

Chair *Katja Mombaur, Univ. of Heidelberg*
Co-Chair *Stefano Stramigioli, Univ. of Twente*

17:00–17:18 FrE3.1

Heterogeneous Leg Stiffness and Roll in Dynamic Running

Sam Burden
Electrical and Engineering, Univ. of Washington, Seattle, USA
Jon Clark, Joel Weingarten, Haldun Komsuoglu, Dan Koditschek
Electrical and Systems Engineering, Univ. of Pennsylvania, Philadelphia, USA

- Introduce *bounding-in-place* ("BIP") template model for straight-ahead level-ground running.
- Present numerical results that suggest asymmetric leg compliance ratios decrease time to recover from disturbances to roll motion.
- Present preliminary experimental data which weakly corroborates numerical results.

EduBot, a RHex-like hexapedal running robot.

17:18–17:36 FrE3.2

Derivation and Application of a Conserved Orbital Energy for the Inverted Pendulum Bipedal Walking Model

Jerry E. Pratt and Sergey V. Drakunov
Institute for Human and Machine Cognition
www.ihmc.us

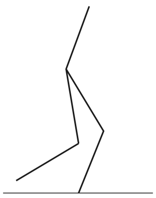
- Derived a simple expression for a conserved Orbital Energy for the Point-Mass Inverted Pendulum Bipedal Walking Model.
- Applied this Orbital Energy equation to velocity control by determining where to step to achieve a next step Orbital Energy.
- Validated the theoretical results in simulation.

17:36–17:54 FrE3.3

A Framework for the Control of Stable Aperiodic Walking in Underactuated Planar Bipeds

T. Yang, E. R. Westervelt
Dept. of Mechanical Engineering, The Ohio State University, USA
A. Serrani
Dept. of Electrical & Computer Engineering, The Ohio State University, USA

- A new definition of stable biped walking, which is not necessarily periodic, is given
- A hierarchical walking controller is given that is able to induce aperiodic walking
- Controllers for individual gaits of walking controller may be unstable themselves
- Switching among individual controllers ensures walking stability



A 5-link planar biped used to demonstrate the approach

17:54–18:12 FrE3.4

Reaction Mass Pendulum (RMP): An explicit model for centroidal angular momentum of humanoid robots

Sung-Hee Lee
Computer Science Dept., University of California at Los Angeles, CA,USA
Ambarish Goswami
Honda Research Institute, Mountain View, CA, USA

- Conceptually simple "inverted pendulum" models are useful for study of humanoid balance. Traditional models do not contain rotational inertia.
- We introduce Reaction Mass Pendulum model which explicitly models centroidal rotational inertia by means of the aggregate composite rigid body (CRB) inertia projected at the mass center.
- Robot motion is instantaneously mapped to RMP
- We present RMP-based simple controller

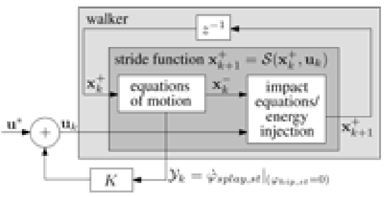
RMP representation of a humanoid

18:12–18:30 FrE3.5

Using time-reversal symmetry for stabilizing a simple 3D walker model

Gijs van Oort and Stefano Stramigioli
Dept. of Electrical Engineering, University of Twente, The Netherlands

- Lateral foot placement controller with one parameter
- Based on the fact that the gait of the walker is symmetric in time
- No explicit knowledge needed about the limit cycle in order to stabilize the walker
- Very robust; can stabilize a large range of gaits



Grasp Planning

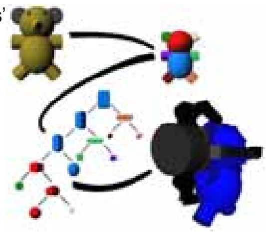
Chair *Vijay Kumar, Department of Mechanical Engineering, Univ. ofPennsylvania*
Co-Chair *Christoph Borst, German Aerospace Center (DLR)*

17:00–17:18	FrE4.1

Grasp Planning via Decomposition Trees

Corey Goldfeder, Peter K. Allen, Raphael Pelossof and Claire Lackner
Computer Science Dept., Columbia University, USA

- Grasp planning using a 'grasping by parts' approach
- Automatically decompose 3D objects into superquadric trees
- Decomposition defines a grasp subspace likely to contain many good grasps
- Explore this subspace in simulation and output stable, realizable grasps

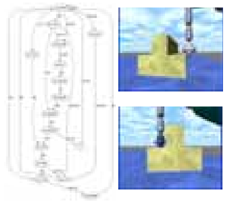


17:18–17:36	FrE4.2

Grasping POMDPs

Kaijen Hsiao, Leslie Pack Kaelbling, Tomás Lozano-Pérez
CSAIL, MIT, USA

- Develops a framework for sensor-based motion planning under uncertainty using probabilistic models of action and sensing.
- Produces **policies** that select guarded compliant motions based on the information (belief) state.
- Applicable to grasping and other contact-based manipulation tasks.



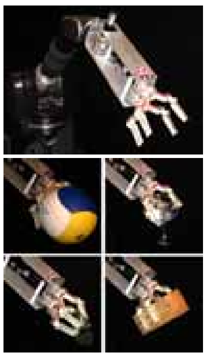
Closed-loop motion policy derived by solving POMDP

17:36–17:54	FrE4.3

Simple, Robust Autonomous Grasping in Unstructured Environments

Aaron M. Dollar and Robert D. Howe
Harvard University

- Hand: four fingers, eight joints, *one actuator*
  - •Shape Deposition Manufacturing (SDM)
- Three degree of freedom manipulator
  - •No wrist for hand orientation control
- Can grasp a wide range of objects
  - •Large allowable positioning errors
  - •Operates well in feed forward control



17:54–18:12	FrE4.4

Positive Span of Force and Torque Components of Four-Fingered Three-Dimensional Force-Closure Grasps

Nattee Niparnan, Attawith Sudsang
Dept. of Computer Engineering, Chulalonkorn University, THAILAND

- Propose a heuristic test of four-fingered three-dimensional force closure grasp
- The test considers quadratic force cone without linearization, utilizing projection of wrenches on 3D force subspace and 3D torque subspace
- The test is very fast to compute but the result might be fault positive (no false negative)
- The time to solve the problem is approximately reduced to 50%

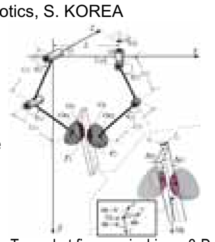
Example of Test Data

18:12–18:30	FrE4.5

Blind Grasp and Manipulation of a Rigid Object by a Pair of Robot Fingers with Soft Tips

Morio Yoshida[1], Suguru Arimoto[12], and Ji-Hun Bae [3]
[1]BMC Research Center, RIKEN, JAPAN
[2]Dept. of Robotics, Ritsumeikan Univ.,JAPAN
[3]Pohang Institute of Intelligent Robotics, S. KOREA

- Mathematical model of dynamics of pinching object by two robot fingers ***with soft tips*** is derived
- Simple control signal rendering ***Stable Blind Grasping*** is found, which is the same as in the case of rigid tips and does neither use the knowledge of object kinematics nor external sensing
- The closed – loop fingers/object system converges to the steady state ***with force/torque balance***



Two robot fingers pinching a 3-D thin object under the gravity effect

18:30–18:48	FrE4.6

Learning and Evaluation of the Approach Vector for Automatic Grasp Generation and Planning

Staffan Ekvall, Danica Kragic
Centre for Autonomous Robots / Computer Vision and Active Perception, Royal Inst. of Technology, Sweden

- Approach direction is chosen based on grasp experience. Initial hand configuration is chosen either automatically or based on recognized grasp type from human demonstration.
- Extensive evaluation of grasp controller performance under imperfect pose estimation.
- Comparison of grasp performance between different robot hands and grasp types.

Range Sensing and Monitoring 3D Scenes

Chair *Ryusuke Sagawa, Osaka Univ.*
Co-Chair *Roger D. Eastman, Loyola Coll. in Maryland*

17:00–17:18 FrE5.1

Accurate Motion Estimation and High-Precision 3D Reconstruction by Sensor Fusion

Yunsu Bok, Youngbae Hwang, and In So Kweon
School of Electical Engineering and Computer Science
Korea Advanced Institute of Science and Technology, Korea

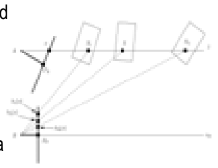
- We present a new sensor system, the fusion of camera and LRF.
- The motion estimation and 3D reconstruction can be performed simultaneously using the sensor system.
- We present a new method of motion estimation for the system.
- The performance of the system of verified by both synthetic and real data.

17:18–17:36 FrE5.2

Depth from the visual motion of a planar target induced by zooming

Guillem Alenyà, Maria Alberich and Carme Torras
Institut de Robòtica i Informàtica Industrial, Catalonia

- New simpler depth estimation procedure based on two image pairs taken at known zoom positions
- No knowledge on the camera parameters is assumed
- Affine scale is computed from deformation of a planar target
- Useful to find the unknown scale factor within a monocular egomotion recovery algorithm



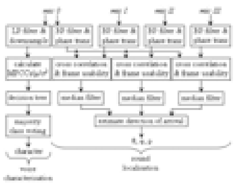
A static zooming camera views the same scene with zoom A and B

17:36–17:54 FrE5.3

Real time robot audition incorporating both 3D source localisation and voice characterisation

Ben Rudzyn, Waleed Kadous, Claude Sammut
ARC Centre of Excellence for Autonomous Systems,
University of New South Wales, Australia

- Can localise sound sources up to 3m away in 3 dimensions (azimuth, elevation and distance)
- Better than 90 per cent accuracy for azimuth and elevation over a large volume
- Can also identify whether it is silence, speech or non-speech with > 98 per cent accuracy
- Works in real time (73 per cent CPU usage), partially by using decision trees

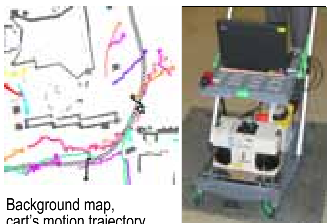


17:54–18:12 FrE5.4

Monitoring a populated environment using single-row laser range scanners from a mobile platform

Huijing Zhao, Yuzhong Chen, Xiaowei Shao, Kyoichiro Katabira, Ryosuke Shibasaki
Center for Spatial Information Science, University of Tokyo, JAPAN

- Without any *a prior* knowledge to environment, using horizontal laser range scanning from a moving cart,
- A background map containing motionless objects and motion trajectory of the moving objects' are extracted.
- Application at an exhibition hall is shown.



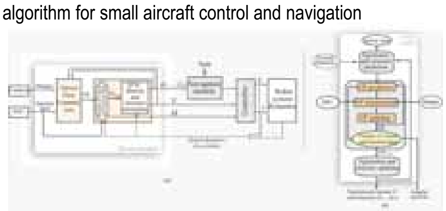
Background map, cart's motion trajectory, pedestrians are measured by horizontal laser range scanning from a moving cart at an exhibition hall.

18:12–18:30 FrE5.5

Three Nested Kalman Filters-Based Algorithm for Real-Time Estimation of Optical Flow, UAV Motion and Obstacles Detection

Farid Kendoul, Isabelle Fantoni, and Gérald Dherbomez
University of Technology of Compiègne, 60200 Compiègne, France

- Real-time computation and interpretation of optical flow
- Fusion of visual and inertial data
- Vision algorithm for small aircraft control and navigation



Advancements in Industrial Automation and Robotics: Ubiquitous Industrial Robotics and Automation Sys

Chair *Ole Madsen, Aalborg Univ.*
Co-Chair *Kleanthis Thramboulidis, Univ. of Patras*

17:00–17:18	FrE6.1

On the robot based surface finishing of moving unknown parts by means of a new slip and force control concept

G. Milighetti, S. Bürger, H.-B. Kuntze
Fraunhofer Institute IITB, Karlsruhe, Germany

- Investigation of the properties of a novel optical slip sensor able to measure relative motions between robot tool and surfaces
- Feedback of the sensor measurements during a surface finishing task while the object to finish is moving
- Automatic calibration of the sensor for a priori unknown surfaces

17:18–17:36	FrE6.2

Optical Seam Following for Automated Robot Sewing

G. Biegelbauer, M. Richtsfeld, W. Wohlkinger, M. Vincze
Automation and Control Institute, Vienna University of Technology, Austria
M. Herkt
EADS Deutschland GmbH, CRC, Dept. LG-CT, Germany

- Automated application → Sensor guided robot for sewing carbon fibre mats.
- Laser-stripe sensor → Detection of a dominating jump-edge in a noisy scan line.
- Approach → Using three complimentary individual edge detection methods.
- Result → Fast and robust edge tracking using two-out-of-three voting.

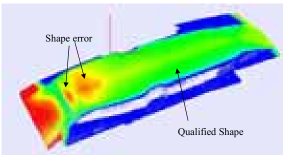
Industrial sewing robot with blindstitching head.

17:36–17:54	FrE6.3

Recursive Measurement Process for Improving Accuracy of Dimensional Inspection of Automotive Body Parts

Quan Shi, and Ning Xi
Electrical and Computer Engineering Dept., Michigan State University, USA
Weihua Sheng
Electrical and Computer Engineering Dept., Oklahoma State University, USA

- Image quality, include image noise, quantization error, and low image contrast etc., are related to the accuracy of 3D shape measurement
- Feedback based robotic range sensor view planning system design



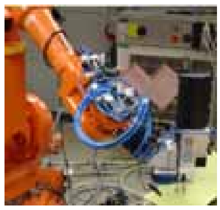
A color-coded error map of an automotive part, pillar-m32510

17:54–18:12	FrE6.4

Flexible Force Control for Accurate Low-Cost Robot Drilling

Tomas Olsson, Anders Robertsson, and Rolf Johansson
Department of Automatic Control, Lund University, Sweden

- Accurate drilling using industrial robots difficult because of mechanical compliance.
- Increased stiffness achieved by accurate application of a tool-mounted pressure foot onto the surface during drilling.
- Fast control of tangential forces necessary to remain in the stiction regime and avoid sliding.
- Experiments show a reduction of undesired motion during drilling with a factor of 10.



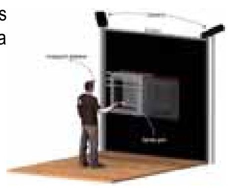
Force-controlled drilling using an ABB Irb 2400 industrial robot

18:12–18:30	FrE6.5

Virtual 3D Environment for Planning Robotic Paint Routes

Kåre Storgaard Nissum, Troels Hessner Larsen
Ole Madsen, Henning Nielsen
Aalborg University, Denmark

- User assisted teaching of robotic paint routes which utilizes paint pistol and 3D glasses in a virtual environment
- Tracking of pistol and user through infrared vision technology
- Visualization of CAD-model through stereo graphic projection
- Real time paint coverage simulation

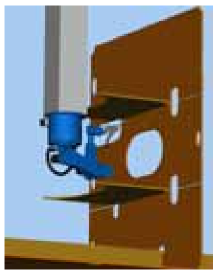


18:30–18:48	FrE6.6

Motion planning for gantry mounted manipulators: A ship-welding application example

Anders Lau Olsen and Henrik Gordon Petersen
The Maersk Mc-Kinney Moller Institute, University of Southern Denmark

- Ship welding at Odense Steel Shipyard
- Roadmap based motion planning for line welding tasks
- Motion planning subject to gantry movement constraints



SLAM and Stereo-Based Applications

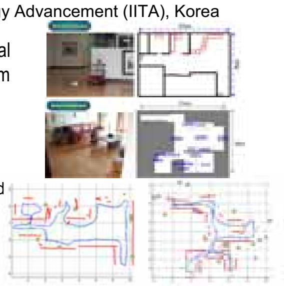
Chair *Kazuhito Yokoi, National Inst. of Advanced Industrial Science andTechnology*
Co-Chair *Agostino Martinelli, ETHZ*

17:00–17:18	FrE7.1

SLAM with Visual Plane: Extracting Vertical Plane by Fusing Stereo Vision and Ultrasonic sensor for Indoor Environment

Sunghwan Ahn, Kyongmin Lee, Wan Kyun Chung
Pohang University of Science and Technology (POSTECH), Korea
Sang-Rok Oh
Institute for Information Technology Advancement (IITA), Korea

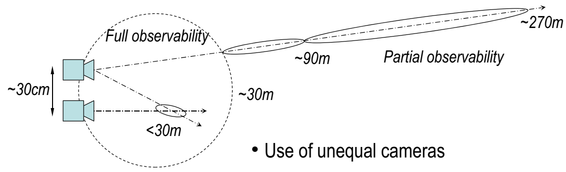
- Visual plane: grouping of co-planar visual features along sonar line features to form landmarks without the need to learn the grouping beforehand
- Multi-sensor SLAM to fuse
  - Stable metric data of sonar line features and
  - Excellent discriminating ability for data association of salient visual features



17:18–17:36	FrE7.2

BiCamSLAM: Two times mono is more than stereo

Joan Solà, André Monin and Michel Devy
LAAS-CNRS, Toulouse, France



- Use of unequal cameras
- Fully undelayed initialization: total for close landmarks and partial for remote ones
- Great landmark updating flexibility
- Admits extrinsic self-calibration

17:36–17:54	FrE7.3

Particle-based Sensor Modeling fr 3D-Vision SLAM

Daniele Marzorati, Domenico G. Sorrenti
Università di Milano - Bicocca, Milano, Italy
Matteo Matteucci
Politecnico di Milano, Milano, Italy

- Problem: inaccurate modeling of uncertainties in the sensed data (approximation to normal) causes data association errors
- Solution:
  - •particle-based distribution modeling
  - •particle-based data association
- Result: increase the success rate of data association and thus overall SLAM improvement

World using 3D Segments

17:54–18:12	FrE7.4

Towards Mapping of Cities

Patrick Pfaff, Cyrill Stachniss, and Wolfram Burgard
Dept. of Computer Science, University of Freiburg, Germany
Rudolph Triebel, Pierre Lamon, and Roland Siegwart
ETH Zurich, IRIS, ASL, 8092 Zurich, Switzerland

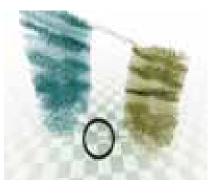
- Mapping using an autonomous car
- Accurate three-dimensional models of the environment
- Large-scale real-world data

18:12–18:30	FrE7.5

Efficient 6-DOF SLAM with Treemap as a Generic Backend

Udo Frese
SFB/TR 8 Spatial Cognition
Universität Bremen

- Treemap algorithm can be used as an extremely efficient backend for various SLAM variants.
- How to design in interface that allows to implement drivers for new SLAM variants easily.
- To be released as an open-source library.



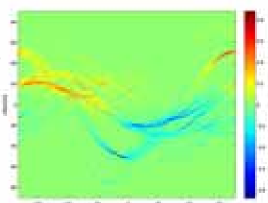
Closing a 6-DOF loop over 106657 features in 209 ms.

18:30–18:48	FrE7.6

Histogram Matching and Global Initialization for Laser-only SLAM in Large Unstructured Environments

Michael Bosse and Jonathan Roberts
Autonomous Systems Laboratory
CSIRO ICT Centre, Australia

- Scan-matching without prior alignment
- Entropy metrics and weighted histograms
- 6 km loop closing using only 1 laser scanner (without odometry)
- Can solve Lost Robot Problem
- Extension for Atlas Framework



Weighted Projection Histogram

Surveillance and Modelling

Chair *Kamal Gupta, Simon Fraser Univ.*
Co-Chair *Bradley Bishop, United States Naval Acad.*

17:00–17:18	FrE8.1

Moving Shadow Detection with Low- and Mid-Level Reasoning

A. Joshi, S. Atev, O. Masoud, and N. Papanikolopoulos
Dept. of Computer Science and Engineering
University of Minnesota, Twin Cities

- Shadow detection has significant applications in Transportation, Autonomous Navigation, Surveillance, etc.
- Coarse resolution of videos using regular cameras makes it a challenging problem
- A multi-level detection scheme is presented which compares favorably with the state of the art
- Promises to substantially improve the quality of other vision-related applications

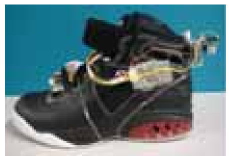

A frame with detected shadows

17:18–17:36	FrE8.2

Gait Modeling for Human Identification

Bufu Huang, Meng Chen, and Yangsheng Xu
Mechanical and Automation Dept., The Chinese Univ. of Hongkong, Hongkong
Panfeng Huang
Astronautics College, Northwestern Polytechnical University, China

- Build intelligent shoe to capture and analysis dynamic human gait
- Classify the wearer into legal and illegal
- Cascade Neural Networks with Node-Decoupled Extended Kalman Filtering (CNN-NDEKF) for gait modeling and classifier generation


Outlook of Intelligent Shoe

17:36–17:54	FrE8.3

Multi-hypothesized Oscillation Models Employing Floor Sensors for Tracking People

Takuya Murakita and Hiroshi Ishiguro
Dept. Adaptive Machine Systems, Osaka University, Japan

- Floor sensing system and an accompanying tracking model are presented.
- The tracking model is based on the particle filter.
- The model showed 98% tracking accuracy for straight walks.
- The model showed more robust data association than a nearest neighbor filter.

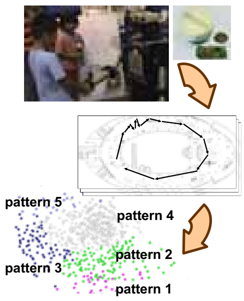

Fig. Floor sensing system

17:54–18:12	FrE8.4

Analysis of People Trajectories with Ubiquitous Sensors in a Science Museum

Takayuki Kanda, Masahiro Shiomi, Laurent Perrin,
Tatsuya Nomura, Hiroshi Ishiguro, and Norihiro Hagita
ATR, Japan

- In a science museum, visitors were invited to wear RFID tags to interact with robots and look around the exhibits.
- We obtained 5,102 visitors' trajectories using 20 RFID readers distributed.
- The trajectories enabled us to recognized typical visiting patterns, such as "visited at every place" and "directly going to robots".
- The trajectories also enabled us to identify atypical behavior and group membership.



18:12–18:30	FrE8.5

Swept Volume Approximations of Polygon Soups

Jesse Himmelstein, Etienne Ferré
Kineo CAM, France
Jean Paul Laumond
Gepetto, LAAS-CRNS, France

- Handles both flat surfaces and volumes of multiple disconnected objects
- GPU boosts performance
- Bounding distance operator controls sampling error


Swept volume of robotic arm movement

Bio-inspired Perception

Chair *Atsushi Konno, Tohoku Univ.*
Co-Chair *Tetsuya Ogata, Kyoto Univ.*

17:00–17:18	FrE9.1

Implementation of Bio-Inspired Vestibulo-Ocular Reflex in a Quadrupedal Robot

Ravi Kaushik, Marek Marcinkiewicz, Jizhong Xiao, Simon Parsons and Theodore Raphan
Dept. of Computer Science, The City University of New York, NY, USA

- Vestibulo-Ocular Reflex is a reflex eye movement that compensates head movements in space.
- Artificial eyes have 3 Degrees of Freedom each (Fick Gimbal system) and obey Listing's law
- Artificial Vestibular system is a 3D accelerometer embedded in the head.
- Euler-Rodrigues Equation for processing 3D matrix

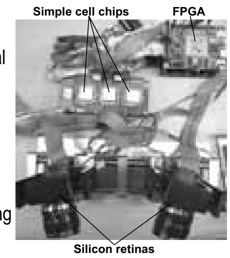
AIBO mounted with 3DOF artificial eyes, Accelerometer and Processing Unit

17:18–17:36	FrE9.2

Neuromorphic binocular vision system for real-time disparity estimation

Kazuhiro Shimonomura, Takayuki Kushima, and Tetsuya Yagi
Dept. of Electrical, Electronic and Information Engineering, Osaka University, Japan

- We present a binocular vision system that emulates disparity computation in the neuronal circuit of the primary visual cortex.
- The system consists of multiple analog VLSIs and field programmable gate array (FPGA) circuit, mimicking the hierarchical architecture of the visual system of the brain.
- Real-time disparity estimation is achieved using compact hardware.

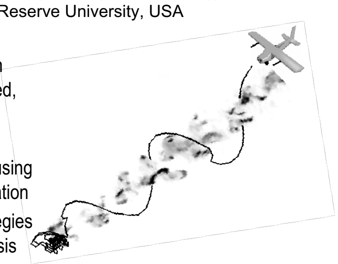


17:36–17:54	FrE9.3

A Sensor Fusion Approach to Odor Source Localization Inspired by the Pheromone Tracking Behavior of Moths

Adam J. Rutkowski[1], Roger D. Quinn[1], and Mark A. Willis[2]
[1]Mechanical and Aerospace Engineering Dept., [2]Biology Dept.
Case Western Reserve University, USA

- Wind-borne odor tracking with an aerial vehicle possessing airspeed, visual, and odor sensors
- Altitude, wind velocity, and groundspeed are estimated by fusing airspeed and optical flow information
- Two different odor tracking strategies are compared: chemo-klino-kinesis and chemo-ortho-klino-kinesis

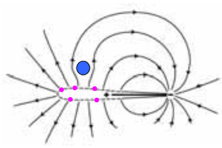


17:54–18:12	FrE9.4

Robotic Electrolocation: Active Underwater Target Localization with Electric Fields

James R. Solberg, Kevin M. Lynch, and Malcolm A. MacIver
Mechanical Engineering Dept., Northwestern University, USA

- Development of 2-D robot for electrolocation of underwater targets.
- Particle filter belief maintenance for fusing sensor information.
- Active controller used to minimize uncertainty of target location.
- Electrolocated test objects successfully in both marine and freshwater conditions.



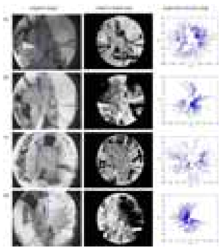
Blue circle is an electric insulator diverting electric field lines.

18:12–18:30	FrE9.5

Real Time Biologically-Inspired Depth Maps from Spherical Flow

Chris McCarthy, Nick Barnes
National ICT Australia, Australian National University, Canberra, Australia
Mandyam Srinivasan
Centre for Visual Sciences, Australian National University, Canberra, Australia

- 3D relative depth maps from de-rotated optical flow under spherical projection, in real-time.
- First known real-time implementation of Nelson and Aloimonos de-rotation algorithm over real images.
- Preliminary tests in simulation, and on two real-world image sequences.
- Results suggest depth maps usable for closed-loop control of a robot.



Space Robotics

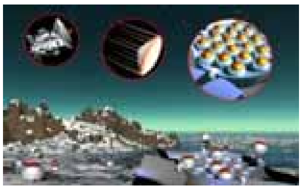
Chair *Ayanna Howard, Georgia Inst. of Tech.*
Co-Chair *Marcello Romano, US Naval Postgraduate School*

17:00–17:18	FrE10.1

Mobility and Power Feasibility of a Microbot Team System for Extraterrestrial Cave Exploration

Samuel B. Kesner , Jean-Sébastien Plante, Steven Dubowsky
Mechanical Engineering Dept., MIT, USA
Penelope J. Boston, Earth and Environ. Sci. Dept., New Mexico Tech, USA
Tibor Fabian, Mechanical Engineering Dept., Stanford, USA

- Introduction of the Microbot extraterrestrial space exploration concept and Mars reference mission
- Analysis of the Microbot mobility and power systems from an energy consumption perspective
- Performance results for a range of system mass values
- Feasibility demonstrated for a specified Microbot design



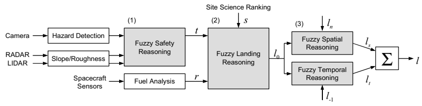
17:18–17:36	FrE10.2

Landing Site Selection using Fuzzy Rule-Based Reasoning

Navid Serrano and Homayoun Seraji
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109, USA

Fuzzy reasoning for landing site selection applied in three phases:

- Assess terrain safety from multiple on-board sensors during autonomous spacecraft descent
- Integrate terrain safety, fuel consumption, and scientific interest in order to obtain a local landing score
- Incorporate spatial and temporal dependence into final landing score

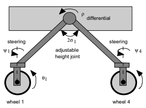


17:36–17:54	FrE10.3

A Systematic Approach to Kinematics Modeling of High Mobility Wheeled Rovers

Mahmoud Tarokh
Department of Computer Science, San Diego State University, U.S.A.
Gregory McDermott
BAE Systems, San Diego, U.S.A.

- A new methodology for kinematics modeling of any high mobility wheeled rover.
- Is general and can deal with both active (actuated) and passive joints and linkages.
- Very efficient computer implementation and needs only a D-H type table.
- Can generate the kinematics equations symbolically or compute various rover transformation matrices numerically.



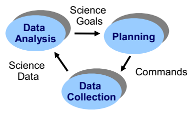
Schematics diagram of right side of the rover

17:54–18:12	FrE10.4

Increased Mars Rover Autonomy using AI Planning, Scheduling and Execution

Tara Estlin, Daniel Gaines, Caroline Chouinard, Rebecca Castano, Benjamin Bornstein, Michele Judd, Issa Nesnas and Robert C. Anderson
NASA Jet Propulsion Laboratory, USA

- As rover traverse distances are increasing, autonomous science capabilities can support the collection of new and valuable data
- Automated planning, scheduling and execution capabilities can be used for supporting opportunistic science, end-of-day science, dynamic plan optimization and fault handling
- OASIS system has been tested extensively on rover hardware using Mars mission scenarios

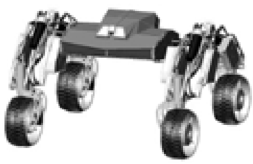


18:12–18:30	FrE10.5

The Mobility System of the Multi-Tasking Rover (MTR)

Antonios K. Bouloubasis and Gerard T. McKee
School of Systems Engineering, Reading University, UK

- The MTR is a novel approach to the surface exploration rover system design
- It employs a set of interchangeable Packs each containing different instruments or tools
- By using different Packs the rover can change its functionality to suit different exploration needs



The MTR carrying a Battery Pack

Calibration and Identification

Chair *Tsutomu Hasegawa, Kyushu Univ.*
Co-Chair *Greg Starr, Univ. of New Mexico*

17:00–17:18	FrE11.1

A New Pose Measuring and Kinematics Calibrating Method for Manipulators

Junhong Ji, Lining Sun and Lingtao Yu
Robotics Institute, Harbin Institute of Technology, P.R.China

- 'Three Planes Method' is proposed to measure the relative pose between coordinate frames
- Using CMM and this method, the requirements about manufacture and operator are obviously decreased
- While the planes are machined onto end-effector, extra assembly accuracy problem will be avoided
- The validity of the proposed method is demonstrated by experimental result

Calibration Experiment's Setup

17:18–17:36	FrE11.2

Granular Space Structure on a Micrometric Scale For Industrial Robots

Jean-François Brethé and Dimitri Lefebvre
GREAH, Le Havre University, France

- New modeling of repeatability phenomena based on stochastic ellipsoids for industrial manipulator robots
- Analysis of stochastic structure of angular space and introduction of granular space concept
- Consequences on the stochastic structure in the Cartesian space
- Influence of granularity ratio and redundancy

17:36–17:54	FrE11.3

Performing Weak Calibration at the Microscale, Application to Micromanipulation

Julien Bert, Sounkalo Dembélé, and Nadine Lefort-Piat
Laboratoire d'Automatique de Besançon
UMR CNRS 6596 – ENSMM – UFC
25000 Besançon, France

- Performing weak calibration of stereo video microscope.
- Improving Harris detector by using a simplex optimization method for feature points detection.
- Improving ZNSSD correlation for points matching by using a "cha" window based.
- Validating by constructing a 3D view of a micromanipulation work field.

Pattern made with a water drop covered with nickel fillings.

17:54–18:12	FrE11.4

Identification of the payload inertial parameters of industrial manipulators

Wisama Khalil, Maxime Gautier, and Philippe Lemoine
IRCCyN UMR CNRS 6597, Nantes, France

- Four methods for the identification of the payload inertial parameters
- Use of inverse dynamic model and weighted least squares solution (WLS)
- Use of industrial control system and its trajectory generator
- Experimental results on the Stäubli RX-90 robot

Stäubli RX-90 robot

18:12–18:30	FrE11.5

Modeling and Identification of a Three DOF Haptic Interface

Alexandre Janot, Catherine Bidard, Florian Gosselin
Delphine Keller, Yann Perrot
CEA-LIST, Interactive Robotic Unit, France
Maxime Gautier
IRCCyN, Robotic Team, France

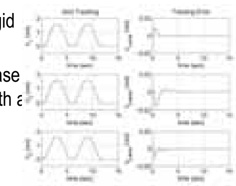
- Modeling and parametric identification dedicated to master arms
- Reducers and friction characterizations
- Evaluation of the performances

18:30–18:48	FrE11.6

On-line parameter identification and adaptive control of rigid robots using base reaction forces/torques

Eftychios G. Christoforou
Dept. of Electrical and Systems Engineering, Washington University, USA

- One source of inertial parameters info for rigid robots are the base reaction forces/torques.
- On-line parameter identification driven by base reaction forces prediction errors, coupled with a model-based feedback control scheme can improve trajectory tracking performance.
- A composite adaptive controller is also examined, which extracts parameter info from tracking errors (direct source) and base forces prediction errors (indirect source).



Simulation studies were based on a three-link rigid robot

Field Robots

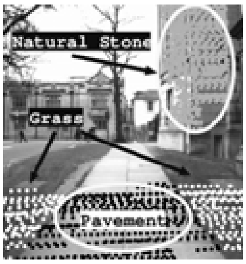
Chair *Satoru Sakai, Chiba Univ.*
Co-Chair *Karl Iagnemma, MIT*

17:00–17:18	FrE12.1

Describing Composite Urban Workspaces

Ingmar Posner, Derik Schroeter, and Paul Newman
Dept. Engineering Science, Oxford University, UK

- Our approach annotates 3D outdoor laser data with *semantic information.*
- *Visual and geometric features* are derived from camera and 3D laser data.
- A *supervised classification* approach is adopted.
- Results are reported on ca. 18 km of outdoor urban data.



17:18–17:36	FrE12.2

Identification of Suitable Interest Points Using Geometric and Photometric Cues in Motion Video for Efficient 3-D Environmental Modeling

T. Nicosevici, R. Garcia, M. Kudzinava and J. Ferrer
Computer Vision and Robotics Group, University Girona, Spain
S. Negahdaripour,
Electrical and Computer Engineering Dept., University of Miami, USA

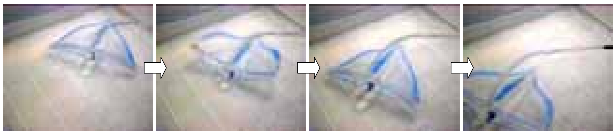
- Mapping and 3D modeling of large environments involve processing huge amounts of data
- We propose a framework that highly reduces the 3D model with minimum impact on its precision
- This is achieved by selecting features using photometric and geometric criteria

17:36–17:54	FrE12.3

A Bending Pneumatic Rubber Actuator Realizing Soft-bodied Manta Swimming Robot

Koichi Suzumori*, Satoshi Endo*, Takefumi Kanda*, Naomi Kato**, and Hiroyoshi Suzuki**
*Okayama University, Japan
** Osaka University, Japan

- A new bending pneumatic rubber actuator was developed.
- The robot was designed by non-linear FEM and fabricated of rubber through a CAD/CAM based rubber molding process.
- The swimming speed is 100 mm/s.



Developed Manta Robot swimming in water

17:54–18:12	FrE12.4

Free Space Mapping and Motion Planning in Configuration Space for Mobile Manipulators

James Ward and Jayantha Katupitiya
Mechanical and Manufacturing Engineering
University of New South Wales, Australia

- Technique for representing obstacles in configuration space
- Guaranteed free areas are calculated rather than direct obstacle representation
- Demonstrated for simple planar mechanism
- Fast and memory efficient

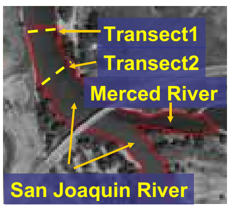
Prototype wall climbing robot

18:12–18:30	FrE12.5

Autonomous robotic sensing experiments at San Joaquin river

Amarjeet Singh, Maxim A. Batalin, Victor Chen, Michael Stealey, Brett Jordan, Jason C Fisher, Thomas C. Harmon, Mark H Hansen and William J Kaiser
Center for Embedded Networked Sensing, UCLA, UC Merced

- Dense deterministic raster scans performed to characterize spatial and temporal variation
- Specific structure (vertical stratification) motivated adaptive experimental design
- Experiments produced coupled velocity and water quality assessments at previously unobservable spatial resolutions
- Discussed learned lessons, typical for cable based robotic system and water quality monitoring applications



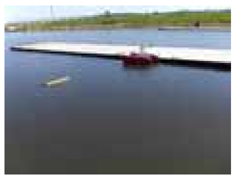
Campaign Site

18:30–18:48	FrE12.6

Autonomous Surface Vehicle Docking Manoeuvre with Visual Information

Alfredo Martins, J. M. Almeida,H. Ferreira, H. Silva, N. Dias, A. Dias, C. Almeida and E. Silva
Autonomous Systems Lab, Instituto Superior de Engenharia do Porto - IPP, Portugal

- ASV docking to a small torpedo shaped AUV
- Vision information at close range
- Hybrid docking manoeuvre
- Preliminary results on outdoor scenario with restricted conditions (calm water)



ROAZ ASV and AUV