Multirobot Coordination

Chair *Nancy Amato, Texas A&M Univ.*
Co-Chair *Domenico G. Sorrenti, Univ. di Milano - Bicocca*

09:20–09:38	WeA1.1

Dynamic Programming for Creating Cooperative Behavior of Two Soccer Robots -Part 1: Computation of State-Action Map

Ryuichi Ueda, Kohei Sakamoto,
Kazutaka Takeshita and Tamio Arai
Dept. of Precision Engineering, School of Engineering,
The University of Tokyo, Japan

- Dynamic programming (DP) is applied to creation of global decision making rule of two soccer robots.
- 8-d state space is divided into 610 million discrete states.
- Decision making rule is obtained in ten days with a Pentium D 3.2 GHz.
- Cooperative behavior is obtained without heuristics by DP.

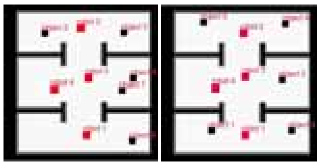
Behavior of two robots
with 610 million state DP result

09:38–09:56	WeA1.2

Rearrangement task realization by multiple mobile robots with efficient calculation of task constraints

Norisuke Fujii, Tsai-Lin Chou, and Jun Ota
Department of Precision Engineering, The University of Tokyo, Japan

- A rearrangement task contains constraints on the order of task execution
- We propose a rearrangement method that calculates constraints efficiently
- Robots calculate a part of, not all, the task constraints step by step
- The proposed method is tested in a simulated environment with up to 5 objects and 4 mobile robots



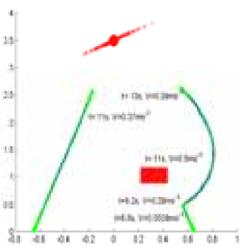
Initial state Final state
robots must grasp object 5 before the finish time of task 2

09:56–10:14	WeA1.3

Two Vision-guided vehicles: temporal coordination using nonlinear dynamical systems

Cristina P. Santos, Manuel Ferreira
Industrial Electronics Dept., University of Minho, Portugal

- Timed trajectories and temporally coordinated movements generation using coupled dynamical architectures
- Relatively low level, noisy sensory information steers action
- Visual sensory information drives movement initiation and termination
- Demonstrated in a non-structured simulated environment where two vision-guided mobile robots must reach a target

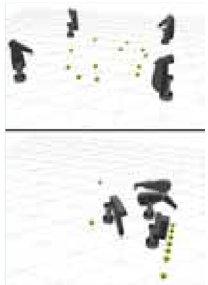


10:14–10:32	WeA1.4

Real-time Motion Planning of Multiple Mobile Manipulators with a Common Task Objective

John Vannoy and Jing Xiao
Dept. of Computer Science, University of North Carolina - Charlotte, USA

- Novel approach to real-time, distributed motion planning for a team of mobile manipulators to perform a task together
- Robots dynamically and spontaneously divide the work
- Each robot achieves real-time adaptiveness by simultaneous planning and execution of motion while treating the other mobile manipulators as dynamic obstacles of unknown trajectories



10:32–10:50	WeA1.5

The Frugal Feeding Problem: Energy-efficient, multi-robot/place rendezvous

Yaroslav Litus, Richard T. Vaughan and Pawel Zebrowski
Autonomy Lab, School of Computing Science, Simon Fraser University, Canada

- Looking for an efficient joint motion plan for a service robot to meet multiple worker robots
- Analysing complexity of optimal meeting order problem
- Proposing solutions for optimal meeting locations given a fixed ordering
- Evaluating solutions empirically

Visual Tracking

Chair *Seth Hutchinson, Univ. of Illinois*
Co-Chair *Malcolm A. MacIver, Northwestern Univ.*

09:20–09:38 WeA2.1

Space-time *A* Contrario Clustering for Detecting Coherent Motions

Thomas Veit, Frédéric Cao, and Patrick Bouthemy
Vista Team – IRISA / INRIA, Rennes, France

- Automatic detection of coherent motions (locally constant speed and direction)
- General *a contrario* grouping framework applied to clustering local motion measurements in an appropriate motion space
- Structured description of dynamic video content (# of moving objects, position, local trajectory)
- Confidence level for each detection
- Applications: track initialization, robot navigation, surveillance, driver assistance, activity recognition

Detection of two local trajectories with high confidence levels

09:38–09:56 WeA2.2

Accurate Quadrifocal Tracking for Robust 3D Visual Odometry

Andrew I. Comport, Ezio Malis and Patrick Rives
INRIA, Sophia-Antipolis, France.

- An accurate image-based approach to tracking the 6dof trajectory of a stereo camera pair.
- 3D odometry over large scale scenes with little drift despite occlusions, large inter-frame movement, illumination changes, …
- Entire image-pair is warped to create novel viewpoints and minimise a quadrifocal relationship between adjacent images.
- Robust efficient second order minimisation.

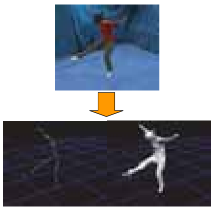
Sequence of about 392m long with ≈ 0.01% drift.

09:56–10:14 WeA2.3

Marker-less Human Motion Estimation using Articulated Deformable Model

Koichi Ogawara, Xiaolu Li* and Katsushi Ikeuchi*
Kyushu University, Japan
*The University of Tokyo, Japan

- Position of the body center and the joint angles are estimated from multiple video streams
- Deformable articulated model of the human body is aligned to the 3D reconstructed volume
- The robustness is due to:
  - •Robust estimator and ICP algorithm with KD-tree search in pose and normal space
  - •Hierarchical estimation and backtrack re-estimation algorithm

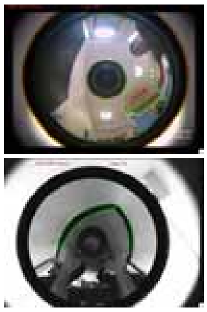


10:14–10:32 WeA2.4

Fitting 3D models on central catadioptric images

Eric Marchand, François Chaumette
IRISA-INRIA Rennes, Lagadic team, Rennes, France

- Omnidirectional camera
- 3D model based tracking
- Virtual visual servoing approach
- Robust minimization (M-estimation)
- New formulation of the interaction matrix related to the projection of a 3D line
- Real-time tracking algorithm

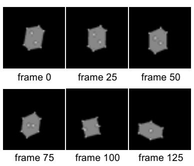


10:32–10:50 WeA2.5

A Moment-Based 3D Object Tracking Algorithm for High-Speed Vision

Takashi Komuro and Masatoshi Ishikawa
Graduate School of Information Science and Technology,
The University of Tokyo, Japan

- High-speed robot manipulation requires real-time and robust pose recognition of the object.
- Using image moments, continuous tracking of a 3D object is possible, even with noisy images.
- Simulation results are shown: box tracking using Newton's method and that using particle filter.



Simulation Result of Box tracking

Evolutionary Robotics

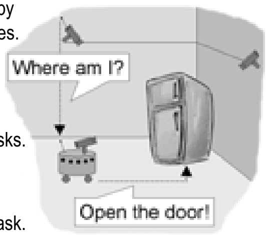
Chair *Henrik Iskov Christensen, Georgia Inst. of Tech.*
Co-Chair *Ben Krose, Univ. of Amsterdam*

09:20–09:38 WeA3.1

Plan-Based Configuration of an Ecology of Robots

Robert Lundh, Lars Karlsson, and Alessandro Saffiotti
AASS Mobile Robotics Lab, Örebro University, Sweden

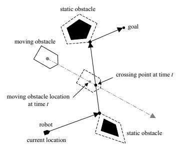
- Ecology of robots: robots help each other by offering information-producing functionalities.
- A *Configuration* is a way to allocate and connect functionalities.
- Problem: To automatically generate sequences of configurations for a given tasks.
- Solution: We propose a plan-based technique for this problem.
- Experiment on a complex robot olfactory task.



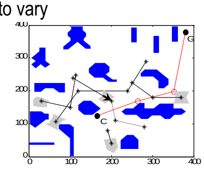
09:38–09:56 WeA3.2

Mobile Robot Path Planning in Dynamic Environments

Yang Wang, Ian Sillitoe and David Mulvaney
Electronic and Electrical Engineering, Loughborough University, UK
Scottish Association for Marine Science



- Paths between obstacles are represented by individual genes
- To aid avoidance of dynamic obstacles the robot speed is allowed to vary
- On-line re-planning allows navigation around unknown dynamic obstacles
- The re-planning typically takes around 5 seconds

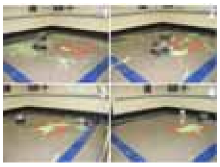


09:56–10:14 WeA3.3

Evolving a Scalable Multirobot Controller Using an Artificial Neural Tissue Paradigm

Jekanthan Thangavelautham, Alexander Smith and Gabriele D'Eleuterio
University of Toronto Institute for Aerospace Studies, Canada
Dale Boucher* and Jim Richard**
*Northern Centre for Advanced Technology, **Electric Vehicle Controllers Ltd, Canada

- A coarse-coding neuroevolutionary approach, allows development, competition and cooperation within a tissue framework
- Application: Multirobot controller for resource collection and pile (berm) formation
- Requires limited supervision, novel emergent behaviors evident
- Fitness function doesn't facilitate task decomposition nor bias solution strategy



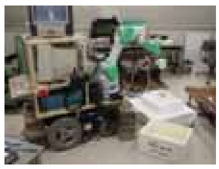
Caption is optional, use Arial Narrow 20pt

10:14–10:32 WeA3.4

Chaos-driving Robotic Intelligence for Catching Fish

Mamoru Minami, Gao Jingyu, and Yasushi Mae
Graduate School of Engineering, Intelligent System, University of Fukui, Japan, Fukui city

- We analyze the intelligent behaviors of fishes
- We propose a new method for intelligence realization
- The BVP chaos generator has been proved effective to exceed the fish intelligence.



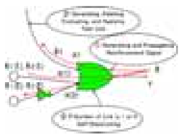
Fish-Catching system with PA10

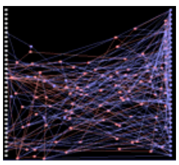
10:32–10:50 WeA3.5

Enhancement of Self Organizing Network Elements for Supervised Learning

*Chyon Hae Kim, †Tetsuya Ogata, *Shigeki Sugano
*Department of Mechanical Engineering Waseda Univ. Japan
†Graduate School of Informatics Kyoto Univ. Japan

- We proposed a new learning method Self-Organizing Network Elements (SONE).
- Autonomous exploration of effective output, simple external parameter, and low calculation cost are the characteristics.
- The proposed method enabled SONE to be used in supervised learning





Analysis of Haptic Systems

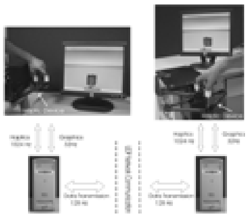
Chair *Paolo Fiorini, Univ. of Verona*
Co-Chair *Claude Andriot, Lab. de Simulation Interactives*

09:20–09:38	WeA4.1

A Multi-rate Control Approach to Haptic Interaction in Multi-user Virtual Environments

M. Fotoohi, S. Sirouspour, and D. Capson
Dept. of Electrical and Computer Eng., McMaster University, Canada

- Multi-user haptic interaction over LANs and MANs
- Performance and stability degradation due to limited network packet rate and delay
- A distributed multi-rate control architecture proposed and analyzed
- Improved stability and performance in analysis and experiments



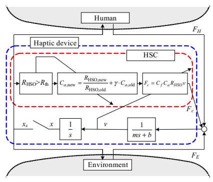
Experimental setup

09:38–09:56	WeA4.2

Frequency Domain Stability Observer and Active Damping Control for Stable Haptic Interaction

Dongseok Ryu, Jae-Bok Song, Junho Choi, Sungchul Kang, and Munsang Kim
Inteligent Robotics Research Center, KIST, Korea
Mechanical Engineering Dept., Korea Univ., Korea

- the frequency separation between human motion and haptic instability are reported, and the practical availability of the phenomenon is discussed.
- The haptic stability observer (HSO) is proposed to detect haptic unstable behavior by analyzing the motion in the frequency domain.
- the haptic stability controller (HSC) is designed to alleviate haptic instability by using the HSO.



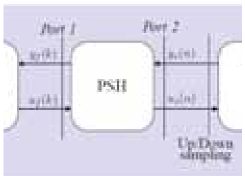
Block diagram of the haptic stable frequency controller

09:56–10:14	WeA4.3

Simulation Issues in Haptics

Gianni Borghesan, Alessandro Macchelli, Claudio Melchiorri
DEIS, University of Bologna

- Simulation of virtual environments for Haptic System
- Passive discrete time simulation of continuous time Port Hamiltonian system
- Passive interconnection of two discrete time virtual environments simulated at different frequencies



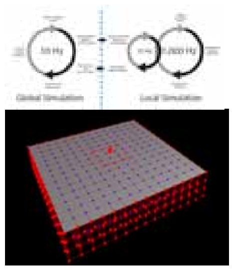
Passive Sample and Hold

10:14–10:32	WeA4.4

High Fidelity Haptic Rendering of Stick-Slip Frictional Contact With Deformable Objects in Virtual Environments Using Multi-Rate Simulation

Paul Jacobs, M. Cenk Cavusoglu
Dept. of Electrical Eng. and Computer Sci., Case Western Reserve University, Cleveland, OH, USA

- Application: Haptic interaction with deformable objects in virtual environments.
- Problem: Difference between the sampling rate requirements of the haptic interfaces (1kHz) and the physical models (10Hz).
- Method: Proposed a multirate simulation approach with a local linear approximation and local geometric model.
- Results: Ability to simulate stick-slip frictional contact.

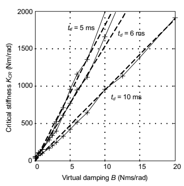


10:32–10:50	WeA4.5

Stability Boundary for Haptic Rendering: Influence of Damping and Delay

Jorge Juan Gil, Emilio Sánchez
CEIT and TECNUN, University of Navarra, Spain
Thomas Hulin, Carsten Preusche, and Gerd Hirzinger
DLR, Institute of Robotics and Mechatronics, Germany

- The influence of viscous damping and delay on the stability of haptic systems is studied.
- A linear condition which relates virtual stiffness, viscous damping and delay is proposed.
- Theoretical results are supported by simulations and experimental data using the DLR Light-Weight Robot.



Experimental results using the LWR-III

Field Robotics: Systems and Applications

Chair *Steven Dubowsky, MIT*

Co-Chair *Milos Zefran, Univ. of Illinois at Chicago*

09:20–09:38 WeA5.1

Development of Fully Automatic Inspection Systems for Large Underground Concrete Pipes

Norbert Elkmann, Sven Kutzner, Thomas Stuerze, José Saenz, B. Reimann
Business Unit Robotic Systems, Fraunhofer Institute for Factory Operation and Automation IFF, Magdeburg, Germany
Heiko Althoff
Emschergenossenschaft, Essen, Germany

- Inspection Strategy, Inspection Systems
- Positioning, Pipe Axis Measurement
- Sensor Systems for Damage Detection

Test in a Real Sewer

09:38–09:56 WeA5.2

Concept and Design of A Fully Autonomous Sewer Pipe Inspection Mobile Robot "KANTARO"

Amir A. F. Nassiraei[1,2], Yoshinori Kawamura[1], Alireza Ahrary[1,2], Yoshikazu Mikuriya[1] and Kazuo Ishii[2]
[1]FAIS-Robotics Development Support Office, [2]Graduate School of Life Science and Systems Engineering, Japan

- An innovative, fast and robust sewer inspection method by using a fully autonomous, mobile robot.
- A novel passive-active intelligent moving mechanism: "naSIR Mechanism"
- Pipe inspection based on designed a mobile intelligent 2D laser scanner and automated fault detection software.

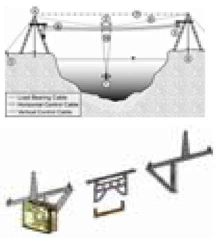
"KANTARO" prototype

09:56–10:14 WeA5.3

NIMS RD: A Rapidly Deployable Cable Based Robot

Brett Jordan, Maxim Batalin, and William Kaiser
Electrical Engineering Dept., University of California- Los Angeles, USA

- NIMS RD is a lightweight compact cable based robotic sensing system that can be rapidly deployed in the field.
- The system's minimal infrastructure allows it to be easily transported and set up.
- The system is currently being used for environmental applications such as terrestrial, aquatic, and contaminant observation and management.



Major components of the NIMS RD system

10:14–10:32 WeA5.4

ICTINEU^{AUV} Wins the First SAUC-E Competition

D. Ribas, N. Palomeras, P. Ridao, M. Carreras and E. Hernàndez
Dept. Electrònica, Informàtica i Automàtica, Universitat de Girona, Spain

- ICTINEU^{AUV} is a vehicle developed by a team of students of the University of Girona to compete in the Student Autonomous Underwater Challenge - Europe (SAUC-E).
- The vehicle was conceived as an open frame structure with a modular design compatible with the earlier vehicles of our laboratory.
- 2 networked computers with Gentoo/Linux run a hybrid control architecture including mission control, a behavioural layer and a map-based localization algorithm.

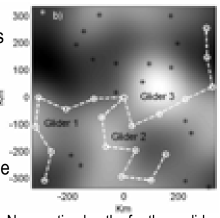
The ICTINEU^{AUV}, winner of the 1st edition of the SAUC-E competition.

10:32–10:50 WeA5.5

Combining networks of drifting profiling floats and gliders for adaptive sampling of the Ocean

Alberto Alvarez and Bartolome Garau
Natural Resources Dept., IMEDEA, Spain
Andrea Caiti
Electrical Systems and Automation Dept., University of Pisa, Italy

- Ocean monitoring is difficult (large dimensions and wide range of spatio-temporal scales)
- An efficient way of sampling it is through networks of small autonomous platforms
- The advent of these networks with still scarce resources demand the optimization of their use
- A Genetic Algorithm approach is used to optimize the path of gliders to sample the ocean, together with drifters



Near-optimal paths for three gliders sampling a temperature field

Parallel Kinematic Machines: Design

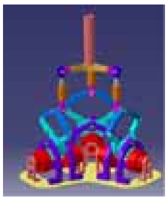
Chair *JPM Jean-Pierre Merlet, INRIA*
Co-Chair *YACINE AMIRAT, Unversity of Paris 12*

09:20–09:38	WeA6.1

The Optimum Design of a 6-DOF Parallel Manipulator with Large Orientation Workspace

Yoon-Kwon Hwang*, Jung-Won Yoon**, Christiand**, and Je-Ha Ryu***
*Technical Research Institute, Hyundai Mobis Co., Korea
**School of Mechanical and Aerospace Eng., Gyeongsang, University,Korea
***Dept. of Mechatronics, GIST, Korea

- To optimize the design parameters of the parallel manipulator with large orientation workspace at the boundary position of COW.
- The method uses a genetic algorithm considering compactness of size, GCI, orientation angle as the constraints.
- Total fifteen types are divided and studied according to the combination of performance indices, and the best model is proposed.



The proposed 6-DOF haptic device with capstan drives.

09:38–09:56	WeA6.2

Development of a Novel 3-DoF Purely Translational Parallel Mechanism

Yunjiang Lou, Jiangang Li, Jinbo Shi, and Zexiang Li
Dept. Electronic and Computer Engineering
The Hong Kong University of Science and Technology
Clear Water Bay, Kowloon, Hong Kong, China

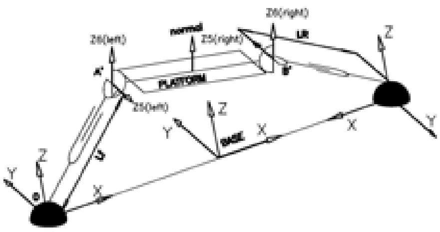
- A novel 3-DoF purely translational parallel mechanism consisting of spatial parallelograms is proposed.
- A mathematically rigorous study shows that the parallel mechanism undergoes pure translation.
- The Orthopod, obtained from architecture and geometry design, is designed and fabricated.

The Orthopod

09:56–10:14	WeA6.3

Kinematic Analysis of the Spherically Actuated Platform Manipulator

H. Pendar[1], M. Vakil[2], R. Fotouhi[2], H. Zohoor[1]
[1]Mechanical Engineering Department, Sharif University of Technology, Azadi Sq., Tehran, Iran
[2]Mechanical Engineering Department, University of Saskatchewan, 57 Campus Drive, Saskatoon, SK, Canada

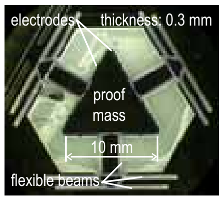


10:14–10:32	WeA6.4

Simplectic Architectures for True Multi-axial Accelerometers: A Novel Application of PKMs

Philippe Cardou and Jorge Angeles
Dept. of Mechanical Engineering, McGill University, Canada

- Novel architectures of parallel-kinematics-machines for multi-axial accelerometers are proposed
- The single-, bi- and tri-axial accelerometers allow the measurement of 1, 2, and 3 components of point acceleration, respectively
- The biaxial accelerometer can be fabricated using proven micromachining processes
- The direct kinematics problems associated with all 3 types of accelerometers are linear



MEMS realization of the biaxial accelerometer

10:32–10:50	WeA6.5

Mechanism and Control of a Novel Type Microrobot for Biomedical Application

Shuxiang Guo, Qinxue Pan
Faculty of Engineering, Kagawa University, Japan

- We propose a new prototype of a wireless microrobot that can be manipulated inside a tube using an external magnetic field.
- The structure, motion mechanism, and characteristic evaluation of a driving fin used for propulsion have been discussed.
- The microrobot can be controlled upward, downward, and also can be suspended in water using frequency adjustments.
- The robot will play an important role in both industrial and medical applications such as microsurgery.

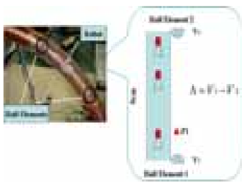


Fig. 1 Position of the Developed Microrobot in Pipe

Grasping

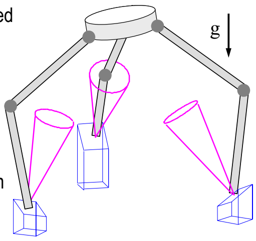
Chair *I-Ming Chen, Nanyang Tech. Univ.*
Co-Chair *Philippe Bidaud, Univ. Pierre et Marie Curie - Paris 6*

09:20–09:38 WeA7.1

Geometric Characterization and Experimental Validation of Frictional 3-Contact Equilibrium Stances in Three-Dimensions

Yizhar Or and Elon Rimon
Dept. Of Mechanical Engineering, Technion, Israel

- Analyze 3D Equilibrium stances of legged mechanisms in frictional environments
- Relation with Support Polygon criterion
- Computing exact equilibrium region
- Physical and geometric interpretations of boundaries and critical contact forces
- Theory validated in experimental system



09:38–09:56 WeA7.2

Grasp Force Magnifying Mechanism for Parallel Jaw Grippers

Takeshi Takaki and Toru Omata
Department of Mechano-Micro Engineering, Tokyo Institute of Technology, Japan

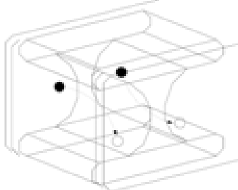
- We propose a force magnifying mechanism for parallel jaw grippers.
- The proposed force magnifying mechanism runs sequentially with only one motor.
- The developed 86g gripper can grasp objects of various sizes with large grasp force over 200N.

09:56–10:14 WeA7.3

Two-Finger Squeezing Caging of Polygonal and Polyhedral Object

Peam Pipattanasomporn, Pawin Vongmasa and Attawith Sudsang
Computer Engineering Dept., Chulalongkorn University, Thailand

- Object squeezing caging with two fingers -- forming a cage by maintaining their separation distance below a critical distance.
- Object is either 2-D or 3-D i.e. *n*-vertices polygons or polyhedra.
- Algorithm based on decomposing workspace into *m* convex sets for characterizing all squeezing caging in $O(n^2 \log n)$ (2-D) and $O(n^4 \log m)$ (3-D).

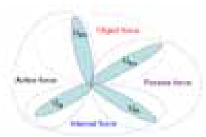


An object is squeezing caged, loosely grasped by two fingers.

10:14–10:32 WeA7.4

Force Analysis of Whole Hand Grasp by Multifingered Robotic Hand

Jijie Xu, Michael Y.Wang, Hong Wang and Zexiang Li



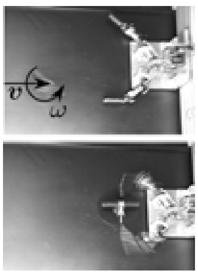
- The contact force space is decomposed into four orthogonal subspaces.
- Force closure and feasibility problems are formulated as LMI feasibility problems with the new decomposition of the contact force space.
- A new cost index is proposed so that the grasping force optimization problem of whole hand grasp is formulated and solved as a convex optimization involving LMIs, which can be solved using convex programming techniques.
- A simplified formulation of grasping force optimization problem is proposed for active force closure grasp.
- Finally, simulation results show the validity and performance of the proposed problem formulation and the new cost index

10:32–10:50 WeA7.5

Friction Independent Dynamic Capturing Strategy for a 2D Stick-shaped Object

Mitsuru Higashimori and Makoto Kaneko
Dept. of Mechanical Engineering, Osaka University, Japan
Maiko Kimura, Mazda Motor Corporation, Japan
Idaku Ishii, Hiroshima University, Japan

- Dynamic capturing strategies for a stick-shaped object with both translational and rotational velocities are discussed.
- Capturing strategies independent upon the contact friction between a fingertip and an object are proposed.
- The proposed strategies are demonstrated by utilizing a high-speed hand and a high-speed vision.



Devices for Surgery

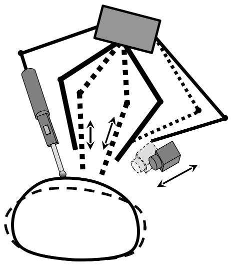
Chair *Russell H. Taylor, The Johns Hopkins Univ.*
Co-Chair

09:20–09:38	WeA8.1

Whisker Sensor Design for Three Dimensional PositionMeasurement in Robotic Assisted Beating Heart Surgery

Ozkan Bebek, M. Cenk Cavusoglu
Case Western Reserve University, Cleveland, Ohio, USA

- Robotic-assisted surgery is performed with intelligent robotic instruments controlled through teleoperation.
- The robotic tools actively cancel the relative motion between the surgical instruments and the beating heart.
- Measuring the motion of the heart is an important part of this scheme.
- A novel whisker sensor design to measure the beating heart motion during this operation is proposed.



09:38–09:56	WeA8.2

An Ultrasound Probe Holder for Image-Guided Robot-Assisted Prostate Brachytherapy

Basem Yousef, Rajni Patel, and Mehrdad Moallem
Dept. of Electrical and Computer Engineering
The University of Western Ontario, Canada

- A device is described for holding and manipulating an ultrasound probe for use in prostate brachytherapy procedures.
- The holder comprises an integrated passive-jointed stabilizer-tracker assembly.
- The stabilizer is used to position, manipulate and lock in place the ultrasound probe.
- The tracker accurately provides the position and orientation of the probe in 3D space.

09:56–10:14	WeA8.3

Development of a New Bending Mechanism and Its Application to Robotic Forceps Manipulator

Chiharu Ishii and Kosuke Kobayashi
Department of Innovative Mechanical Engineering, Kogakuin University, Japan

- A novel omni-directional bending mechanism, Double-Screw-Drive (DSD) mechanism is proposed.
- DSD mechanism was applied to a multi-DOF robotic forceps manipulator for laparoscopic surgery.
- Tracking control experiments for bending motion were executed using a remote controller.
- Experimental results showed the effectiveness of the constructed servo system.

Double-Screw-Drive
robotic forceps manipulator

10:14–10:32	WeA8.4

Detachable-Fingered Hands for Manipulation of Large Internal Organs in Laparoscopic Surgery

Toshio Takayama, Toru Omata, Takashi Futami
Tokyo Institute of Technology
Hideki Akamatsu, Toshiki Ohya, Kazuyuki Kojima,
Kozo Takase, and Naofumi Tanaka.
Tokyo Medical and Dental University

- We developed detachable-fingered hands for laparoscopic surgery.
- The hands can be disassembled into small pieces that can be passed through trocars.
- The hands are reassembled in the abdominal cave and can handle large internal organs.
- The goal of this study is to develop assemblable hands for Robot-HALS.

10:32–10:50	WeA8.5

A Modular, Automated Laparoscopic Grasper with Three-Dimensional Force Measurement Capability

Gregory Tholey* and Jaydev P. Desai**
*Department of Mechanical Engineering and Mechanics, Drexel University
**Department of Mechanical Engineering, University of Maryland, College Park

- Design of a modular, automated laparoscopic grasper with tri-directional force measurement capability
- Grasper can measure normal grasping forces, as well as, sideways manipulation forces
- Application to grasping and palpation tasks.

Modular Laparoscopic tool with
force measurement capability

Bio-inspired Locomotion

Chair *Yasuhisa Hasegawa, Univ. of Tsukuba*
Co-Chair *Ambarish Goswami, Honda Res. Inst.*

09:20–09:38 WeA9.1

Feedback design for 3D movement of an Eel-like robot

M. Alamir, M. El Rafei, G. Hafidi, N. Marchand,
M. Porez and F. Boyer

Control System Department,
GIPSA-Lab, CNRS-INPG-UJF, Grenoble, France

- Feedback laws for the 3D movement of an Eel-like robot
- Model independent control
- Tracking of a desired 3D position of the Eel head

09:38–09:56 WeA9.2

Online trajectory generation in an amphibious snake robot using a lamprey-like central pattern generator model

Auke Jan Ijspeert and Alessandro Crespi
EPFL - Ecole Polytechnique Fédérale de Lausanne
Switzerland

- Swimming and crawling of an amphibious snake robot
- Locomotion control based on a central pattern generator inspired from the lamprey
- Interactive control with a human in the loop
- Agile locomotion with rapid changes of speed, direction, and type of gait
- Smooth transitions from crawling to swimming

Amphibot II

09:56–10:14 WeA9.3

Polychaete-like Pedundulatory Locomotion

Michael Sfakiotakis, Dimitris P. Tsakiris, and Kostas Karakasiliotis
Institute of Computer Science - FORTH, Greece

- A novel pedundulatory locomotion mode is inspired by the polychaete marine worms.
- It combines body undulations with the paddle-like action of active lateral appendages.
- Computational models have been developed, to study its thrust generation characteristics in unstructured locomotion environments.
- Experiments with the *Nereisbot* prototype demonstrate the enhanced performance and the rich gait repertoire of the pedundulatory mode on sand.

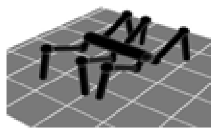
The ***Nereisbot*** pedundulatory robotic prototype

10:14–10:32 WeA9.4

A Biologically Inspired Approach to the Coordination of Hexapedal Gait

Keith Wait and Michael Goldfarb
Mechanical Engineering Dept., Vanderbilt University, USA

- Approach is based on the WalkNet structure of Cruse and corrects for some initial deficiencies
- New method successfully tested in simulation that includes dynamics and other effects not originally included
- Included video shows that simulated method provides stable gait with some emergent characteristics

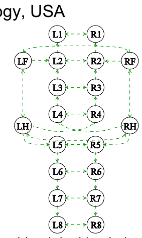


10:32–10:50 WeA9.5

Models for Global Synchronization in CPG-based Locomotion

Keehong Seo and Jean-Jacques E. Slotine
Nonlinear Systems Lab., Dept. of Mechanical Engineering,
Dept. of Brain and Cognitive Sciences,
Massachusettes Institute of Technology, USA

- Central pattern generator (CPG) allows modularized control of robot locomotion.
- Coupled oscillators in single-chain, double-chain architectures are considered for CPG.
- Global exponential stability of the CPG is discussed from synchronization point of view.
- Simple CPG models can be combined for complicated behaviors preserving stability.



Combined double-chain CPG for amphibian locomotion

Control Architectures and Programming

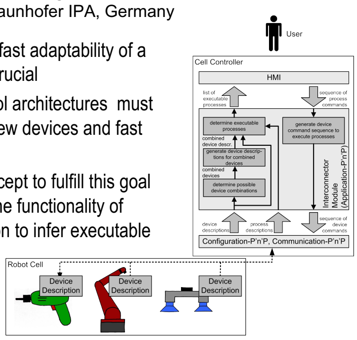
Chair *Joachim Hertzberg, Univ. of Osnabrueck*
Co-Chair *Debora Botturi, Univ. of Verona*

09:20–09:38	WeA10.1

Control Architecture for Robot Cells to Enable Plug'n'Produce

Martin Naumann, Kai Wegener, and Rolf Dieter Schraft
Fraunhofer IPA, Germany

- In small-series production fast adaptability of a robot cell to new tasks is crucial
- Therefore, robot cell control architectures must allow easy integration of new devices and fast programming of new tasks
- This paper presents a concept to fulfill this goal based on descriptions of the functionality of devices and their evaluation to infer executable processes

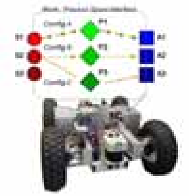


09:38–09:56	WeA10.2

The Process Information Space: The Importance of Data Flow in Robotic Systems

Aaron Morris
Robotics Institute, Carnegie Mellon University, USA

- Reliable robot performance is opposed by the ubiquitous nature of failure in uncertain working conditions.
- Knowledge of computational data flow can assist a robot in understanding its current state of operation.
- Such information provides leverage to planning frameworks, allowing the robot to devise strategies for trustworthy performance.



Data flow is created via interaction of robot processes.

09:56–10:14	WeA10.3

Enhancing Software Modularity and Extensibility A Case for Using Generic Data Representation

Greg Broten
Defence Research and Development Canada

- Portable and modular software allows researchers share algorithms.
- Generic data representations enhance software modularity and extensibility.
- C++ STL vectors and CORBA sequences implement dynamic arrays.
- Dynamic arrays allow for generic data representations.
- Experiments show dynamic arrays do not incur an unmanageable performance penalty.

```
//! A vector of sensor readings.
typedef sequence<long>
RangeGroup;

//! A vector of sensor groups.
typedef sequence<RangeGroup>
RangeScanIDL;
```

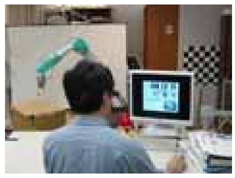
Dynamic Data Representations

10:14–10:32	WeA10.4

Task instruction by putting task information in work space

Kazuyuki Nagata, Yujin Wakita, and Eiichi Ono
National Institute of Advanced Industrial Science and Technology (AIST)
Intelligent Systems Research Institute
1-1-1 Umezono, Tsukuba, 305-8568, Japan

- User selects a task model according to an object type and situation in an environment.
- Object Template Model (OTM) is the list of the task model which can be applied to an object category.
- Task Space Model (TSM) describes a list of OTMs and spatial information on an object which fixed in an environment related to tasks of a robot.

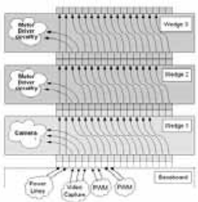


10:32–10:50	WeA10.5

Morphing Bus: A rapid deployment computing architecture for high performance, resource-constrained robots

Colin D'Souza, Byung Hwa Kim
Electrical and Computer Engineering Dept., Univ of Minnesota, USA
Richard Voyles
Computer Engineering Dept, University of Denver, USA

- Flexible hardware for sensor interfacing and hardware-accelerated computation
- No interface circuitry at sensor/ actuator. Bus "morphs" to accommodate the sensor signals
- Intuitive interface allowing a user to reconfigure the system without writing any code
- Useful for field operation, for robotic multi-tasking, to save operator time and to simplify technical details



Conceptual diagram of the Morphing Bus

Motion Planning

Chair *Oliver Brock, Univ. of Massachusetts Amherst*
Co-Chair *James Kuffner, Carnegie Mellon Univ.*

09:20–09:38 WeA11.1

An Analytical Method for the Planning of Robust Assembly Tasks of Complex Shaped Planar Parts

• Stemmer, A. Albu-Schaeffer, and G. Hirzinger
Institute of Robotics and Mechatronics,
German Aerospace Center (DLR), Germany

- The assembly sequence is automatically generated and parameterized.
- Convergence of the assembly process can be guaranteed within a region of attraction (ROA).
- Assembly trajectories are optimized such that the ROA is maximal for a given part geometry.
- Image processing is used in experiments for positioning within the ROA, impedance control is used for robust assembly.

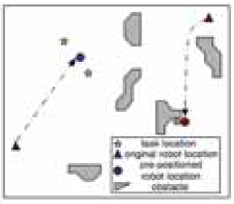
DLR-KUKA light-weight robot inserts planar parts automatically using vision and impedance control.

09:38–09:56 WeA11.2

Pre-positioning Assets to Increase Execution Efficiency

Laura M. Hiatt* and Reid Simmons†
*Computer Science Department, †Robotics Institute
Carnegie Mellon University, USA

- Dynamic domains such as search and rescue have uncertainty in which task will start next and whether or not a task will need an agent for execution.
- We exploit this uncertainty to minimize the overhead of beginning tasks in such domains by intelligently positioning robots near tasks before the tasks are actually allocated.
- By doing so, we can reduce the overhead time robots spend traveling to their next allocated task by up to 90%.



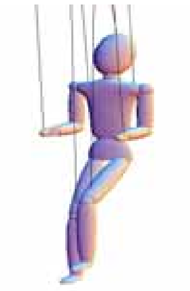
A scenario in which the robots pre-position to be closer to tasks with a high probability of being executed next.

09:56–10:14 WeA11.3

Dynamic Modeling and Motion Planning for Marionettes

Elliot Johnson and Todd D. Murphey
Electrical and Computer Engineering Dept., University of Colorado, USA

- Mixed Dynamic-Kinematic Model based on Euler-Lagrange Dynamics
- Decouple interesting puppet dynamics from complicated mechanism dynamics
- Constraint-based modeling of actuating strings
- Example application in a Sampling-based Motion Planner

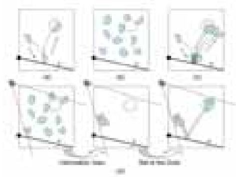


10:14–10:32 WeA11.4

Planar batting under shape, pose, and impact uncertainty

Jiaxin L. Fu[1], Siddhartha S. Srinivasa[2], Nancy S. Pollard[1] and Bart C. Nabbe[2]
[1]The Robotics Institute, CMU [2]Intel Research Pittsburgh

- Uncertainty is pervasive in real-world manipulation
- We explore planar batting with uncertainty in object shape and pose, and in impact
- Particle filter to represent uncertainty
- Two-step strategy for batting to goal:
  1)Bat for information gain
  2)Bat reduced set to goal



Planar batting: (a) ideal, (b) pose, shape, and (c) impact uncertainty; (d) strategy: bat to reduce uncertainty, bat to goal

10:32–10:50 WeA11.5

A Practical Pursuit-Evasion Algorithm: Detection and Tracking

Amna AlDahak and Ashraf Elnagar
Department of Computer Science, University of Sharjah, UAE

- This paper presents a practical algorithm for evader detection and tracking using one or more pursuers
- The solution employs two advanced data structures RRT and Kd-Tree
- A lazy collision detection strategy is used to resolve collisions with obstacles at runtime
- The Kd-Tree will be queried repeatedly for retrieving the set of potential locations to be used by each pursuer during tracking

An example after the detection phase. The paths of the two pursuers are shown in bold

Aerial Robotics: Design and Modelling

Chair *Satoshi Tadokoro, Tohoku Univ.*
Co-Chair *Kanna Rajan, Monterey Bay Aquarium Res. Inst.*

09:20–09:38 WeA12.1

Development of a Flying Robot with Pantograph-based Variable Wing Mechanism

Naohiro Hara, Kazuo Tanaka, Hiroshi Ohtake
Dept. of Mechanical Engineering and Intelligent Systems,
University of Electro-Communications, JAPAN
Hua O. Wang
Dept. of Aerospace and Mechanical Engineering, Boston University, Boston

- Pantograph-based variable wing is a new mechanism about drag-type horizontal axis rotorcraft
- Unique motion does not only change angles of attack but also expand and contract according to wing positions
- Developed rotorcraft generates 144% force for its own weight
- Simulation results show that the optimized model generates 200gf payload

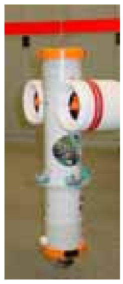
Flying Robot with Pantograph-based variable wing Mechanism

09:38–09:56 WeA12.2

The design of a tethered aerial robot

Phillip McKerrow and Danny Ratner
School of Computer Science and Software Engineering
University of Wollongong, Australia

- Design and modelling of a robot that swings on the end of a tether
- Its height is controllled by the length of the tether
- Its location on a spherical shell at the end of the tether is controlled by 2 ducted fans
- It acts like a double pendulum with 2 modes of natural movement
- A dynamic simulation model is presented



09:56–10:14 WeA12.3

Energy-Efficient Autonomous Four-Rotor Flying Robot Controlled at 1 Khz

Daniel Gurdan, Jan Stumpf
Technical University of Munich, Visiting at CSAIL, MIT
Michael Achtelik, Klaus-Michael Doth
Technical University of Munich, University of Erlangen
Gerd Hirzinger
German Aerospace Center (DLR), Oberpfaffenhofen
Daniela Rus
Distributed Robotics Lab, CSAIL, MIT

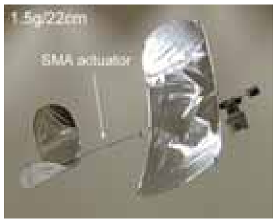
- Efficient and reliable four-rotor flying platform driven by brushless-DC motors
- Capable to carry payloads up to 350g
- Autonomous navigation using a motion tracking system

10:14–10:32 WeA12.4

A 1.5g SMA-Actuated Microglider looking for the Light

Mirko Kovac, André Guignard, Jean-Daniel Nicoud,
Jean-Christophe Zufferey and Dario Floreano
EPFL, Lausanne Switzerland

- **1.5g** microrobot flying at **1.5m/s** with a **gliding ratio of 5.6**
- **0.2g** Shape Memory Alloy (**SMA**) Actuator for rudder control
- Autonomous light source localisation and following (**phototaxis**)
- First step towards a microrobot that can **jump and glide** to overcome obstacles

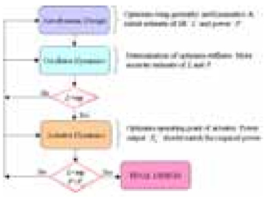


10:32–10:50 WeA12.5

Design and Optimization of a Biologically Inspired Flapping Mechanism for Flapping Wing Micro Air Vehicles

Zaeem A. Khan, Graduate Student,
Sunil K. Agrawal, Professor
Mechanical Systems Laboratory, University of Delaware, Newark, DE 19716

- Describes a resonant flapping mechanism motivated from insects.
- Mechanism studied as integration of Aerodynamics, Oscillator dynamics and actuator dynamics.
- Presents Design and optimization Methodology for Maximum performance
- Simulation results presented.



Outline of the Design and Optimization Procedure

Multirobot Coverage and Deployment

Chair *Enrico Pagello, Univ. of Padua*
Co-Chair *Richard Wagner, Northrop Grumman Corp.*

11:10–11:28	WeB1.1

Robust Distributed Coverage using a Swarm of Miniature Robots

Nikolaus Correll and Alcherio Martinoli
Swarm-Intelligent Systems Group
Ecole Polytechnique Fédérale Lausanne (EPFL), Switzerland

- Distributed coverage of regular structure with unreliable miniature robots
- Task progress is modeled by a combination of deterministic and probabilistic models
- Reliability of the individual platform explicitly modeled
- Validation by extensive realistic simulations

11:28–11:46	WeB1.2

Multi-Robot Area Patrol under Frequency Constraints

Yehuda Elmaliach, Noa Agmon and Gal A. Kaminka
The MAVERICK Group
Department of Computer Science, Bar Ilan University

Key property of multi-robot patrolling: Frequency of visits at locations

Area patrol:
- Uniform frequency if robots move along circular path
- Maximal frequency if time to complete cycle is minimal

Contributions:
- First algorithm finds minimal-time cycle under terrain directionality and velocity constraints
- Second algorithm positions robots uniformly along the cycle in minimal commute time

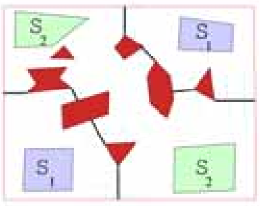
We guarantee robust, maximal, uniform frequency in multi-robot patrol

11:46–12:04	WeB1.3

Barrier Coverage for Variable Bounded-Range Line-of-Sight Guards

Stephen Kloder and Seth Hutchinson
Beckman Institute for Advanced Science
University of Illinois at Urbana-Champaign, USA

- A barrier is a set of robot sensors that prevents an intruder from moving from S_1 to S_2 without being seen by a sensor.
- We give a method to find the minimum-length barrier using a Barrier Candidate Graph, and network flows.
- We prove this method to be successful in all two-dimensional polygonal environments.



12:04–12:22	WeB1.4

The Cost of Reality: Effects of Real-World Factors on Multi-Robot Search

Jim Pugh and Alcherio Martinoli
Swarm-Intelligent Systems Group,
École Polytechnique Fédérale de Lausanne, Switzerland

- Multi-robot systems complex and expensive -- tempting to use high-level abstractions for design
- If systems not validated using realistic models or simulations, designed algorithms may contain flaws
- Simple coordinated search algorithm exhibits reduced performance or failure in presence of real-world factors
- Randomized search algorithms more robust to these effects

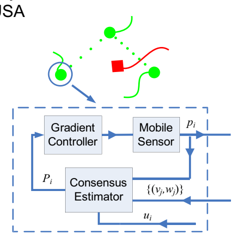
Robots in simulation and reality

12:22–12:40	WeB1.5

Distributed Cooperative Active Sensing Using Consensus Filters

Peng Yang, Randy A. Freeman and Kevin M. Lynch
Northwestern University
Evanston, IL, 60201, USA

- A distributed architecture for active sensing
- Estimation: Use a distributed Kalman-Bucy filter for sensor information fusion
- Control: Sensors follow local gradients to reduce estimation uncertainty
- Simulation results provided on range-bearing and range-only sensor models



Distributed control & estimation architecture

Active Perception and Vision

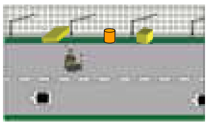
Chair *Nikos Papanikolopoulos, Univ. of Minnesota*
Co-Chair *Patrick Rives, INRIA*

11:10–11:28	WeB2.1

Active Illumination for Robot Vision

S.Y. Chen, J. Zhang, H. Zhang, W. Wang, and Y.F. Li
Zhejiang University of Technology, China
University of Hamburg, Germany
City University of Hong Kong, Hong Kong

- Factors and conditions of illumination in machine vision system
- Strategies of adaptive illumination control
- Comfortable illumination for a vision sensor
- Emphasis on controlling lighting intensity and avoiding glares

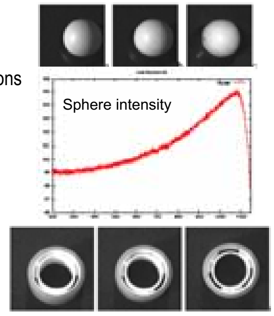


11:28–11:46	WeB2.2

Control camera and light source positions using image gradient information

Eric Marchand
IRISA-INRIA Rennes, Lagadic team, Rennes, France

- Control camera position or lighting conditions
- Use only image gradient information
- Maximize brightness or contras
- Integration in a visual servoing framework
- Validation on synthetic and real images

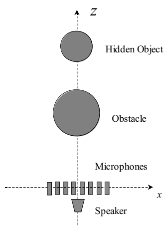


11:46–12:04	WeB2.3

Distance Estimation of Hidden Objects Based on Acoustical Holography by applying Acoustic Diffraction of Audible Sound

Haruhiko Niwa, Tetsuya Ogata,
Kazunori Komatani and Hiroshi G. Okuno
Department of Intelligence Science and Technology, Kyoto University, Japan

- Occlusion is a problem for range finders.
- We applied acoustic diffraction of audible sound.
- Our method is based on time-of-flight and acoustical holography.
- Our method was effective for raging two objects of the same size within 1.2 m



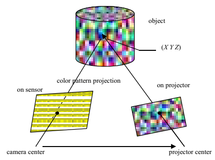
Our system

12:04–12:22	WeB2.4

Realtime Structured Light Vision with the Principle of Unique Color Codes

S. Y. Chen, Y. F. Li, and Jianwei Zhang
Zhejiang University of Technology, China,
City University of Hong Kong,
and University of Hamburg of Germany

- Structured Light Vision System.
- Principle of Unique Color Codes.
- 3D reconstruction only in local image processing.
- Real-time 3D vision perception

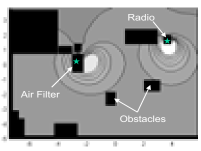


12:22–12:40	WeB2.5

Robotic Discovery of the Auditory Scene

Eric Martinson
Georgia Institute of Technology, Atlanta, Ga
Alan Schultz
U.S. Naval Research Laboratory

- Autonomous mobile robotic system for finding and investigating ambient noise sources in the environment
  - Use evidence grids to localize multiple sound sources in the environment
  - Investigate each source to identify directivity and volume
- Uses the discovered source location and directivity to model ambient noise levels in the area



A noise contour map estimates sound propagation for two directional sources.

Micro/Nano Robots I

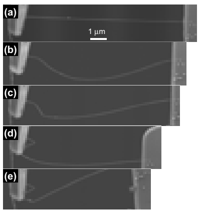
Chair *Bradley J. Nelson, ETH Zurich*
Co-Chair *Metin Sitti, Carnegie Mellon Univ.*

11:10–11:28 | WeB3.1

Nanorobotic Manipulator Assisted Assembly of Complex Nanostructures based on Carbon Nanotubes

Pou Liu[1], Kalle Kantola[2], Toshio Fukuda[1] and Fumihito Arai[3]
[1]Dept. of Micro-Nano Systems Engineering, Nagoya Univ., Japan
[2]Dept. of Automation and Systems Engineering, Helsinki Univ. of Tech., Finland
[3]Dept. of Bioengineering and Robotics, Tohoku Univ., Japan

- A series of *in situ* nanofabrication technique of CNTs including cutting, bending and welding inside the SEM were reported.
- A gas supplying system was built for cutting, bending and welding techniques.
- A 3D nanostructure, the letter N, was assembled from a single CNT and set to stand on a surface of a substrate by using nanofabrication techniques and nanomanipulation.



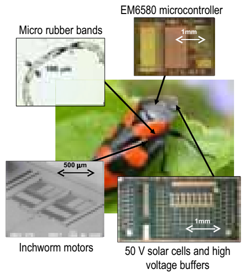
Assembly of a 3D nanostructure with a single CNT

11:28–11:46 | WeB3.2

Design of an Autonomous Jumping Microrobot

Sarah Bergbreiter and Kristofer S. J. Pister
Berkeley Sensor and Actuator Center
University of California, Berkeley, USA

- Design of a millimeter-sized autonomous jumping robot divided into 4 areas: energy storage, actuation, power, and control
- Silicone micro rubber bands have been fabricated and demonstrated to store up to 20 µJ of energy (equivalent to a 20 cm jump for a 10 mg robot)
- Prototype system has been demonstrated using solar cells to power microcontroller and drive inchworm motors

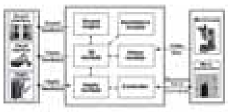


11:46–12:04 | WeB3.3

Robotic Assisted Micromanipulation System using Virtual Fixtures and Metaphors

Mehdi Ammi
LIMSI-CNRS, Université de Paris Sud, France
Antoine Ferreira
Laboratoire Vision et Robotique, ENSI Bourges-Université d'Orléans, France

- Multisensory AFM-based telemicromanipulation system.
- Haptic virtual fixtures for operator guidance.
- Use of potential fields for path planning, operator gesture guidance and safety.
- Introduction of metaphors with human sensory substitution for immersion.
- Experimentation of pushing-based and adhesion-based micromanipulation tasks.


Multisensory telemicromanipulation system

12:04–12:22 | WeB3.4

µ³: Multiscale, Deterministic Micro-Nano Assembly System for Construction of On-Wafer Microrobots

Aditya N. Das, Ping Zhang, Woo H. Lee
Dan Popa, Harry Stephanou
Automation & Robotics Research Institute,
University of Texas at Arlington, Texas, USA

- A table-top 3-D microassembly station consisting of 19 DOF arranged into 3 micro-manipulators, with 3nm motion resolution and stereo microscope vision.
- Careful calibration of end-effectors with respect to part allows high yield micro-assembly.
- Experimental results achieving deterministic serial microscale assembly of MEMS parts with high accuracy.

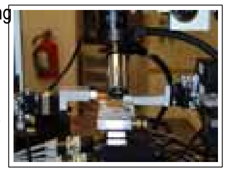


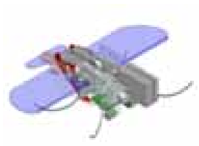
Image of µ³, 3-D Micro-Nano assembly system with 3 precision robots and stereo vision

12:22–12:40 | WeB3.5

Design and Development of the Long-Jumping "Grillo" Mini Robot

U. Scarfogliero
IMT Lucca Institute for Advanced Studies, Lucca, Italy
C. Stefanini, P. Dario
Scuola Superiore Sant' Anna, Pisa, Italy

- This paper describes the design of a fast long-jumping robot for locomotion in unstructured environments
- Inspired by frog locomotion, a tiny motor load the springs connected to the hind limbs. At take-off, an escapement mechanism releases the loaded springs.
- Passive compliant fore legs and wings provide landing and flight stability



Haptic Devices

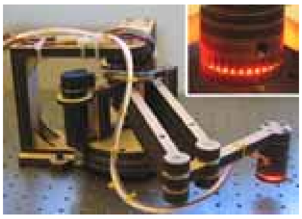
Chair *Matthew T. Mason, Carnegie Mellon Univ.*
Co-Chair *Jee-Hwan Ryu, Korea Univ. of Tech. and Education*

11:10–11:28 WeB4.1

An Optical Fiber Proximity Sensor for Haptic Exploration

Sean Walker, Kevin Loewke, Michael Fischer, Carl Liu, and J. Kenneth Salisbury
Depts. of Computer Science and Mechanical Eng., Stanford University, USA

- Design and control of new low-cost optical fiber proximity sensor.
- Array of 32 emitter and receiver optical fiber pairs measure reflected light.
- Useful alternative to conventional tactile sensors for robot hands.



11:28–11:46 WeB4.2

☐ Encountered-type Visual Haptic Display Using Flexible Sheet

Tsuyoshi Furukawa, Kenji Inoue and Tomohito Takubo and Tatsuo Arai
Graduate School of Engineering Science., Osaka University, JPN

- Encountered-type visual haptic display using flexible sheet is proposed
- Users can feel like seeing and pushing virtual soft objects directly
- It expresses the shape of virtual object by controlling pose of sheet using manipulators
- A method of correcting CG image distortion projected on the sheet is proposed

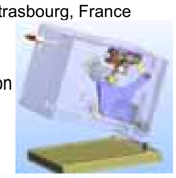
Visual haptic display presenting virtual cylinder

11:46–12:04 WeB4.3

Design and Evaluation of a Linear Haptic Device

L. Barbé, B. Bayle, J. Gangloff, M. de Mathelin
LSIIT UMR ULP-CNRS 7005, France
O. Piccin
LGeCo
INSA-Strasbourg, France

- Design of a new 1-DOF linear haptic device based on a slider-crank mechanism
- Computation and analysis of the kinematic and dynamic models
- Identification of the dynamic parameters
- Device evaluation with teleoperated needle insertio experiments in soft material

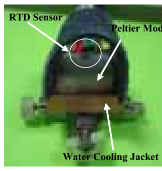


12:04–12:22 WeB4.4

Compact Tactile Display for Fingertips with Multiple Vibrotactile Actuator and Thermoelectric Module

G.H. Yang, T.H. Yang, S.C. Kim and D.S. Kwon
Human-Robot Interaction Research Center, KAIST, Korea
S.C. Kang
Intelligent Robotics Research Center, KIST, Korea

- A compact tactile display which consists of multiple vibrotactile actuators with 4-different vibrotactile unbalanced mass and a peltier thermoelectric module is proposed
- 3 experiments were conducted for the performance evaluation of the proposed device
- Experimental results shows that the developed device can be used to display surface texture and temperature together



Tactile and Thermal Display Unit

12:22–12:40 WeB4.5

Reality-Based Haptic Force Models of Buttons and Switches

Mark B. Colton
Department of Mechanical Engineering, Brigham Young University, USA
John M. Hollerbach
School of Computing, University of Utah, USA

- Presents a method for generating nonlinear, dynamic, haptic force models of passive mechanical devices
- Models are derived from experimental measurements on physical devices
- Model parameters are estimated using a modified recursive least-squares algorithm
- Results are presented for two push-button switches

Actuation of a push-button switch using an instrumented probe

Field Robotics: Planning and Navigation

Chair *Simon Lacroix, LAAS/CNRS*
Co-Chair *Richard Voyles, Univ. of Denver*

11:10–11:28 WeB5.1

Vegetation Detection for Driving in Complex Environments

David M. Bradley, Ranjith Unnikrishnan, and James Bagnell
Robotics Institute, Carnegie Mellon University, USA

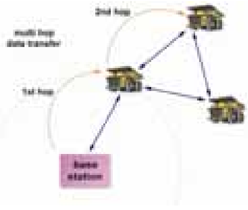
- Off-road environments require discrimination between rigid obstacles and non-rigid vegetation
- Vegetation has a distinctive signature in the red and near-infrared (NIR) bands
- We present experimental results quantifying how adding color and NIR features improved classification performance for an autonomous robot.

11:28–11:46 WeB5.2

Using Non-Parametric Filters and Sparse Observations to Localise a Fleet of Mining Vehicles

Stewart Worrall and Eduardo Nebot
Australian Center for Field Robotics, University of Sydney, Australia

- Localising vehicles in a mine is useful to efficiently manage resources.
- An ad-hoc mesh network is used to transfer information between vehicles.
- Data is collected and a graph representation of the mine is constructed.
- Two methods are implemented to localise vehicles using non-parametric filters.



Mesh network in a mine

11:46–12:04 WeB5.3

Simultaneous Localization and Mapping for Forest Harvesters

Mikko Miettinen, Matti Öhman, Arto Visala and Pekka Forsman
Automation Technology Laboratory,
Helsinki University of Technology, Finland

- Graph-based real-time SLAM algorithm for large forest environments
- Data association is based on the joint compatibility of a set of geometric constraints computed among neighboring features
- Generation of tree map for harvester operator support system and forest operation planning

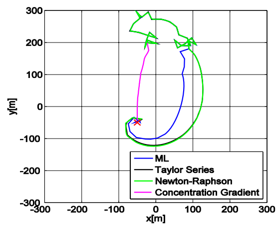
A commercial full-scale forest harvester

12:04–12:22 WeB5.4

Locating a Circular Biochemical Source: Modeling and Control

Panos Tzanos and Miloš Žefran
Dept. of Electrical and Computer Eng., University of Illinois at Chicago, USA

- Applies ***modified Fisher Information Matrix (FIM)*** algorithm to a circular biochemical source.
- Show that the source location is a ***unique*** equilibrium point of the system.
- Proposed algorithm compared to conventional concentration gradient motion algorithms.
- Simulations confirm that source is located with a high degree of accuracy.



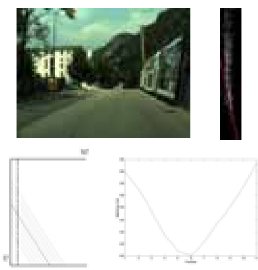
Robot trajectories for various parameter estimation methods

12:22–12:40 WeB5.5

Global Correlation Based Ground Plane Estimation UsingV-Disparity Image

Jun Zhao, Jayantha Katupitiya and James Ward
School of Mechanical and Manufacturing Engineering
The University of New South Wales, Sydney, NSW 2052, Australia

- Recently V-disparity image is widely used for ground plane estimation.
- Previous methods rely heavily on distinct road features.
- A global correlation method is introduced in this paper to estimate ground plane even without distinct road features.



A Common Benchmark of a Group of Parallel Kinematic Machines

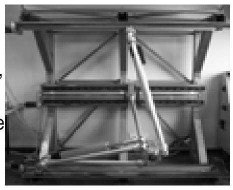
Chair *Geir Hovland, Agder Univ. Coll.*
Co-Chair *Damien Chablat, Univ.*

11:10–11:28	WeB6.1

Benchmark of the 3-DOF Gantry-Tau Parallel Kinematic Machine

*G. Hovland, **M. Choux, **M. Murray, ***T. Brogårdh
*Agder University College, **University of Queensland, ***ABB Robotics

- New, fast method for resonance frequencies
- Benchmark of stiffness, resonance, workspace, singularities, sensitivities
- Robot satisfies machining requirements in large sections of the workspace
- Main benefit: the large workspace-to-installation-space ratio

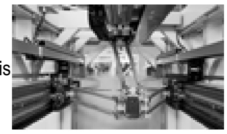

Gantry-Tau Prototype,
3-DOF and 5-DOF Motions

11:28–11:46	WeB6.2

Development of a Triglide-Robot with Enlarged Workspace

Christoph Budde, Philipp Last and Jürgen Hesselbach
Institute of Machine Tools and Production Technology,
Technical University Braunschweig, Germany

- Development and design issues of a Triglide-robot based on the linear delta are presented
- Robot's workspace to installation-space ratio is maximized by using workspaces of several assembly modes
- Structure is characterized using standardized criteria to benchmark it against similar structures presented in the same session


Prototype of Triglide-robot

11:46–12:04	WeB6.3

Kinematic and stiffness analysis of the Orthoglide, a PKM with simple, regular workspace and homogeneous performances

Anatoly Pashkevich[1], Philippe WENGER[2], Damien CHABLAT[2]
[1]Robotic Laboratory, Minsk, Belarus
[2]Institut de Recherche en Communications et Cybernétique de Nantes, France

- Kinematic and stiffness properties of the Orthoglide, a 3-axis Delta-type, overconstrained parallel kinematic machine.
- New method to analyse the translational and rotational stiffness, taking into account the overconstrained model.
- A benchmark against workspace to footprint ratio, velocity and force transmission factors, sensitivity to geometric errors, and translational and rotational stiffness .


Orthoglide
(©CNRS Photothèque/CARLSON Leif)

12:04–12:22	WeB6.4

Parallel Mechanisms of the Multipteron Family: Kinematic Architectures and Benchmarking

Clément M. Gosselin, Mehdi Tale Masouleh, Vincent Duchaine, Pierre-Luc Richard, Simon Foucault and Xianwen Kong
Département de Génie Mécanique, Université Laval, Canada

- Architectures of parallel mechanisms of the Multipteron family including a novel 5-DOF Pentapteron
- Benchmarking of the 3-DOF Tripteron: singularity-free, decoupled input-output, and maximum acceleration of 8 g
- Benchmarking of the 4-DOF Quadrapteron: singularities easily avoided; partially decoupled input-output; maximum acceleration of 5 g

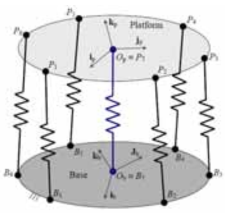

Parallel mechanisms of the multipteron family

12:22–12:40	WeB6.5

Static and Stiffness Analyses of a Class of Over-Constrained Parallel Manipulators with Legs of Type US and UPS

Rocco Vertechy and Vincenzo Parenti-Castelli
Mechanical Engineering Dept. (DIEM), University of Bologna, Italy

- Static and stiffness analyses of a class of over-constrained parallel manipulators obtained from architecturally singular mechanisms.
- Use of a symmetric stiffness matrix derived from the elastic potential energy, as an alternative to the Cartesian stiffness matrix.
- A case study of an over-constrained 2-dof parallel spherical wrist.



Elastic model of an over-constrained parallel manipulator

Contact Modelling and Touching

Chair *Pedro J Sanz, Jaume I*

Co-Chair *Ales Ude, ATR Computational Neuroscience Lab.*

11:10–11:28	WeB7.1

Probabilistic Estimation of Whole Body Contacts for Multi-Contact Robot Control

Anna Petrovskaya, Jaeheung Park, Oussama Khatib
Computer Science Dept., Stanford University, USA

- Just like humans, robots can benefit from utilizing whole body contacts
- Locating contact points is necessary for control, yet difficult as most robots do not possess skin
- Using our active sensing strategy robots can estimate link contacts even without skin
- Experiments show that performance is significantly improved with contact estimation

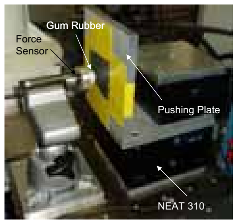
Humans use bracing to increase precision during fine manipulation tasks. It is known that bracing improves manipulator precision as well.

11:28–11:46	WeB7.2

Frictional Compliance Model Development and Experiments for Snake Robot Climbing

Amir Shapiro
Mechanical Engineering Dept., Ben Gurion University, Israel
Aaron Greenfield, Howie Choset
Robotics Institute, Carnegie Mellon University, USA

- A frictional contact model is needed to prevent slip, maintain balance, and provide stability during a robot's motion
- The model should be both accurate and simple enough to allow robotic system analysis
- We propose a simple parametric contact model, based on the form of the Hertz-Walton model
- Experimental results show that this model can be used for linear and near-linear loading paths
- We briefly discuss the applicability of the presented contact model for snake robot climbing



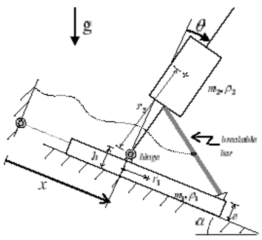
Experimental setup

11:46–12:04	WeB7.3

Experimental Verification and Graphical Characterization of Dynamic Jamming in Frictional Rigid-Body Mechanics

Daniel Meltz, Yizhar Or, and Elon Rimon
Dept. Of Mechanical Engineering, Technion, Israel

- Analysis of dynamic jamming in planar frictional mechanical systems
- General formulation of dynamic jamming conditions
- Geometric interpretation in terms of instantaneous center of acceleration
- Experimental system demonstrates dynamic jamming for the first time

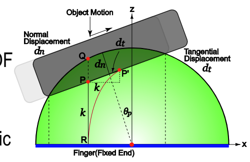


12:04–12:22	WeB7.4

Dynamic Stable Manipulation via Soft-fingered Hand

Takahiro Inoue and Shinichi Hirai
Department of Robotics, Ritsumeikan University, Japan

- An enhanced two-dimensional soft fingertip model is proposed.
- An elastic potential energy formula on a 2 DOF soft-fingered hand is derived.
- Equations of motion of the whole handling system including holonomic and nonholonomic constraints are written.
- Show that the stable manipulation is easily achieved in soft-fingered handling.



An enhanced two-dimensional fingertip model.

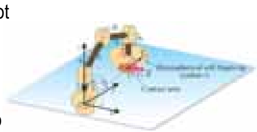
12:22–12:40	WeB7.5

On Control for "Blind Touching" by Human-Like Thumb Robots

Kenji Tahara[1], Suguru Arimoto[2,1], Zhi-Wei Luo[3,1], Morio Yoshida[1]

1 Bio-Mimetic Control Research Center, RIKEN, Japan
2 Ritsumeikan Univ., Japan
3 Kobe Univ., Japan

- Modeling a human-like 5 D.O.F. thumb robot with hemispherical soft finger-tip
- Considering 3-Dimensional non-holonomic rolling constraints
- Proposing a sensory-motor control signal to realize contact position and force control
- This control law, called "Blind Touching", does not require any external sensings



A human-like 5 D.O.F. thumb robot with hemispherical soft finger-tip

Session WeB8 | Aula 7 | Wednesday, 11 April 2007, 11:10–12:40

Surgical Robots

Chair *Alicia Casals, Tech. Univ. of Catalonia*

Co-Chair *Loredana Zollo, Biomedical Robotics & EMC Lab. - Univ. CampusBio-Medico*

11:10–11:28 WeB8.1

Lightweight Hand-held Robot for Laparoscopic Surgery

Francesco Focacci[1,2], Marco Piccigallo[2,1], Oliver Tonet[1,2], Giuseppe Megali[1,2], Andrea Pietrabissa[2], and Paolo Dario[1,2]

[1] CRIM Lab, Scuola Superiore Sant'Anna, Pisa, Italy

[2] EndoCAS Center for Computer-Assisted Surgery, University of Pisa, Italy

- We developed a hand-held robotic instrument for laparoscopic surgery
- It can be operated with one hand only, while standing at the operating table
- Its main advantages are low weight and end-effector switching capability
- It allows to approach sutures at a wider range of angles than conventional instruments

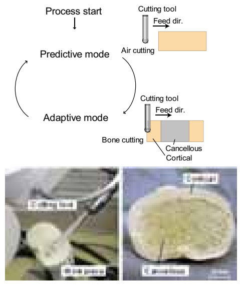
11:28–11:46 WeB8.2

Adaptive Controlled Milling Robot for Orthopedic Surgery

Naohiko Sugita, Fumiaki Genma, Yoshikazu Nakajima and Mamoru Mitsuishi

School of Engineering, The University of Tokyo, Japan

- In this study of robotic end milling during orthopedic surgery, the objectives were
  (1) Shortening of the cutting time
  (2) Detection of tool overload and protection from precision degradation and temperature elevation and
  (3) Improvement of machine safety by force control. In the minimally invasive joint replacement, a problem of tool collision came to the geometric one.



11:46–12:04 WeB8.3

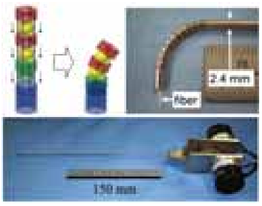
Bending Laser Manipulator for Intrauterine Surgery and Viscoelastic Model of Fetal Rat Tissue

Kanako Harada, Zhang Bo, Shin Enosawa, Toshio Chiba, and Masakatsu G. Fujie

Graduate School of Science and Engneering,Waseda Univ., JAPAN

National Center for Child Health Development, JAPAN

- The Bending Laser manipulator is 2.4mm in diameter, 2 DOF bending through 90 deg.
- The results of positioning test, *in vitro* test and *in vivo* test are reported.
- Viscoelastic features are evaluated for fetal rats compared to other soft organs (brain, lung and liver).



12:04–12:22 WeB8.4

A Novel Manipulator for 3D Ultrasound Guided Percutaneous Needle Insertion

H. Bassan, T. Hayes, R.V. Patel, and M. Moallem

Department of Electrical and Computer Engineering, The University of Western Ontario, London, Ontario, Canada

- Five degrees of freedom.
- ±20º motion about RCM point.
- 150mm linear motion and ± 180º rotary motion of needle.
- Backdrivable, low friction transmission with fully counterbalanced manipulator.
- Stationary actuators to reduce manipulator inertia.

12:22–12:40 WeB8.5

Development and Application of a New Steady-Hand Manipulator for Retinal Surgery

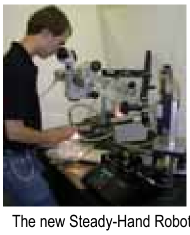
Ben Mitchell, Iulian Iordachita, Peter Kazanzides, Ankur Kapoor, Gregory Hager, and Russell Taylor

Computer Science Dept., Johns Hopkins University, USA

John Koo, M.D., James Handa, M.D.

Opthalmology Dept., Johns Hopkins Medical Institute, USA

- The Steady-Hand Robot is a co-operative manipulator for micro-surgical instruments
- The surgeon manipulates an instrument, and the robot helps to stabilize and guide it
- We have demonstrated the ability to perform retinal surgical tasks on a phantom using the robot system



The new Steady-Hand Robot

Bio-inspired Control

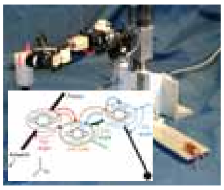
Chair *Koichi Koganezawa, Tokai Univ.*
Co-Chair *Xinyan Deng, Univ. of Delaware*

11:10–11:28 WeB9.1

Simple Muscle Models Regularize Motion in a Robotic Leg with Neurally-Based Step Generation

Brandon L. Rutter, William A. Lewinger, and Roger D. Quinn
Mech & Aero Engr and Electrical Engr, Case Western Reserve Univ., USA
Marcus Blümel and Ansgar Büschges
Animal Physiology, Inst. for Zoology, Univ. of Cologne, Germany

- In animals, the neural and mechanical systems work together to provide limb control
- Traditional control methods for legged robots tend to be complex to give this level of performance
- We control a 3-DOF robotic leg using SCASM, a simple neurally-based scheme
- Leg movements with this method are significantly regularized when simple muscle models are used in actuation

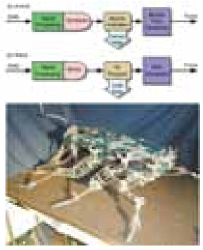

Our 3-DOF robotic leg with stick-insect based kinematics and control

11:28–11:46 WeB9.2

Transforming Insect Electromyograms into Pneumatic Muscle Control

Brandon L. Rutter and Roger D. Quinn
Mech. and Aero. Engineering, Case Western Reserve University, USA
Laiyong Mu and Roy E. Ritzmann
Biology, Case Western Reserve University, USA

- We use recorded cockroach EMGs to drive artificial muscle (BPA) activation for a single joint of a cockroach-inspired robot
- Parameters for a muscle activation model are found using hardware-in-the-loop error minimization
- Results from reduced-amplitude data strongly suggest that BPAs can be used in physical modeling

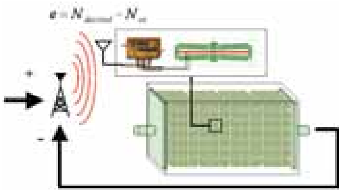


11:46–12:04 WeB9.3

Broadcast Feedback for Stochastic Cellular Actuator Systems Consisting of Nonuniform Actuator Units

Jun Ueda, Lael Odhner, and H. Harry Asada
Department of Mechanical Engineering, Massachusetts Institute of Technology

- Broadcast feedback for stochastic cellular actuator systems
- Robustness against nonuniform cellular length and/or nonuniform embedded transition probability

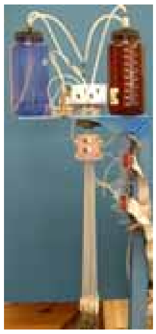


12:04–12:22 WeB9.4

Control of a Scalable Matrix Vasoconstrictor Device (MVD) for Wet Actuator Arrays

Leslie Flemming, Stephen Mascaro
Mechanical Engineering Department
University of Utah, USA

- The MVD is scalable device that has 2*n*+2 constrictors to control the fluid flow to an *nxn* array of wet SMA actuators.
- The ternary control logic of the MVD is presented that optimizes time response of the wet SMA actuators.
- The wet SMA actuators are treated as binary and are connected in series for discrete positioning.


Matrix Vasoconstrictor Device

12:22–12:40 WeB9.5

A Novel Type of Micropump Using Solenoid Actuator for Biomedical Applications

Shuxiang Guo, Jian Wang and Jian Guo
Faculty of Engineering, Kagawa University, Japan

- We propose □ a new prototype model of micropump using a solenoid actuator as the servo actuator.
- We also discussed the structure, characteristic measurement, flow evaluation and output pressure of the micropump.
- The proposed micropump is able to make a micro flow (200μl/min. ~ 1000μl/min.) and is suitable for medical applications.

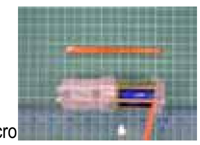


Fig. 1 Developed Micropump

Manufacturing Systems

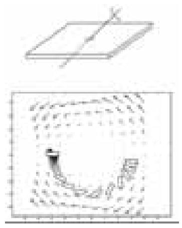
Chair *Dongjun Zhang, hong kong Univ. of science and Tech.*
Co-Chair *Fan-Tien Cheng, National Cheng Kung Univ.*

11:10–11:28 WeB10.1

Vibration-Induced Frictional Force Fields on a Rigid Plate

Thomas H. Vose, Paul Umbanhowar, and Kevin M. Lynch
Mechanical Engineering Dept., Northwestern University, USA

- Vibration of a rigid plate with 6 degrees-of-freedom gives rise to a broader class of programmable force fields than previously achievable.
- A linear squeeze field can be created on a plate using just a single actuator.
- Sensorless part orientation and transport is feasible by sequencing simple plate motion primitives.



11:28–11:46 WeB10.2

M³: Multiscale, Deterministic and Reconfigurable Macro-Micro Assembly System for Packaging of MEMS

Rakesh Murthy, Aditya N. Das, Dan Popa, Harry Stephanou
Automation & Robotics Research Institute,
The University of Texas at Arlington, USA

- M^3 is a 4-robot multiscale robotic platform used for modular and reconfigurable packaging applications of MEMS.
- M^3 implements kinematics calibration, inverse kinematics, and servoing using a microscope camera located on one of the robots.
- Experimental results of MOEMS assemblies with part sizes ranging from 126 μm to 30mm within tolerance band of 4 μm to 300 μm.

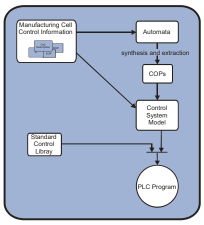
M^3 multiscale system uses a RobotWorld® air bearing platen and additional precision positioning hardware

11:46–12:04 WeB10.3

Implementing a Control System Framework for Automatic Generation of Mfg. Cell Controllers

Oscar Ljungkrantz, Knut Åkesson and Kristin Andersson
Dept. of Signals and Systems, Chalmers U. of Technology, Göteborg, Sweden
Johan Richardsson
Advanced Equipment Engineering, Volvo Car Corporation, Göteborg, Sweden

- Automatic generation of PLC programs for manufacturing cells.
- Reuses information from earlier design phases.
- Formal methods are used to generate control functions that by construction fulfill given specifications.
- General and object-oriented component structure. May generate PLC programs for different platforms.



12:04–12:22 WeB10.4

A New Solder Paste Inspection Device: Design and Algorithm

Xinyu Wu, Wingkwong Chung, Hang Tong,
Jun Cheng and Yangsheng Xu
Department of Automation and Computer-Aided Engineering,
The Chinese University of Hong Kong

- An innovative parallel solder paste inspection device using a mirrors box
- An accurate height acquisition algorithm using a hybrid weighting approach
- 2-D image synthesis by the use of inspection images to save inspection time

Solder paste inspection device

12:22–12:40 WeB10.5

Quality Evaluation in Flexible Machining Systems: A Flexible Fixture Case Study

Jingshan Li
Dept. of ECE, Univ. of Kentucky, Lexington, KY, USA
Ningjian Huang
General Motors R&D Center, Warren, MI, USA

- Flexibility has an impact on product quality.
- A quantitative model to evaluate quality in flexible production lines is developed based on Markov chain analysis.
- Quality performance under different sequence policies is investigated.
- A flexible fixture case study is introduced.

Constrained Path Planning

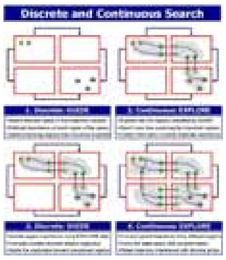
Chair *Zexiang Li, Hong Kong Univ. of Science and Tech.*
Co-Chair *Jing Xiao, UNC-Charlotte*

11:10–11:28 WeB11.1

A Motion Planner for a Hybrid Robotic System with Kinodynamic Constraints

Erion Plaku, Lydia E. Kavraki, and Moshe Y. Vardi
Department of Computer Science, Rice University
Houston, Texas, USA

- Motion planning for hybrid robotic systems is challenging: hybrid systems combine discrete and continuous dynamics
- This work integrates discrete searching with sampling-based motion planning for continuous spaces.
- The result is an effective motion planner especially well-suited for hybrid robotic systems with numerous modes and discrete transitions

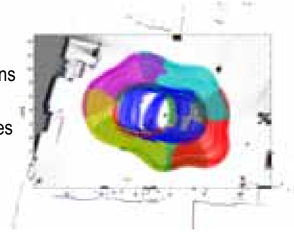


11:28–11:46 WeB11.2

Coverage Algorithms for an Under-actuated CarLike Vehiclein an Uncertain Environment

Michael Bosse, Navid Nourani-Vatani and Jonathan Roberts
Autonomous Systems Laboratory
CSIRO ICT Centre, Australia

- Coverage using spiral patterns
- Takes under-actuated vehicle limitations into account
- Deals with static and dynamic obstacles in unknown environments
- >95% coverage in real world experiments



Real World Coverage Result

11:46–12:04 WeB11.3

Greedy but Safe Replanning Under Kinodynamic Constraints

Kostas E. Bekris and Lydia E. Kavraki
Computer Science Dept., Rice University, Houston, TX

Greedy, Incremental, Path-Directed (GRIP) planner replans online for systems with dynamics:

Biased Tree Expansion with GRIP

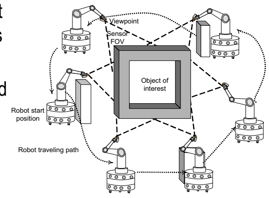
- **greedily** biases search while guaranteeing probabilistic **completeness**
- reuses computations from previous cycles
- guarantees **safety** by avoiding Inevitable Collision States (ICS)
- controls the cycle's duration and employs lazy evaluation to **minimize ICS related collision checking**

12:04–12:22 WeB11.4

View Planning Problem with Combined View and Traveling Cost

Pengpeng Wang[1], Ramesh Krishnamurti[2], and Kamal Gupta[1]
[1]RAMP Lab, School of Engineering Science; [2]School of Computing Science
Simon Fraser University, Canada

- We introduce the problem of view planning by a robot-sensor system with combined view and traveling cost, and formulate it as an integer linear problem.
- We develop an approximation algorithm that guarantees worst-case performance bounds w.r.t. the optimal solution cost.
- The algorithm is a linear program (LP) based rounding algorithm that achieves an approximation ratio of the order of view frequency, the maximum number of viewpoints that see a single object surface.
- We give a polynomial sized LP for the special case where the traveling graph is a tree.



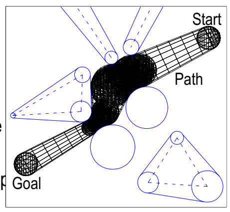
A schematic illustration with six viewpoints and a path to completely inspect the object surfaces

12:22–12:40 WeB11.5

Generation of Homotopic Paths for a Size-Changing Sphere

Enrique J. Bernabeu
Instituto de Automática e Informática Industrial.
Universidad Politécnica de Valencia, Spain

- Path planner for a mobile sphere between obstacles in narrow regions
- When a collision is detected, a collision-free intermediate position for the sphere is defined
- This sphere position is reduced or grown to be in contact with a second obstacle
- Homotopic paths are defined and they envelop the fee space between obstacles



Aerial Robotics: Identification and Control

Chair *Anibal Ollero, Univ. of Seville*
Co-Chair *Kimon Valavanis, Univ. of South Florida*

11:10–11:28	WeB12.1

Stabilization of a Small Unmanned Aerial Vehicle Model without Velocity Measurement

Sylvain Bertrand[1], Tarek Hamel[2] and Hélène Piet-Lahanier[1]
[1] Long-term Design and Systems Integration Department, ONERA, France
[2] I3S – UNSA – CNRS, France

- Stabilization of miniature Vertical Take Off and Landing Unmanned Aerial Vehicles
- No measurement of linear velocity nor angular velocity is available for control design
- The proposed approach is based on the introduction of virtual states in the system dynamics; no observer design is required
- Closed loop stability is ensured and performances are analyzed

11:28–11:46	WeB12.2

Bounded attitude stabilization: Application on four-rotor helicopter

J.F. Guerrero, H. Hably, N. Marchand and S. Lesecq
Control System Department,
GIPSA-Lab, CNRS-INPG-UJF, Grenoble, France

- Bounded global stabilizing control law for rigid body
- Quaternion-based representation
- Cascaded-saturation design

Four-Rotor helicopter prototype of GIPSA-Lab

11:46–12:04	WeB12.3

Autonomously Flying VTOL-Robots: Modeling and Control

Konstantin Kondak, Markus Bernard, Nicolas Meyer and Günter Hommel
Real-Time Systems and Robotics Group, Faculty of Electrical Engineering and Computer Science, Technische Universität Berlin, Germany

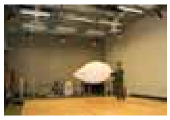
- Unified behavior description and control scheme for different kinds of VTOL-robots (e.g. helicopters and quad-rotors) are presented.
- Presented control scheme is based on linearization and decoupling using inversion of the system model blocks. Disturbances observer and compensator is used to enhance the control performance.
- Robot orientation is determined by means of reduced state observer without using accelerometers.
- Results from flight experiments with helicopters and quad-rotors are presented.

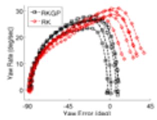
12:04–12:22	WeB12.4

Gaussian Processes and Reinforcement Learning for Identification and Control of an Autonomous Blimp

Jonathan Ko [*] Daniel Klein [+] Dieter Fox [*] Dirk Haehnel [**]
[*]Dept. of CSE, Univ. of Washington
[+]Dept. of Aero/Astro, Univ. of Washington
[**]Intel Research Seattle

- Dynamics of blimps are highly non-linear
- *Gaussian process (GP) regression* to learn non-parametric model of blimp dynamics
- GP provides accurate prediction model along with *uncertainty estimates*
- Combination with *deterministic non-linear model* produces further improvements
- Prediction model used to learn controller via *reinforcement learning*





GP prediction improves accuracy of learned controller

12:22–12:40	WeB12.5

A Reinforcement Learning Approach to Lift Generation in Flapping MAVs: Experimental Results

Mehran Motamed
Motion Metrics International Corp., Vancouver, BC, CA
Joseph Yan
Department of Electrical and Computer Engineering, UBC, Vancouver, BC, CA

- Previously the RL framework for MAV control and the simulation results using a quasi-steady model has been presented by the authors.
- A dynamically scaled model has been built based on *Drosophila melanogaster* as a prototype.
- Flapping flight has been experimentally found by RL on the scaled model.
- A Comparison between a biological *Drosophila m.* and the experimental results has been discussed.

Multirobot Exploration

Chair *Gaurav Sukhatme, Univ. of Southern California*
Co-Chair *Zack Butler, Rochester Inst. of Tech.*

14:10–14:28 WeC1.1

Adaptive Sampling for Multi-Robot Wide-Area Exploration

Kian Hsiang Low, Geoffrey J. Gordon, John M. Dolan, and Pradeep Khosla
Carnegie Mellon University, USA

- This work describes an adaptive exploration strategy for large environments with hotspots
- It yields more information about the environment by directing exploration towards hotspots and incurs lower resource costs
- Rao-Blackwellized estimators provide more accurate estimates of environmental properties
- This work analyzes the characteristics and distribution of the environmental phenomena that favor the adaptive strategy and estimators

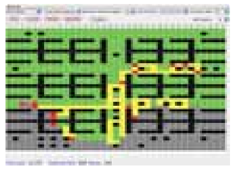

Multi-robot mineral prospecting

14:28–14:46 WeC1.2

Brick&Mortar: an on-line multi-agent exploration algorithm

Ettore Ferranti, Niki Trigoni and Mark Levene
SCSIS, Birkbeck College, University of London, UK

- Emergency scenario (CBRNE event)
- No localization, no radio communication among agents
- Area divided into cells
- Distributed exploration algorithm that visits each cell at least once in the minimum amount of time.

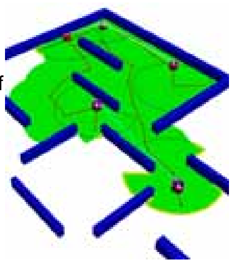

Simulation suite

14:46–15:04 WeC1.3

A Randomized Strategy for Cooperative Robot Exploration

A. Franchi, L. Freda, G. Oriolo and M. Vendittelli
DIS, Università di Roma "La Sapienza", Italy

- A cooperative exploration strategy for a team of mobile robots based on the parallel construction of Sensor-based Random Trees (SRTs)
- Each robot tends to move towards the frontier of its perceived Local Safe Region
- Decentralized cooperation and coordination guarantee efficiency and safe collective motion even with limited communication ranges
- Robots that have completed their individual exploration proceed to support others



15:04–15:22 WeC1.4

Exploring Mars Using a Group of Tumbleweed Rovers

Lori Southard*, Thomas Hoeg*, Daniel Palmer**, Jeffry Antol†, Richard Kolacinski††, and Roger Quinn*
*Mechanical Engr. Dept., Case Western Reserve University, Cleveland, OH
**John Carroll University, University Heights, OH
† NASA Langley Research Center, Hampton, VA
††Charles Stark Draper Laboratory, Cambridge, Ma

•Most geologically interesting places are far from suitable Mars landing sites
•Wind can propel rovers great distances
•A dynamic model of an individual Tumbleweed rover enhances a stochastic simulation of multiple rovers traversing Mars
•A group of rovers equipped with minimal control mechanisms can autonomously disperse and explore Mars


Group of Tumbleweeds in Mars Dao Vallis

Vision Hardware

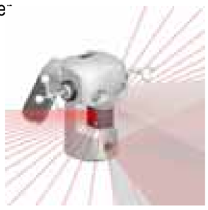
Chair *Kok-Meng Lee, Georgia Inst. of Tech.*
Co-Chair *Yoshihiro Watanabe, The Univ. of Tokyo*

14:10–14:28	WeC2.1

The 3D-Modeller: A Multi-Purpose Vision Platform

M. Suppa, S. Kielhöfer, J. Langwald, F. Hacker, K. H. Strobl, and G. Hirzinger
Institute for Robotics and Mechatronics,
German Aerospace Center (DLR), Germany

- Multi-sensor data acquisition: stereo vision, lase- range sensing, laser-stripe profiler, texture.
- Light-weight integrated mechatronic system for both robotic and manual operation.
- Low latency communication and *novel* synchronization concept.
- Applications: sensor-based exploration, surface model generation, object recognition, tracking, pose estimation.



14:28–14:46	WeC2.2

Realtime and Robust Motion Tracking by Matched Filter on CMOS+FPGA Vision System

Kazuhiro Shimizu and Shinichi Hirai
Department of Robotics, Ritsumeikan University,
Kusatsu, Shiga 525-8577, Japan

- 1,000Hz visual feedback using the □ CMOS+FPGA vision.
- Implementing matched filter algorithm on the CMOS+FPGA vision to detect the translation.
- 0.647ms for the matched filter between two 64x64 images.
- Realtime and robust detection against change of illumination, occlusion, and background texture.

CMOS+FPGA vision system

14:46–15:04	WeC2.3

Realtime collision avoidance using a robot manipulator with light-weight small high-speed vision systems

Sho Morikawa,Taku Senoo,Akio Namiki,Masatoshi Ishikawa
University of Tokyo Graduate School of Information Science and Technology
Department of Information Physics and Computing

- A new realtime collision avoidance algorithm based on a new visual servo control
- A robot manipulator can avoid a fast moving object
- This visions are placed on the surface of the manipulator
- An avoidance trajectory of the arm link describes a spiral

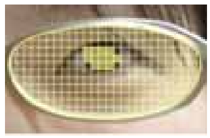
Avoidance trajectory (piled)

15:04–15:22	WeC2.4

Wearable Line-Of-Sight Detection System Using Dye-Sensitized Photovoltaic Devices

Takeshi Shigeoka and Norihisa Miki
Mechanical Engineering Dept., Keio University, Japan

- Detection of line-of-sight (LOS) has a variety of applications, such as communication tools
- We propose a novel wearable LOS detection system using dye-sensitized photovoltaic devices
- This system detects the reflection light from the pupils and white of the eyes
- This system affects the users as little as possible both physically and mentally



Conceptual view of the wearable LOS detection system

Micro/Nano Robots II

Chair *Lixin Dong, Swiss Federal Inst. of Tech. (ETH), Zurich*
Co-Chair *Max Meng, The Chinese Univ. of Hong Kong*

14:10–14:28 WeC3.1

Gel-tool Sensor Positioned by Optical Tweezers for Local pH Measurement in a Microchip

Hisataka Maruyama, Toshio Fukuda
Department of Micro-Nano Systems Engineeering, Nagoya University, Japan
Fumihito Arai
Department of Bioengineering and Robotics, Tohoku University, Japan

- We developed a novel on-chip measurement technique using gel-tool impregnated a pH indicator.
- We succeeded in fabrication of gel-tool impregnated a pH indicator within a few minutes.
- We succeeded in measurement of local pH value by manipulation and location of gel-tool.
- This measurement method will make great contributions for life science.

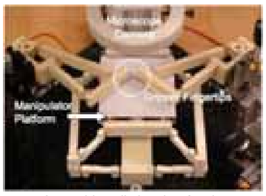
pH sensing gel-tool for local pH measurement

14:28–14:46 WeC3.2

Rapidly Prototyped Orthotweezers for Automated Microassembly

A. M. Hoover
Mechanical Engineering Dept., University of California, Berkeley, USA
R. S. Fearing
Electrical Engineering and Computer Science Dept., University of California, Berkeley, USA

- Low-cost integrated microassembly cell
- 2 DOF compliant parallel kinematic manipulator
- Servo-actuated compliant Orthotweezers gripper for microparts
- Automated vision-based calibration



Assembly cell showing 2 axis stage, compliant gripper, and low-cost vision system

14:46–15:04 WeC3.3

Polymer sensorised microgrippers using SMA actuation

Keith Houston, Clemens Eder, Arne Sieber, Arianna Menciassi, Maria Chiara Carrozza, Paolo Dario

Scuola Superiore Sant'Anna, Pisa, Italy

- Microgripper actuated by SMA wire
- Gripper structure and strain gauges combined in one moulding step
- Low cost and mass producable
- Robust, all sensors and wiring embedded in polymer

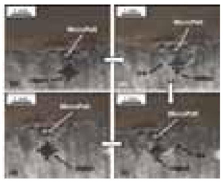

Force sensorised microgripper

15:04–15:22 WeC3.4

A Submerged Freeze Microgripper for Micromanipulations

Beatriz López Walle, Michaël Gauthier, and Nicolas Chaillet
Laboratoire d'Automatique de Besançon,
UMR CNRS 6596 – ENSMM – UFC, France

- Interest of liquid medium for micro-assembly.
- A freeze gripper for submerged micromanipulations: interest, principle, prototype, and experimental manipulations.
- Static thermal modelling using electrical analogy.


Micromanipulation with the submerged freeze gripper

Haptics and Interfaces

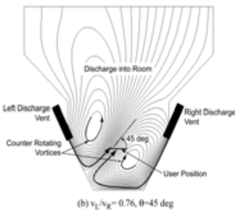
Chair *Rajni Patel, The Univ. of Western Ontario*
Co-Chair *Alessandro Macchelli, Univ. of Bologna*

14:10–14:28	WeC4.1

Output Feedback Control of Wind Display in a Virtual Environment

Sandip Kulkarni, Mark Minor, Mark Deaver and Eric Pardyjak
Mechanical Engineering, University of Utah, USA

- Goal: Controlled air flow (speed and heading) at the user's position in the Treadport Active Wind Tunnel (TPAWT) haptic interface.
- Implementation of the Small Gain Theorem an dynamic extension for output feedback control
- Simulations using CFD and experiments on scaled test-bed evaluate control system.



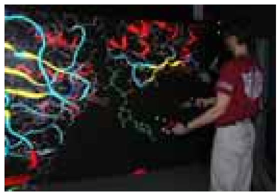
Wind Stream function plots

14:28–14:46	WeC4.2

6 DOF haptic feedback for molecular docking using wave variables

Bruno Daunay, Alain Micaelli
Laboratoire Simulation Interactive, CEA LIST, France
Stéphane Régnier
Laboratoire de Robotique de Paris, CNRS UPMC, France

- Real time haptic interaction even in the case of classical molecular simulation
- Energetic descritpion of the force field
- Macro transcription of nano forces
- Wave variables : Robust solution to ensure stability even if the simulation has a time delayed response



14:46–15:04	WeC4.3

Intuitive command of manipulators in micro-scale tasks

Andrew Shacklock, Matthew Pritchard, Hong Luo and Wei Lin
Singapore Institute of Manufacturing Technology
Etienne Burdet
Imperial College London and National University of Singapore

- Visualisation tools to reduce operator strain of microscope navigation.
- Techniques for viewing through occluding structure.
- Haptic feedback to assist contact tasks in conditions of poor depth perception.

15:04–15:22	WeC4.4

A Survey of Commercial & Open Source Unmanned Vehicle Simulators

Jeff Craighead, Robin Murphy, Jenny Burke
Computer Science and Engineering Dept., University of South Florida, USA

- Brief review of 14 commercial and open source computer based robot simulators
- Identify four important factors for choosing a simulator
- Rate the reviewed simulators based on the four factors

USARSim
X-Plane
FlightGear
MS Flight Simulator
Webots
Simbad
Player/Stage
eyeWyre
MS Robotics Studio
MATLAB
MissionLab
SimRobot
SubSim
Unity

Intelligent Transportation Systems

Chair *Kjerstin Williams, Applied Minds, Inc.*
Co-Chair *Alberto Broggi, Univ. of Parma*

14:10–14:28 WeC5.1

Integrated Design Methodology for an Automated Transportation System in a Seaport Terminal

Satoshi Hoshino
Chemical Resources Laboratory, Tokyo Institute of Technology, Japan
Jun Ota
Department of Precision Engineering, The University of Tokyo, Japan

- An automated transportation system in a seaport terminal as shown in the figure is an design object.
- We propose an integrated design methodology.
- Machines' specifications are appropriately designed for an imposed demand in addition to the number of machines, system layout, and management model.

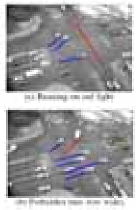
An automated transportation system in a seaport terminal

14:28–14:46 WeC5.2

Detecting Unusual Activities at Vehicular Intersections

Joaquín Salas, Hugo Jiménez, Joel Gonzalez-Barbosa and Juan B. Hurtado-Ramos
CICATA-IPN

- Activity vehicular intersection modeling with the alm of detecting unusual events
- We present methods to detect, track and model the activity of moving objects.

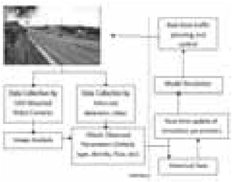


14:46–15:04 WeC5.3

Generating Traffic Statistical Profiles Using Unmanned Helicopter- Based Video Data

Anuj Puri, Kimon Valavanis, and Michael Kontitsis
Department of Computer Science and Engineering,
University of South Florida, Tampa, FL, USA

- Small unmanned vertical take off and landing vehicles for traffic monitoring
- Dynamic spatial-temporal visual data collection in real-time
- Traffic-related statistical profile generation
- Calibration and update of traffic simulation models to achieve improved accurate results

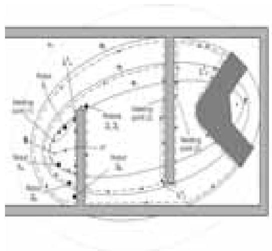


15:04–15:22 WeC5.4

MRBUG: A Competitive Multi-Robot Path Finding Algorithm

Shahar Sarid and Amir Shapiro
Mechanical Engineering Dept., Ben-Gurion University, Israel
Yoav Gabriely
Mechanical Engineering Dept., Technion, Israel

- On-line motion planning Algorithm for a group of robots searching for a path
- A known target position in an a priori unknown planar environment
- **Any** multi-robot on-line navigation algorithm in an unknown environment must have at least a **quadratic** competitive performance
- **MRBUG** achieves the quadratic competitive complexity and thus **optimal**



Parallel Kinematic Machines: Kinematics

Chair *Jorge Angeles, McGill Univ.*
Co-Chair *Federico Thomas, UPC-CSIC*

14:10–14:28	WeC6.1

Accuracy of Kinematic and Dynamic Models of a Gantry-Tau Parallel Kinematic Robot

Isolde Dressler, Anders Robertsson and Rolf Johansson
Department of Automatic Control, LTH, Lund University, Sweden

- Presentation of a new, more accurate kinematic model for the Gantry-Tau robot
- Development of a dynamic model
- Improved positioning accuracy of the new kinematic model shown by a calibration experiment
- Use of dynamic model in control improved tracking performance in simulations

Gantry-Tau robot prototype (in the left of the picture)

14:28–14:46	WeC6.2

Accuracy Analysis of General Parallel Manipulators with Joint Clearance

Jian Meng, Dongjun Zhang, Tinghua Zhang, Wang Hong and Zexiang Li

Department of Electrical and Computer Engineering
Hong Kong University of Science and Technology
Clear Water bay, Hong Kong, P.R.China

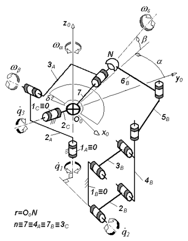
- A general and efficient approach is proposed for accuracy analysis of general parallel manipulators (no matter overconstraining or non-overconstraining, spatial or planar)
- Formulated as the convex optimization problem, the algorithm is capable to compute the global maximal pose error of a parallel mechanism, other than just at one theoretical configuration

14:46–15:04	WeC6.3

Fully-isotropic Three-degree-of-freedom Parallel Wrists

Grigore Gogu
Mechanical Engineering Research Group, French Institute of Advanced Mechanics and Blaise Pascal University, Clermont-Ferrand, France

- The paper presents for the first time fully-isotropic 3-dof parallel wrists (PWs)
- Fully-isotropic PWs are useful in applications of orienting and tracking an object in space.
- A new method for structural synthesis of 3-dof PWs founded on the theory of linear transformations.

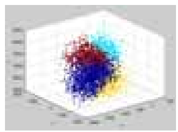


15:04–15:22	WeC6.4

Real-Time Forward Kinematics Solutions for General Stewart Platforms

Mahmoud Tarokh
Department of Computer Science,
San Diego State University, U.S.A.

- A novel approach based on random configuration generation, decomposition, classification and approximation.
- Immune to problems such as local minima, initial estimates, solutions with imaginary parts.
- Applicable to general platforms with no restrictions on geometry.
- Finds all solutions extremely fast.



Solutions classification

Hand Design

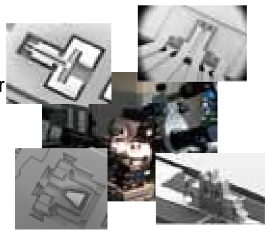
Chair *Kenneth John Waldron, Stanford Univ.*
Co-Chair *Toru Omata, Tokyo Inst. of Tech.*

14:10–14:28	WeC7.1

Design Tradeoffs for Electrothermal Microgrippers

Mohammad Mayyas, Ping Zhang, Woo H. Lee,
Panos Shiakolas and Dan Popa
Automation & Robotics Research Institute,
The University of Texas at Arlington, Fort Worth, Texas

- Development of multipurpose micro to meso end-effectors.
- A microheater embedded microgripper for soldering of microparts
- Characterization of dynamic performance of microgrippers



14:28–14:46	WeC7.2

Development of Multi-fingered Hand for Life-size Humanoid Robots

Kenji Kaneko, Kensuke Harada, and Fumio Kanehiro
National Institute of Advanced Industrial Science and Technology, Japan

- Multi-fingered hand, which is modularized and can be attached to life-size humanoids
- Life-size hand with 4 fingers
- 17 joints (13 D.O.F.)
- Designed hand so as to realize about 8 [N] forces on the pad point of stretched finger

Developed hand

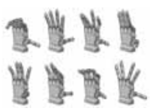
Humanoid robot: HRP-3P with developed hand

14:46–15:04	WeC7.3

SBC Hand: A Lightweight Robotic Hand with an SMA Actuator Array implementing C-segmentation

Kyu-Jin Cho, Josiah Rosmarin, and H. Harry Asada
Mechanical Engineering Dept.,
Massachusetts Institute of Technology, USA

- Dimensionality Reduction using Nonnegative Matrix Factorization
- C-segment for grouping the cells of Cellular Actuator Array
- Total Weight less than 1kg, 16 DOF
- Control a Robotic hand with 8 ON-OFF Binary Signals



8 C-segment Postures

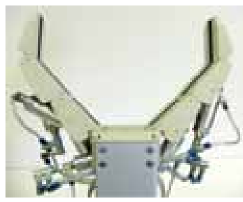
Robotic Hand

15:04–15:22	WeC7.4

Mechanical Design of a New Pneumatically-Driven Underactuated Hand

Vincent Bégoc, Sébastien Krut, Etienne Dombre
and François Pierrot
Robotics Dept., LIRMM, France
Claude Durand
B+ Equipment, France

- the TWIX Hand is highly underactuated: 6 dof and a single pneumatic input
- form-closure capable, justified by a new method dedicated to the study of underactuated grasps
- ejection free, thanks to non-backdrivable mechanisms



Teleoperation in Medical Procedures

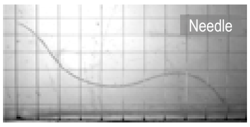
Chair *Shahin Sirouspour, McMaster Univ.*
Co-Chair *Antonio Frisoli, Scuola Superiore Sant'Anna*

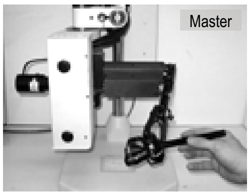
14:10–14:28	WeC8.1

Teleoperation of Steerable Needles

Joseph M. Romano, Robert J. Webster III, Allison M. Okamura
Mechanical Engineering, Johns Hopkins University, USA

- Development of Position, Rate, and Ballistic control for teleoperation of steerable needles.
- Improved targeting accuracy with Ballistic technique.
- Classification of human path planning strategies in complex task environment.
- Paves the way for clinical adoption of steerable needles.



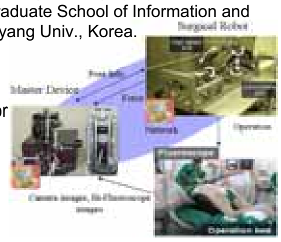


14:28–14:46	WeC8.2

A Noble Bilateral Teleoperation System for Human Guided Spinal Fusion

Keehoon Kim[1], Jongwon Lee[2], Wan Kyun Chung[2], Seungmoon Choi[3], Young Soo Kim[4] and Il Hong Suh[5]
[1]Laboratory for Intelligent Mechanical Systems, Northwestern Univ., USA. [2]Robotics and Bio-mechatronics Lab., POSTECH, Korea. [3]Laboratory for Virtual Reality, POSTECH, Korea. [4]Center for Intelligent Surgery System, School of Medicine, Hanyang Univ., Korea. [5]Graduate School of Information and Communications, Hanyang Univ., Korea.

- Bilateral teleoperation system that supports spinal fusion surgery
- Development of an adequate end effector for spinal fusion that can substitute the surgeon's manual operation
- Surgical robot designed for orthopedic surgical tasks that require resisting large reaction forces



14:46–15:04	WeC8.3

Development of a Master Slave System with Force Sensing Using Pneumatic Servo System for Laparoscopic Surgery

Kotaro Tadano and Kenji Kawashima
Tokyo Institute of Technology, Japan

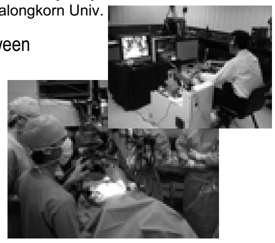
- A pneumatic manipulator for supporting forceps for laparoscopic surgery is developed.
- A master manipulator using delta mechanism and gimbal mechanism is developed.
- Impedance control is applied to the master-slave system for safe operation.
- Experimental results of the system are presented.

15:04–15:22	WeC8.4

A remote surgery experiment between Japan and Thailand over Internet using a low latency CODEC system

Jumpei Arata, Hiroki Takahashi, Phongsaen Pitakwatchara, Shin'ichi Warisawa, Kazuo Tanoue, Kozo Konishi, Satoshi Ieiri, Shuji Shimizu, Naoki Nakashima, Koji Okamura, Yuichi Fujino, Yukihiro Ueda, Pornarong Chotiwan, Mamoru Mitsuishi and Makoto Hashizume
Nagoya Inst. Of Tech, The Univ. Of Tokyo, Kyushu Univ.
NTT, NTT Com, Chulalongkorn Univ.

- Remote surgery experiment on a pig between Japan and Thailand over Internet
- Using the master slave system for MIS
- Newly developed low latency CODEC
- Lapacol was successfully performed:
  Time-delay of control signal: 124.7 ms
  Time-delay of image and audio: 540 ms (round-trip)



Bio-inspired Design

Chair *Mark Cutkosky, Stanford Univ.*
Co-Chair *Bryan Jones, Mississippi State Univ.*

14:10–14:28 WeC9.1

Micro Autonomous Robotic Ostraciiform (MARCO): Design and Fabrication

Parasar Kodati, Jonathan Hinkle, and Xinyan Deng
Mechanical Engineering Dept., University of Delaware, USA

- Recent biological observations demonstrate that the boxfish (class Ostraciiform) is highly stable and maneuverable.
- Body shape simulations used to determine characteristics important for self correcting vortices.
- Flapping fin experiments used to design shape and flexibility of the caudal fin.
- Robotic prototype design based on the above studies presented.

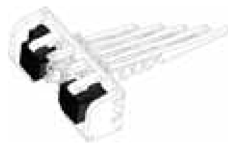
Bio-inspired Design Process

14:28–14:46 WeC9.2

Design of a Biomimetic Controlled-Curvature Robotic Pectoral Fin

John Palmisano, Ravi Ramamurti, Jonah Cohen, William Sandberg, and Banahalli Ratna
Naval Research Laboratory, Washington DC, USA
Kerr-Jia Lu
Dept. Of Mechanical and Aerospace Eng., George Washington Uni., USA

- Actuation of deformable fin, based on bird wrasse pectoral fin, successfully demonstrated
- 3D unsteady CFD force time-histories and velocity fields compared with experimental data and flow visualization
- Key design parameters identified
- Controlled fin curvature shown to produce greater thrust than passive fin curvature



Biomimetic Pectoral Fin

14:46–15:04 WeC9.3

Design and Control of a Fish-like Robot Using an Electrostatic Motor

Zu Guang Zhang, Masahiko Gondo, Norio Yamashita, Akio Yamamoto, and Toshiro Higuchi
Department of Precision Engineering, Graduate School of Engineering, The University of Tokyo, JAPAN

- Several ***biological concepts*** are considered in the design of the fish-like robot.
- A novel 2-4-phase ***electrostatic film motor*** is invented to actuate the robot.
- A ***muscle function*** of real fish is imitated by using the novel actuator and a sophisticated power transmission system.
- Fast and stable fish-like locomotion can be achieved with an ***open-loop*** actuation pattern.

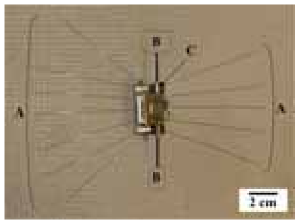
A fish-like robot using an electrostatic film motor

15:04–15:22 WeC9.4

STRIDE: A Highly Maneuverable and Non-Tethered Water Strider Robot

Yun Seong Song and Metin Sitti
NanoRobotics Lab, Carnegie Mellon University

- A highly maneuverable and non-tethered water strider robot, called STRIDE, is proposed.
- Repulsive surface tension force on 0.33 mm diameter Teflon® coated supporting legs with an optimal shape lifts the robot.
- The 6.13 gr non-tethered robot with twelve supporting legs demonstrated a linear motion of 8.7 cm/s and a rotational motion of 0.8 rad/s.



Discrete Event Systems and Scheduling

Chair *Pedro Lima, Inst. Superior Técnico*
Co-Chair *Jingshan Li, Univ. of Kentucky*

14:10–14:28	WeC10.1

Scheduling Analysis of Cluster Tools with Buffer/Process Modules

J. Yi[1], S. Ding[2], D. Song[3], and M. T. Zhang[4]
[1]Dept of ME, San Diego State University, USA
[2]Dept of IEOR, University of California at Berkeley, USA
[3]Dept of CS, Texas A&M University, USA
[4]AzFSM Industrial Eng., Intel Corporation, USA

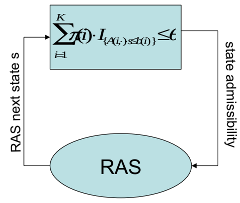
- Scheduling and throughput analyses for multi-cluster tools with buffer/process modules for semiconductor manufacturing.
- A decomposition method for analytical optimal schedules and throughput calculation.
- Experimental validations at Intel Corporation.

14:28–14:46	WeC10.2

Generalized Algebraic Deadlock Avoidance Policies for Sequential Resource Allocation Systems

Spyros Reveliotis
School of Industrial & Systems Engineering, Georgia Tech, USA
Elzbieta Roszkowska
Institute of Comp. Eng., Control and Robotics, Wroclaw Univ. of Tech., Poland
Jin Young Choi
Digital Communications Infra Division, Samsung Networks Inc., Korea

- *Algebraic* DAPs are defined by systems of linear inequalities on the RAS state.
- A *design methodology* for computing the most "efficient" DAP under a restriction of the number of the employed inequalities.
- Extension of the concept of algebraic DAP and of the relevant design methodology so that the derived policies can admit *non-convex* sub-spaces.



14:46–15:04	WeC10.3

Optimal Admission Polices for a Retailer of Seasonal Products with Drop-Shipping

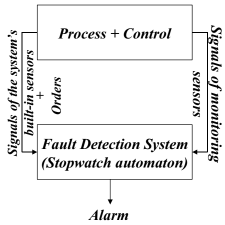
Frank Y. Chen
Dept. of Systems Engineering \& Engineering Management,
The Chinese University of Hong Kong
Yhchen@se.cuhk.edu.hk
Jian Chen & Yongbo Xiao
School of Economics and Management, Tsinghua University, Beijing, China
{chenj, xiaoyb}@sem.tsinghua.edu.cn

15:04–15:22	WeC10.4

Monitoring of a Class of Timed Discrete Events Systems

Adib ALLAHHAM and Hassane ALLA
GIPSA-LAB, Control system Dept., Institute National Polytechinque de Grenoble, France

- Extend the notion of residuals applied in the continuous system to the TDES.
- Main result is the detection the system faults as early as.
- The monitoring system is based on stopwatch automata model.
- Reachability analysis techniques of stopwatch automata are used to delimit the range of normal behavior in each system's situation



Structure of proposed monitoring system

Path Planning

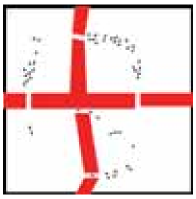
Chair *Lydia Kavraki, Rice Univ.*
Co-Chair *Kevin M. Lynch, Northwestern Univ.*

14:10–14:28	WeC11.1

Motion Planning of Multiple Agents in Virtual Environments on Parallel Architectures

Yi Li and Kamal Gupta
Robotic Algorithms & Motion Planning (RAMP) Lab
School of Engineering Science, Simon Fraser University
Burnaby, BC, V5A 1S6, Canada

- Parallelize our hybrid two-layered approach for motion planning of multiple agents on a Symmetric Multiprocessing (SMP) system.
- Construct and process multiple Coordination Graphs (CG) in parallel based on the Supervisor-Worker paradigm.
- Good parallel efficiency is achieved by reducing the parallel overhead to a minimum.
- Significant, scalable speedups are obtained.



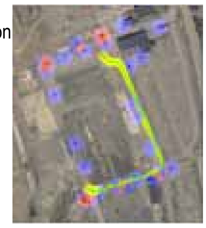
50 agents' motions are planned in real-time and in parallel.

14:28–14:46	WeC11.2

Planning with Uncertainty in Position Using High-Resolution Maps

Juan Pablo Gonzalez and Anthony Stentz
Robotics Institute
Carnegie Mellon University, USA

- Uses high-resolution maps to enable navigation in outdoor environments without GPS
- Calculates optimal paths and uses landmarks to localize as part of the planning process
- Reduces or eliminates the need for GPS and enables the use of prior maps with imperfect map registration

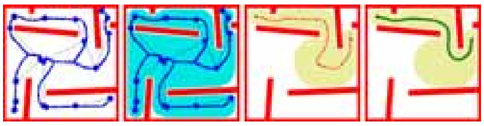


14:46–15:04	WeC11.3

The Corridor Map Method: Real-Time High-Quality Path Planning

Roland Geraerts and Mark H. Overmars
Department of Information and Computing Sciences
Utrecht University, the Netherlands

- We present a new framework for path planning using *corridors*
- Global motions are directed by a high-quality roadmap graph
- Local motions are controlled by potential fields inside corridors
- Smooth and short paths are provided while avoiding obstacles in real-time



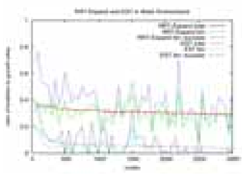
High-quality graph Corridor map Corridor Smooth path

15:04–15:22	WeC11.4

Analysis of the Evolution of C-Space Models built through Incremental Exploration

Marco Morales, Roger Pearce, Nancy M. Amato
Parasol Laboratory, Department of Computer Science
Texas A&M University, College Station, Texas, USA

- Enable qualitative analysis of models of C-Space produced by incremental exploration motion planners
- Applicable for motion planners that incrementally sample valid robot placements and motions
- Evolution of model characterized by the efficiency in which new areas of C-Space are explored at local and global levels
- Results shown for RRT-Expand, RRT-Connect, EST, and RPP



Caption is optional, use Arial Narrow 20pt

Aerial Robotics: Motion Planning

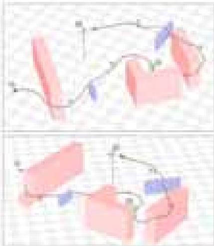
Chair *Phillip McKerrow, Univ. of Wollongong*
Co-Chair *Tarek Hamel, UNSA-CNRS*

14:10–14:28	WeC12.1

Efficient Two-Phase 3D Motion Planning for Fixed-Wing UAVs

Myung Hwangbo, James Kuffner, and Takeo Kanade
Robotics Institute, Carnegie Mellon University, USA

- Two-phase real-time motion planning for 3D air slalom tasks in environments with obstacles.
- The first phase of the planner computes a global path via a 3D grid of kinematically feasible motions.
- The second phase involves a local planner that interconnects precomputed sets of dynamic motion primitives at the fine level.
- New heuristic introduced based on 2D Dubins curves that can account for altitude changes.


3D slalom results

14:28–14:46	WeC12.2

3-D Path Planning and Target Trajectory Prediction for the Oxford Aerial Tracking System

Heiko Helble and Stephen Cameron
Computing Laboratory, Oxford University, UK

- Autonomous robotic helicopter designed to track moving ground obstacles
- Path planner based on superquadratic potential fields, uses height change mechanism to avoid local minima
- Can predict target trajectory when occluded using an artificial neural network

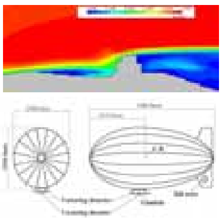

3-D Path Planning

14:46–15:04	WeC12.3

Method for Designating the Wind Condition in MDP-based Motion Planning of Under-actuated Blimp type UAV

Hiroshi Kawano
NTT Communication Science Lab., NTT Corporation, Japan

- Simple rule for estimating the distribution of disturbed wind velocity from obstacle geometry.
- The method is applied to the motion planning of blimp type UAV flying in boundary layer.
- The proposed method is suitable for MDP based stochastic motion planning.
- Examination by CFD based simulation shows high performance of the method.

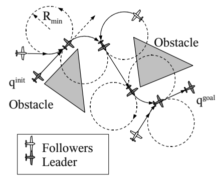


15:04–15:22	WeC12.4

Trajectory Generation for Rendezvous of UAVs with Kinematic Constraints

Jin-Wook Lee and H. Jin Kim
Institute of Advanced Aerospace Technology, School of Mechanical and Aerospace Engineering, Seoul National University, Korea

- Rendezvous plan for an UAV team to form a formation
- Modified Visibility Graph (MVG) to consider the separation from obstacles and the turning radius constraint
- Advanced velocity tuning when searching MVG to consider inter-vehicle collision and the bounded velocity constraint



Rendezvous of an UAV team to form a formation

Multirobot Control

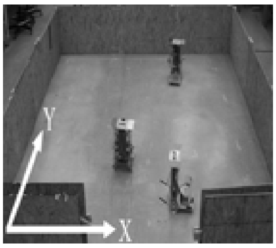
Chair *George Bekey, Univ. of Southern California*
Co-Chair *James Kuffner, Carnegie Mellon Univ.*

15:28–15:46	WeD1.1

Remote Formation Control and Collision Avoidance for Multi-Agent Nonholonomic Systems

Silvia Mastellone, Dušan M. Stipanović and Mark W. Spong
Coordinated Science Laboratory, University of Illinois, 1308 W. Main St., Urbana, IL 61801, USA

- Decentralized control scheme for dynamic formation control, tracking and collision avoidance for nonholonomic robots
- Real time mutual collision avoidance control using arbitrarily shaped local avoidance functions
- Experimental results that validate the ease of implementation and effectiveness of the controller

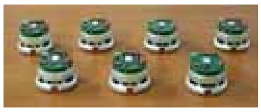


15:46–16:04	WeD1.2

Experiences of formation control of multi-robot systems with the Null-Space-based Behavioral Control

Gianluca Antonelli, Filippo Arrichiello, Stefano Chiaverini
DAEIMI, Università degli Studi di Cassino, Cassino (FR), Italy
Suryarghya Chakraborti
Indian Institute of Technology, Kharagpur, India

- two experimental case studies of formation control with dynamic obstacles
- experiments aimed at testing performances and robustness of a behavioral approach, the Null-Space-based Behavioral control (NSB)
- experiences performed with a multi-robot system made of 6 Khepera II mobile robots

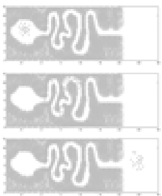


16:04–16:22	WeD1.3

A Computationally Efficient Path Planner for a Collection of Wheeled Mobile Robots with Limited Sensing Zones

Turker Sahin and Erkan Zergeroglu
Computer Engineering Dept., Gebze Institute of Technology, Turkey

- A single robot path planner is integrated with a geometric formation to form a computationally efficient flock planner.
- The method is fast and efficient for navigation of relatively large collections of WMRs in obstacle cluttered environments.
- Real time planning in excess of 20 agents is possible using common platforms (Windows XP + Matlab / Simulink on a laptop PC).



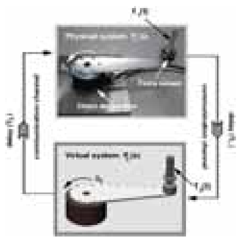
Path planning for a group of agents in a tunnel with complicated geometry.

16:22–16:40	WeD1.4

Control for Multi-subsystem Synchronization with Invariant Local Natural Dynamics

J. Cheong, and C. Kim
* Dept. of Control & Instrumentation Eng., Korea University

- Real-time motion synchronization for distributed dynamic systems is achieved.
- Input-output relation of each subsystem is invariant under the control.
- Generalization of the proposed scheme to heterogeneous N-subsystem case is formulated.



3D Range Sensing and Registration

Chair *Hyukseong Kwon, Purdue Univ.*

Co-Chair *Juan Andrade-Cetto, Consejo Superior de Investigaciones Científicas*

15:28–15:46 WeD2.1

Efficient 3D Object Detection by Fitting Superquadrics to Range Image Data for Robot's Object Manipulation

Georg Biegelbauer and Markus Vincze
Automation and Control Institute, Vienna University of Technology, Austria

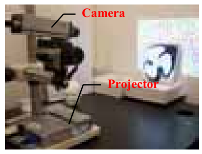
- Fast and robust 3D detection approach without the need of a previous scene segmentation.
- Prior knowledge of objects is flexibly described by approximated Superquadric models.
- Pose hypothesis generation: RANSAC based on sub-scaled laser range data.
- Pose hypothesis verification: Ranked voting procedure, embedded in a hierarchical structure.

15:46–16:04 WeD2.2

A Study on the Relative Pose Problem in an Vision System with varying Focal Lengths

B. Zhang and Y. F. Li
Dept. of Manufacturing Engg and Engg Management
City University of Hong Kong, Kowloon, Hong Kong

- The relative pose problem is addressed in the structured light system;
- The varying focal lengths are allowed and can be obtained with the calibration algorithm;
- The plane-based Homography and parallax are employed in the method;
- The real data experiments are implemented using this system.

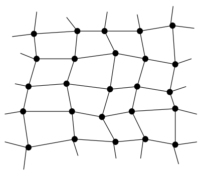


16:04–16:22 WeD2.3

Feature Extraction on Range Images – A New Approach

[1]Sonya A. Coleman, [2]Bryan W. Scotney, [1]Shan Suganthan
[1]School of Computing and Intelligent Systems
[2]School of Computing and Information Engineering
University of Ulster, Northern Ireland

- We present a design procedure for shape-adaptive derivative operators
- Directly applicable to irregularly distributed data
- Hence appropriate for range image data without pre-processing
- Comparative evaluation performed with scan-line methods

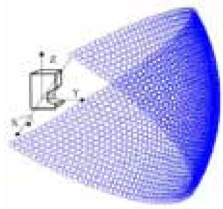


16:22–16:40 WeD2.4

Spherical Laser Point Sampling with Application to 3D Scene Genetic Registration

Jorge L. Martinez, Antonio Reina and Anthony Mandow
Systems Engineering and Automation Dept., University of Malaga, Spain

- New point sampling strategy that considers the spherical scanning process of most 3D laser scanners:
  - ➢ Equalizes the measure-direction density.
  - ➢ Fast and systematic data reduction based on a binary mask.
  - ➢ Avoids that peripheral regions of the scene bias the matching process.



Spherical point sampling

Micro/Nano Robots III

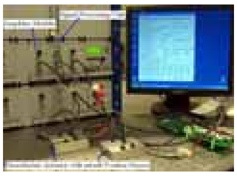
Chair *Ari Requicha, USC*
Co-Chair *Antoine Ferreira, Univ. of Orléans*

15:28–15:46 WeD3.1

Robust Adaptive Motion Tracking Control of Piezoelectric Actuation Systems for Micro/Nano Manipulation

Hwee-Choo Liaw[1], Bijan Shirinzadeh[1], and Julian Smith[2]
[1]Robotics and Mechatronics Research Laboratory,
Mechanical Engineering Dept., Monash University, Australia
[2]Monash Medical Centre,
Surgery Dept., Monash University, Australia

- Control methodology is proposed to overcome problems of parametric uncertainties, non-linearities including hysteresis effect, and external disturbances in piezoelectric actuation systems.
- Control formulation and stability analysis are detailed.
- A precise tracking performance is demonstrated experimentally.



Experimental Research Facility

15:46–16:04 WeD3.2

On The Force Capabilities Of Centripetal Force-actuated Microrobotic Platforms

P. Vartholomeos, K. Vlachos, and E. Papadopoulos
Mechanical Engineering Dept.,
National Technical University of Athens, Greece

- **Goal**: Employ centripetal actuation to perform **micromanipulation.**
- Analysis of the force capabilities of centripetal force-actuated microrobotic platform.
- Design guidelines for reduction of impulses and ripples on the force transmitted to the object.
- Force experiments using on-board force sensor.

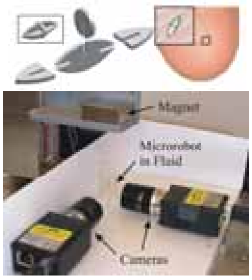
Dynamic model of the platform-needle-object system

16:04–16:22 WeD3.3

Measuring the Magnetic and Hydrodynamic Properties of Assembled-MEMS Microrobots

Michael P. Kummer, Jake J. Abbott, Karl Vollmers, and Bradley J. Nelson
Institute of Robotics and Intelligent Systems, ETH Zurich, Switzerland

- Implemented a system to measure magnetic and hydrodynamic properties of assembled-MEMS microrobots
- Measured the magnetic force on an assembled-MEMS microrobot
- Measured the coefficient of viscous friction for an assembled-MEMS microrobot in Newtonian fluid

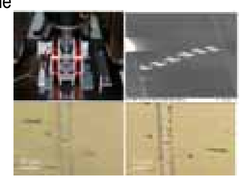


16:22–16:40 WeD3.4

Flagella-like Propulsion for Microrobots Using a Nanocoil and a Rotating Electromagnetic Field

Dominik J. Bell, Stefan Leutenegger, K. Magnus Hammar, Lixin Dong, and Bradley J. Nelson
Institute of Robotics and Intelligent Systems, ETH Zurich, CH-8092 Zurich, Switzerland

- First imitation of helical, bacterial flagella at the same size scale as natural flagella
- Bilayer nanocoil propeller with small Ni plate "head" attached to one end
- Rotation of nanocoil is induced by a rotating electromagnetic field using macro coils
- Rotation results in net axial force due to low Reynolds number flow



Methods for Safe Control of Robots

Chair *Takafumi Matsumaru, Shizuoka Univ.*
Co-Chair *Jianwei Zhang, Univ. of Hamburg*

15:28–15:46 WeD4.1

Don't Do Things You Can't Undo: Reversibility Models for Safe Behaviors

Maarja Kruusmaa and Yuri Gavshin
Tartu University Institute of Technology, Tartu, Estonia
Adam Eppendahl
University of Malaya, Kuala Lumpur, Malaysia

- Irreversibility characterizes bad actions.
- Programming a robot to identify irreversible actions can be done knowing very little about the robot.
- We get obstacle avoidance 'for free'.
- Not only do we get it for free, but just as fast as less abstract methods.

The New First Law of Robotics

15:46–16:04 WeD4.2

A Short Paper about Motion Safety

Thierry Fraichard
Inria Rhône-Alpes & LIG-CNRS Lab., Grenoble (FR)

- Question: do mobile robots move safely?
- Three motion safety criteria are given.
- Mobile robots do not respect these criteria $\Rightarrow$ they are not safe!
- Answer to the motion safety issue: concept of Inevitable Collision States (ICS).

16:04–16:22 WeD4.3

Double Actuator Unit with Planetary Gear Train for a Safe Manipulator

Byeong-Sang Kim, Jung-Jun Park and Jae-Bok Song
Dept. of Mechanical Engineering, Korea University, Korea

- Two actuators in a single unit with planetary gear train
- Simultaneous control of position and stiffness for a single DOF
- Force estimation by encoders without expensive force/torque sensor
- Improved collision safety during collision with environment or humans

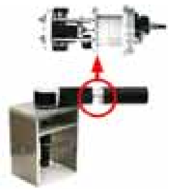
Double Actuator Unit

16:22–16:40 WeD4.4

Safe Link Mechanism based on Passive Compliance for Safe Human-Robot Collision

Jung-Jun Park, Byeong-Sang Kim, and Jae-Bok Song
Dept. of Mechanical Engineering, Korea University, Korea
Hong-Seok Kim
Control and Research Team, Korea Institute of Industrial Technology, Korea

- A Safe Link Mechanism consists of linear springs, a double-slider and shock absorbing module.
- Variable stiffness capability is implemented only by a passive mechanical system.
- High safety performance and positioning accuracy of a robot arm can be achieved.
- Collision safety for both static and dynamic collision can be implemented.



Safe link mechanism

Ground and All Terrain Vehicles

Chair *Yunhui Liu, Chinese Univ. of Hong Kong*
Co-Chair *Fumitoshi Matsuno, The Univ. of Electro-Communications*

15:28–15:46	WeD5.1

A rollover indicator based on the prediction of the load transfer in presence of sliding

N. Bouton[1], R. Lenain[1], B. Thuilot[2] and J-C. Fauroux[3]
[1]Cemagref, [2]LASMEA and [3]LAMI, Clermont-Ferrand, France

- Model for lateral dynamic behaviour of All Terrain Vehicles including sliding effects and ground irregularities
- Design of rollover risk indicator based on the prediction of lateral load transfer on a lookahead horizon
- Application to quad bikes and validation with multibody dynamic software Adams

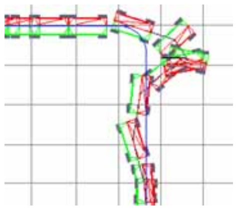

Quad bike in rollover situation

15:46–16:04	WeD5.2

Trajectory Control of a Four-Wheel Skid-Steering Vehicle over Soft Terrain using a Physical Interaction Model

Damien Lhomme-Desages, Christophe Grand and Jean-Claude Guinot
Laboratoire de Robotique de Paris
Université Pierre et Marie Curie, France

- Model-based trajectory control of a fast four-wheel skid-steering mobile robot
- Soil-wheel interaction model including slip and skid effects
- Analysis of the controller performance by using dynamic simulation


Trajectory tracking in slipping conditions

16:04–16:22	WeD5.3

Dynamic Stability of Off-Road Vehicles Considering a Longitudinal Terramechanics Model

Zvi Shiller, Moshe P. Mann, and Dror Rubinstein
College of Judea and Samaria, Israel

- Dynamic stability reflects the vehicle's ability to traverse uneven terrain at high speeds
- Stability margins are computed for a planar all-wheel drive vehicle model
- Ground-wheel interactions are modeled using Brixius empirical model
- Method accounts for terrain topography, vehicle dynamics, and ground properties

16:22–16:40	WeD5.4

Autonomous Hot Metal Carrier (HMC)

Ash Tews, Cédric Pradalier and Jonathan Roberts
Autonomous Systems Laboratory, CSIRO ICT Centre, Australia

- HMC's are 20 tonne forklift-like vehicles that carry 8 tonnes of molten aluminium in 2 tonne crucibles
- Our in-house automated HMC uses lasers and cameras for localisation and crucible operations
- It has conducted over 100 hours of autonomous operations indoors and outdoors


The autonomous HMC picking up the crucible

Parallel Kinematic Machines: Singularities

Chair *Grigore Gogu, French Inst. of Advanced Mechanics and Blaise Pascal Univ.*
Co-Chair *Marcelo H Ang Jr, National Univ. of Singapore*

15:28–15:46 WeD6.1

Assembly Problem of Overconstrained and Clearance-free Parallel Manipulators

Jian Meng, Dongjun Zhang and Zexiang Li
Department of Electrical and Computer Engineering
Hong Kong University of Science and Technology
Clear Water bay, Hong Kong, P.R.China

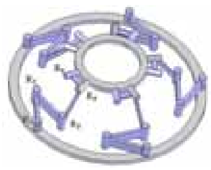
- Provide a rigorous and mathematical model for the assembly and manufacturing errors in a clearance-free parallel manipulator
- Provide a mathematical reasoning on how the assembly problem of overconstrained and clearance-free parallel manipulators is caused by the assembly and manufacturing errors
- Differentiate non-overconstrained parallel manipulators from overconstrained ones according to the "transversality" of subchains' configuration spaces

15:46–16:04 WeD6.2

Singularity Analysis for a 5-DoF Fully-Symmetrical Parallel Manipulator 5-RRR(RR)

Si-Jun Zhu[1], Zhen Huang[1], Ming-Yang Zhao[2]
[1]Robotics Research Center, Yanshan University, China
[2]Shenyang Institute Automation of Chinese Academy of Science, China

- 3R2T fully-symmetrical PM have many general applications such as bionics simulation.
- Both singularity and limb singularity for 5-RRR(RR) are illustrated.
- Result in this study is helpful to the singularity analysis for other 3R2T fully-symmetrical PM.



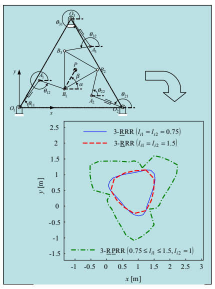
5-RRR(RR)

16:04–16:22 WeD6.3

Singularity Avoidance for the 3-RRR Mechanism Using Kinematic Redundancy

Sung-Hoon Cha, Ty A. Lasky, and Steven A. Velinsky
Department of Mechanical & Aeronautical Engineering
Univ. of California – Davis, USA

- Presents singularity avoidance of the 3-RRR mechanism using kinematic redundancy
- Describes singularity analysis of the proposed 3-RPRR mechanism
- Presents a simple & effective redundancy resolution algorithm based on local optimization suitable for real-time control
- The mechanism can avoid singularities associated with the 3-RRR mechanism, and enlarge the usable workspace



16:22–16:40 WeD6.4

Avoiding Parallel Singularities of 3UPS and 3UPU Spherical Wrists

Davide Paganelli
Mechanical Engineering Dept. (DIEM), University of Bologna, Italy

- Differential topology methods are applied to path-planning for singularity avoidance
- A numerical procedure is proposed for a class of parallel spherical wrists
- A singularity-free path between any two positions of the platform is always found, if it exists
- The disjoint regions into which the workspace is split by singularities are identified and counted

A 3UPS spherical wrist

Handling Deformable Objects

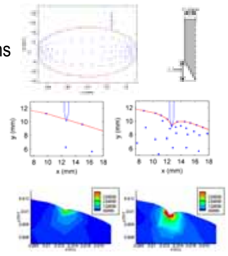
Chair *Claudio Melchiorri, Univ. of Bologna*
Co-Chair *Mikhail Svinin, RIKEN*

15:28–15:46	WeD7.1

An Adaptive Meshless Method for Modeling Large Mechanical Deformation and Contacts

Qiang Li and Kok-Meng Lee
The G. W. Woodruff School of Mechanical Engineering,
Georgia Institute of Technology, USA

- Automatic error estimation combined with the sliding line algorithm for solving contact problems
- Improved computational efficiency by automatic insertion of additional nodes to large error and contact regions
- Validated the method using analytical solutions and other numerical methods
- Demonstrated the potentials of the method on robotic and automation applications

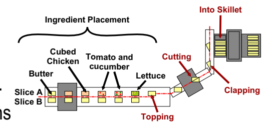


15:46–16:04	WeD7.2

Automated Handling, Assembly and Packaging of Highly Variable Compliant Food Products- Making a Sandwich

S. Davis, M.G. King, J.W. Casson, J.O.Gray and Darwin G Caldwell
Centre for Robotics and Automation, University of Salford,Manchester M5 4WT

- This paper describes an automated system for the assembly and packaging of triangular sandwiches.
- This process is currently highly labour intensive with little automation available.
- This work develops modular workstations which can be incorporated into lines in place of human operators.
- The system was tested in a sandwich production factory.



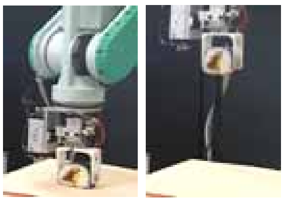
Chicken Salad Sandwich Production Line

16:04–16:22	WeD7.3

An Optimum Design of Robotic Hand for Handling a Visco-elastic Object Based on Maxwell Model

Naoki Sakamoto,
Advanced Technology Lab., Mayekawa Mfg. Co., Ltd., Japan
Mitsuru Higashimori and Makoto Kaneko, Osaka University, Japan
Toshio Tsuji, Hiroshima University, Japan

- An optimum design of robotic hand is discussed with a visco-elastic model of food.
- The visco-elastic parameters of “Norimaki-sushi” are obtained.
- A set of design parameters leading to the minimum plastic deformation of food are found.



16:22–16:40	WeD7.4

Design of an Automated Handling System for Limp, Flexible Sheet Lasagna Pasta

René J. Moreno Masey, and Darwin G. Caldwell
Centre for Robotics and Automation, University of Salford, UK

- Low cost pick and place system for the industrial assembly of lasagne ready meals.
- Accurate, repeatable placement of lasagna pasta sheets into trays.
- Continuous, fully automatic operation with a cycle time of less than 4 seconds.
- Designed to be easy to clean and meet sanitary requirements for food use.

Automated machine for lasagna pasta handling

Rehabilitation Robotics I

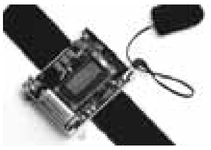
Chair *Sunil Agrawal, Univ. of Delaware*
Co-Chair *Edward Grant, North Carolina State Univ.*

15:28–15:46	WeD8.1

Biorhythm-Based Awakening Timing Modulation

*Yuki Wakuda, * Akiko Noda, * Kosuke Sekiyama,
**Yasuhisa Hasegawa, * Toshio Fukuda
*Nagoya UNIV.
**Tsukuba UNIV.

- Development of wristwatch type awakening timing controller based on pulse wave information
- Evaluation of relationship between awakening timing and balance function after wake-up.

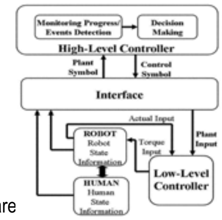


15:46–16:04	WeD8.2

Intelligent Control Framework for Robotic Rehabilitation after Stroke

Duygun Erol[1], Nilanjan Sarkar[1,2]
[1]Electrical and Computer Engineering Dept., Vanderbilt University, USA
[2]Mechanical Engineering Dept., Vanderbilt University, USA

- Design an intelligent control framework
  - To determine the task parameters dynamically based on patients' performance and
  - To monitor the safety related events in an automated manner and generate an accommodating plan of action
- Experimental results on unimpaired subjects are presented to demonstrate the efficacy of the intelligent controller



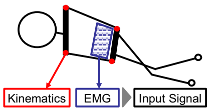
Control Architecture

16:04–16:22	WeD8.3

Development of roll-over support system with EMG control for cancer bone metastasis patients

Takeshi Ando[1)], Jun Okamoto[2)], and Masakatsu G. Fujie [2) 3)]
1) Graduate School of Science and Engineering, Waseda University, JAPAN
2) Consolidated Research Institute for Advanced Science and Medical Care, Waseda University, Japan
3) Faculty of Science and Engineering, Waseda University, JAPAN

- Analyze Kinematics of three types' roll-over
- Analyze the EMG signal of roll-over about four muscles
- Define the EMG signal of IO muscle as the input signal to the equipment



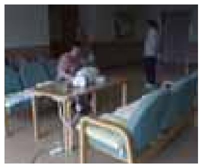
Decision on the input
to the roll-over support system

16:22–16:40	WeD8.4

Social Effects of Robot Therapy in a Care House - Change of Social Network of the Residents for Two Months -

Kazuyoshi Wada[1], and Takanori Shibata[1,2]
1.Intelligent Systems Research Institute, AIST
2. SORST, JST

- Two therapeutic seal robots have operated in a care house for over 9 hours, every day, since June 2005.
- To assess its influences, the residents' social network was analyzed.
- In addition, their behaviors were recorded by video over two months.
- The results showed that their social ties were increased though interaction with Paro.



Bio-inspired Climbing

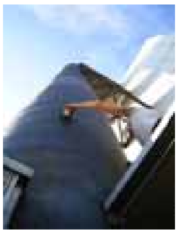
Chair *Ian Walker, Clemson Univ.*
Co-Chair *Shuxiang Guo, Kagawa Univ.*

15:28–15:46	WeD9.1

Compliant Distributed Magnetic Adhesion Device for Wall Climbing

J. Berengueres[1], K. Tadakuma[2], T. Kamoi[1] and R. Kratz[3]
[1]Tokyo Institute of Technology, Japan
[2]Massachusetts Institute of Technology, USA
[3]Technische Universität Darmstad□ , Germany

- Introducing a climbing device based on the bio-concept of **Distributed Adhesion**
- Limited Compliance
- Nears Gecko Efficiency (95%)
- High performance, Low Cost (100$)


Climbing test on a giant pipe

15:46–16:04	WeD9.2

Directional Adhesive Structures for Controlled Climbing on Smooth Vertical Surfaces

Daniel Santos, Sangbae Kim, Matthew Spenko, Aaron Parness, and Mark Cutkosky
Mechanical Engineering Dept., Stanford University, USA

- Robust climbing requires *controllable, directional* adhesion.
- Arrays of Directional Polymer Stalks (DPS) were manufactured for a climbing robot.
- DPS exhibit adhesion only when loaded in the proper direction (pulling inward).
- The anisotropic (directional) adhesion leads to specialized force control strategies in geckos and robots.

SEM photo of DPS and DPS geometry in unloaded and loaded states

16:04–16:22	WeD9.3

Whole body adhesion

Sangbae Kim, Matthew Spenko, Salomon Trujillo, Barrett Heyneman, Virgilio Mattoli, and Mark Cutkosky
Mechanical Engineering Dept., Stanford University, USA

Smooth vertical surface climbing with Van der Waals forces depends on:

- **hierarchical compliance** for conforming to surfaces at cm to µm scales,
- **directional adhesion** to control adhesion by controlling tangential forces,
- **distributed force control** using passive and active mechanisms.

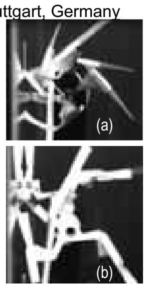

Stickybot and toe detail

16:22–16:40	WeD9.4

Passive Foot Design and Contact Area Analysis for Climbing Mini-Whegs™

Kathryn A. Daltorio, Terence E. Wei, Roy E. Ritzmann, and Roger D. Quinn
Mechanical Engineering Dept., Case Western Reserve University, USA
Stanislav N. Gorb
Max-Planck-Institute for Metals Research, Stuttgart, Germany

- Applying and detaching the feet is critical to the performance of a vertical glass climbing robot
- Contact area is observed throughout individual steps using synchronous high speed video.
- The contact area is measured by analyzing the pixels in the image and is used to compare (a) small one-piece wheel-legs and (b) larger wheel-legs with ankle joints
- Attached video shows typical steps of five foot configurations



Production Planning

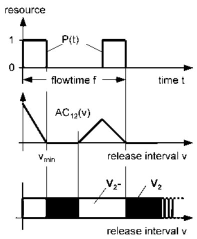
Chair *Spiridon Reveliotis, Georgia Inst. of Tech.*
Co-Chair *Frank van der Stappen, Utrecht Univ.*

15:28–15:46	WeD10.1

Robotic Cycle Shop Control based on deterministic Correlation Maps

Wolfgang Meyer and Claudia Fiedler
Institute of Automation, Hamburg University of Technology, Germany

- Deterministic scheduling approach for robotic cycle shops based on a n-dimensional collision map
- The map facilitates the optimization of periodic and non periodic robot schedules
- Release intervals of processes and auto correlation lengths of operations are identical
- For zero correlation, collisions of operations are avoided

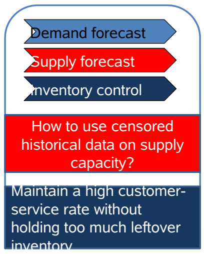


15:46–16:04	WeD10.2

Optimal Multiperiod Inventory Decisions with Partially Observed Markovian Supply Information

Haifeng Wang
CFINS, Dept. of Automation, Tsinghua University, Beijing, China
Houmin Yan
Dept. of SEEM, the Chinese University of Hong Kong

- A new model for supply capacity forecast based on partial supply information:
  - if the ordering quantity is greater than the current period supply capacity, the buyer observes the value of the current period supply capacity
  - otherwise, the buyer knows that the current period supply capacity is greater than its ordering quantity.
- Optimal inventory policy
  - Existence
  - Uniqueness

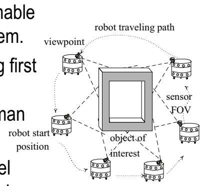


16:04–16:22	WeD10.3

Metric View Planning Problem with Traveling Cost and Visibility Range

Pengpeng Wang[1], Ramesh Krishnamurti[2], and Kamal Gupta[1]
[1]RAMP Lab, School of Engineering Science; [2]School of Computing Science
Simon Fraser University, Canada

- We introduce the problem of view planning by a point robot with visibility range for object inspection, while minimizing the combined view and travel cost.
- We show this optimization problem is log-inapproximable via an L-reduction from the Set Covering Problem.
- We analyze the natural two-level algorithm of solving first the view planning problem to get an approximate solution, and then solving the Metric traveling salesman problem to connect the planned viewpoints.
- We show that the approximation ratio of this two-level algorithm is in the order of *log(n)*, where n is the number of surface patches of the object, matching (in the same order) the problem inapproximability.



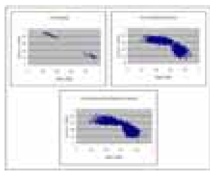
A schematic illustration with six viewpoints and a path to completely inspect the object surfaces.

16:22–16:40	WeD10.4

E-Negotiation of Dependent Multiple Issues by Using a Joint Search Strategy

Ta-Chiun Chou, Li-Chen Fu, and Kuang-Ping Liu
National Taiwan University, Taiwan

- The Joint Genetic Algorithm (JGA) is proposed to deal with negotiations of dependent multiple issues.
- JGA can learn and predict the preferences of the opponent to get the better offer.
- Experimental results show that JGA can improve the performance and get the higher joint payoffs.



Scenario with high conflict between seller's and buyer's preferences

Path Planning in Dynamic Environments

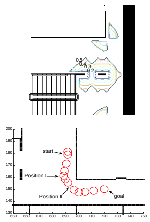
Chair *Steven M LaValle, Univ. of Illinois*
Co-Chair *Amir Shapiro, Ben Gurion Univ. of the Negev*

15:28–15:46	WeD11.1

Safe navigation of a mobile robot using the visibility information

Seokgyu Kim, Woojin Chung, Chang-bae Moon and Jae-Bok Song
Dept. of Mechanical Engineering
Korea University, Korea

- A safe navigation scheme to reduce the collision risk due to unexpected dynamic obstacles considering field of view.
- The possibility of collision is dually reflected to a path planning and a speed control.
- Experimental results show that the robot makes a detour to obtain sufficient field of view.



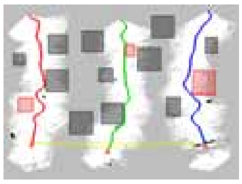
Collision risk under the limited field of view and the resultant motion of a robot

15:46–16:04	WeD11.2

Anytime, Dynamic Planning in High-dimensional Search Spaces

Dave Ferguson
Intel Research Pittsburgh, Pittsburgh, USA
Tony Stentz
Carnegie Mellon University, Pittsburgh, USA

- We present a sampling-based path planning algorithm for high-dimensional search spaces
- Our algorithm, **Anytime Dynamic RRTs,** is able to plan and replan in an anytime fashion
- Resulting approach well-suited to complex, partially-known planning problems
- Number of nice theoretical properties and applications to multirobot coordination
- Implemented on a team of outdoor vehicles



Three vehicles performing constrained exploration

16:04–16:22	WeD11.3

Lazy Reconfiguration Forest (LRF) - An Approach for Motion Planning with Multiple Tasks in Dynamic Environments

Russell Gayle
Dept. of Computer Science, University of North Carolina at Chapel Hill, USA
Kristopher R. Klingler and Patrick G. Xavier
Sandia National Laboratories

- Simultaneously maintains multiple task paths and performs re-planning to adjust to moving obstacles
- Represents the collision-free configuration space as a forest of RRTs
- Efficiently maintains the forest through growing, splitting, and merging operations and lazy evaluation
- Robot is free to choose from any task path

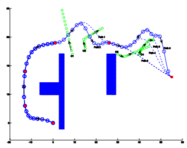
Path of an arrow-shaped robot among two moving circles in their final position

16:22–16:40	WeD11.4

Global Trajectory Generation for Nonholonomic Robots in Dynamic Environments

Yi Guo, Yi Long
ECE Dept., Stevens Institute of Technology, USA
Weihua Sheng
Oklahoma State University, USA

- Polynomial type of regional path
- Collision avoidance with dynamic obstacles
- Smooth irregular curve and steering control constructed by differential flatness
- Analytic solutions working in dynamic environments with given path way-points



Aerial Robotics: Visual Servoing

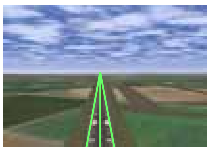
Chair *Roberto Lampariello, German Aerospace Center (DLR)*
Co-Chair *Thomas Veit, Irisa / Inria*

15:28–15:46 WeD12.1

Visual Servoing of an Airplane for Alignment with respect to a Runway

Odile Bourquardez and François Chaumette
IRISA - CNRS and INRIA, Rennes, France

- Linearized state space model of an airplane equipped with a fly-by-wire system
- Design of decoupled visual features using the runway lines
- Design of visual lateral and longitudinal control laws
- Simulation using a quite realistic flight simulator, to drive again the airplane to its equilibrium flight

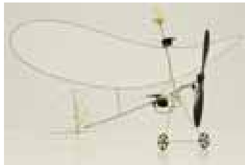


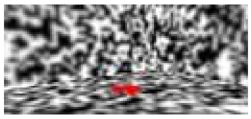
15:46–16:04 WeD12.2

3D Vision-based Navigation for Indoor Microflyers

Antoine Beyeler, Jean-Christophe Zufferey, Dario Floreano
Laboratory of Intelligent Systems, EPFL, Lausanne, Switzerland

- Optic flow has been used in **10-gram indoor microflyers** to avoid textured walls. However, altitude control is still unsolved at this stage.
- We extend the existing 2D control strategy to 3D by avoiding collisions with walls as well as ground and ceiling, in order to **achieve full autonomy**.
- Our **3D simulations** demonstrate the feasibility of this approach and pave the way toward its implementation in real indoor microflyers.





16:04–16:22 WeD12.3

A practical Visual Servo Control for a Unmanned Aerial Vehicle

Nicolas Guenard, Tarek Hamel, Robert Mahony
CEA/LIST(France), CNRS/I3S (France), ANU (Australia)

- An image-based visual servo control is presented for a Unmanned aerial vehicle (UAV) capable of stationary or quasi-stationary flight.
- The proposed control design addresses visual servo of 'eye-in-hand' type systems. The control o the position and orientation dynamics are decoupled using a visual error based on a spherical centroid data, along with estimation of the gravitational inertial direction.

The X4-Flyer

- A nonlinear controller is derived for the full dynamics of the system.
- Experimental results on an experimental UAV known as an X4-flyer made by the French Atomic Energy Commission (CEA) demonstrate the robustness and performances of the proposed control strategy.

16:22–16:40 WeD12.4

Autonomous Vision-based Landing and Terrain Mapping Using an MPC-controlled Unmanned Rotorcraft

Todd Templeton and S. Shankar Sastry
Electrical Engineering and Computer Sciences Dept., UC Berkeley, USA
David Hyunchul Shim
Korea Advanced Institute of Science and Technology, South Korea
Christopher Geyer
Robotics Institute, Carnegie Mellon University, USA

- High-accuracy vision-based terrain mapping using the Recursive Multi-Frame Planar Parallax (RMFPP) algorithm.
- Efficient terrain analysis for rotorcraft landing.
- Safe and plausible trajectory planning (terrain coverage, closer inspection, and landing) using a real-time MPC-based algorithm.
- Implementation on a lightweight rotorcraft UAV.

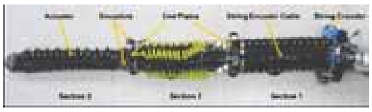
Continuum and Redundant Systems

Chair *Anthony A. Maciejewski, Colorado State Univ.*
Co-Chair *Rodney Roberts, Florida State Univ.*

17:00–17:18 WeE1.1

Dynamic Modelling for Planar Extensible Continuum Robot Manipulators

Enver Tatlicioglu, Ian Walker, and Darren Dawson
Electrical and Computer Engineering, Clemson University, USA



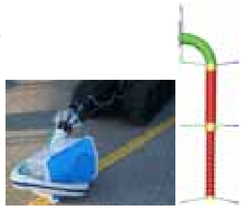
- Dynamic model formulation for continuum robot manipulators
- Refinement of previous models to include extension of manipulator sections
- Numerical simulation results presented for planar three section extensible robot

17:18–17:36 WeE1.2

Limiting-case Analysis of Continuum Trunk Kinematics

Bryan A. Jones
Electrical and Computer Engineering Dept., Mississippi State Univ., USA
Ian D. Walker
Electrical and Computer Engineering Dept., Clemson University, USA

- Many continuum robot tasks require section(s) of the robot to be straight.
- Common continuum robot kinematics exhibit singularity-like conditions near and at straight configurations.
- The analysis presented provides a method to eliminate these conditions.
- Expressions for numerically stable computation of position and velocity kinematics are given.



Trunk configurations requiring limiting-case analysis

17:36–17:54 WeE1.3

Casting Control for Hyper-Flexible Manipulation

Takahiro Suzuki and Yuji Ebihara
IIS, University of Tokyo, Japan
Takahiro Suzuki
Dept. of Elec. Eng., Shibaura Institute of Technology, Japan

- Casting and winding manipulation with hyper-flexible manipulator(HFM) was considered.
- HFM is well modeled by a multi-link model with non-elastic passive joints.
- An integrated online visual estimation with dynamic simulation is proposed.
- Casting motion for winding is realized by pumping up an energy-like function.

Casting and Winding Manipulation with Hyper-Flexible Manipulator

17:54–18:12 WeE1.4

A Dynamic Programming Approach to Redundancy Resolution with Multiple Criteria

A. Guigue, M. Ahmadi, M.J.D. Hayes and R. Langlois
Mechanical and Aerospace Engineering Dept., Carleton University, Canada
F.C. Tang
Institute for Aerospace Research (IAR), National Research Council, Canada

- Generation of optimal joint trajectories with respect to multiple criteria for redundant manipulators
- Comparison between the traditional weighting method and a new approach based on Dynamic Programming with Pareto optimality
- Simulation on the 7-DOF redundant manipulator as part of a Captive Trajectory Simulation (CTS) system.

Educational Robotics

Chair *Ron Lumia, Univ. of New Mexico*
Co-Chair *Roland Siegwart, ETH Zurich*

17:00–17:18 | WeE2.1

A Web Lab for Mobile Robotics Education

Paulo R. S. L. Coelho, Rodrigo F. Sassi, Eleri Cardozo, Alex Z. Lima, Luis F. Faina, Rossano P. Pinto
School of Electrical and Computer Engineering – Unicamp – Brazil
Eliane G. Guimarães
Renato Archer Research Center – CenPRA – Brazil

- WebLabs are powerful tools for bringing experimentation into distance learning.
- A SOC-based architecture for building WebLabs is proposed.
- A WebLab for Mobile Robotics Education is presented with examples of remote experiments.

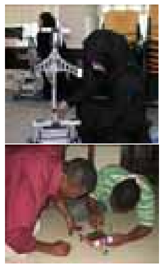
Basic Telemetry Interface

17:18–17:36 | WeE2.2

Undergraduate Robotics Education in Technologically Underserved Communities

M. B. Dias, B. Browning, G. A. Mills-Tettey, and N. El-Moughny
School of Computer Science, Carnegie Mellon University, USA and Qatar
N. Amanquah
Computer Science Department, Ashesi University, Ghana

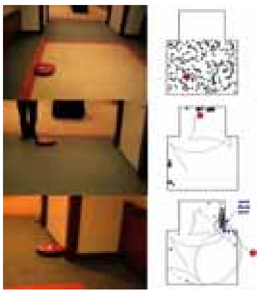
- We present two case studies in undergraduate robotics education in technologically underserved communities in Qatar and Ghana
- We describe and analyze our experiences in these two case studies, and extract relevant lessons to teaching robotics; especially in underserved communities
- We also address the impact of these courses on the local communities and the broader academic community



17:36–17:54 | WeE2.3

Evaluating the Roomba: a low-cost, ubiquitous platform for robotics research and education

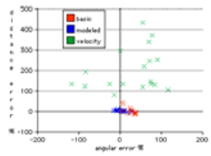
Ben Tribelhorn and Zach Dodds
Harvey Mudd College Computer Science



Monte Carlo Localization at AAAI 2006

Evaluating a low-cost platform for education and research purposes.

Our odometric models improve localization and mapping algorithms.

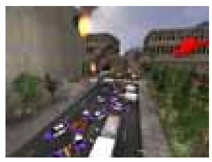


17:54–18:12 | WeE2.4

USARSim: a robot simulator for research and education

Stefano Carpin[1], Mike Lewis[2], Jijun Wang[2], Stephen Balakirsky[3] and Chris Scrapper[3]
[1]University of California, Merced, USA
[2]University of Pittsburgh, USA
[3]National Institute of Standards and Technologies, USA

- Built on top of a state-of-the-art commercial game engine
- Open source
- Compatible with existing robot controllers
- Used within the Robocup community for Urban Search and Rescue competitions



Nanoscale Automation

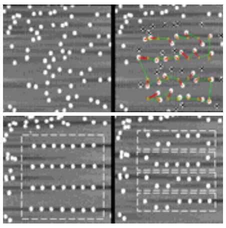
Chair *Fumihito Arai, Tohoku Univ.*
Co-Chair *Peter Luh, Univ. of Connecticut*

17:00–17:18	WeE3.1

Automated Nanomanipulation with Atomic Force Microscopes

B. Mokaberi, J. Yun, M. Wang, A. A. G. Requicha
Laboratory for Molecular Robotics, USC, Los Angeles, CA, USA

- First demonstration of fully automatic nanomanipulation for particles ~ 10 nm.
- Automatic planning of the manipulaton task.
- Execution in an AFM with software compensation for thermal drift, creep and hysteresis.
- Figure shows 15 nm Au particles on mica coated with poly-L-lysine: initial random configuration, computed paths and results.

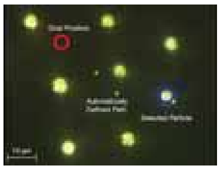


17:18–17:36	WeE3.2

A Strategy for Vision-Based Controlled Pushing of Microparticles

Nicholas A. Lynch and Eugenio Schuster
Electrical and Mechanical Engineering Department, Lehigh University, USA
Cagdas Onal and Metin Sitti
Mechanical Engineering Department, Carnegie Mellon University, USA

- A strategy for controlled pushing of 4.5µm polystyrene particles is presented
- Utilizes real-time visual feedback to track particle positions relative to the tip and target position
- Implements cell decomposition and wavefront expansion algorithms to identify navigable path
- Single and multiple target experiments demonstrate effectiveness of controller



17:36–17:54	WeE3.3

A Novel Actuator for High-Precision Alignment in a Nano-Imprint Multi-Layers-Interconnection Fabrication

Tat Joo Teo[1,2], I-Ming Chen[1], Guilin Yang[2] and Wei Lin[2]
[1]School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore
[2]Mechatronics Group, Singapore Institute of Manufacturing Technology

- A novel nano-positioning actuator for driving alignment stages in nano-imprint process.
- With flexural bearings, it offers 3 mm of stroke with ± 10 nm of positioning accuracy.
- This compact-sized actuator offers 60 N/Amp linear and continuous thrust force.
- Detailed theoretical and experimental analyses are conducted on this development.

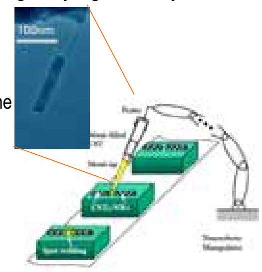
A prototype of Flexure-Based Electromagnetic Linear Actuator (FELA)

17:54–18:12	WeE3.4

Nanorobotic Spot Welding by Attogram Precision Metal Deposition from Copper-filled Carbon Nanotubes

Lixin Dong[1], Xinyong Tao[2], Li Zhang[1], Xiaobin Zhang[2], and Bradley J. Nelson[1]
[1]Inst. of Robotics and Intelligent Systems, ETH Zurich, Switzerland
[2]Dept. of Materials Science and Engineering, Zhejiang University, China

- Nanorobotic spot welding using single-crystalline Cu-filled carbon nanotubes (CNTs) demonstrated experimentally
- 120 ag/s (~1 atom/µs) mass flow rate of the copper from nanotube channels achieved
- Soldering of a Cu-filled CNT onto another CNT succeeded
- Promising for the assembly of nanoelectronic circuits and NEMS



Underactuation and Control Methods

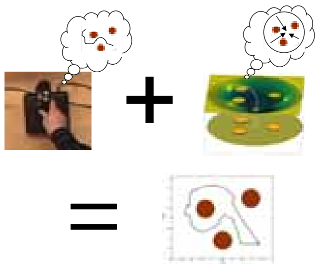
Chair *Mark Spong, Univ. of Illinois*
Co-Chair *Danwei Wang, Nanyang Tech. Univ.*

17:00–17:18	WeE4.1

Mixed Initiative Control of Autonomous Vehicles

Savvas G. Loizou and Vijay Kumar
Department of Mechanical Engineering, GRASP Laboratory
University of Pennsylvania

- A systematic way for human operators for modifying navigation plans
- Analytically guaranteed safety and stability
- Implementation based on Navigation Functions
- Experimental results

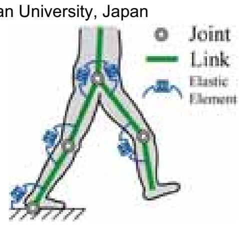


17:18–17:36	WeE4.2

A New Control Method Utilizing Stiffness Adjustment of Mechanical Elastic Elements for Serial Link Systems

Mitsunori Uemura, Katsuya Kanaoka, and Sadao Kawamura
Department of Robotics, Ritsumeikan University, Japan

- Tracking Control of Periodical Motions
- Stiffness Adjustment to Reduce Requirement of Torque to Generate the Motions
- Nonlinear Robot Dynamics
- Stability Analysis
- Application to Power Assist Systems



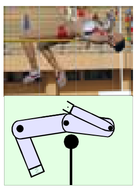
Walking Robots, or Human with Power Assist Systems, or Human with Prostheses

17:36–17:54	WeE4.3

On Robot Gymnastics Planning with Non-zero Angular Momentum

Evangelos Papadopoulos, Ioannis Fragkos, and Ioannis Tortopidis
Mechanical Engineering Department,
National Technical University of Athens, Greece

- Robot gymnastics are subject to nonholonomic behavior, underactuation and time dependence
- A method is developed that can lead a mechanism to a desired configuration from an initial one, in prescribed time
- This method is optimization-based and exploits the mechanism initial angular momentum
- In-flight obstacle avoidance is also achieved



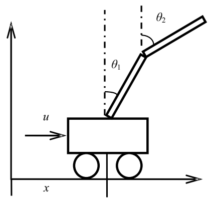
A four link robot imitates the high jump movement of an athlete

17:54–18:12	WeE4.4

Robust Control Using Sliding Mode for a Class of Under-Actuated Systems With Mismatched Uncertainties

Dianwei Qian, Jianqiang Yi, and Dongbin Zhao
Laboratory of Complex Systems and Intelligence Science,
Institute of Automation, Chinese Academy of Sciences,
Beijing, P.R. China

- A hierarchical sliding mode controller is designed for nominal system.
- A lumped sliding mode compensator is designed for mismatched uncertainties.
- The controller and the compensator work together and realize robust control.
- System stability is analyzed and simulation is demonstrated by a series double inverted pendulum system.



Structure of series double inverted pendulum system

Legged Locomotion on Rough Terrain

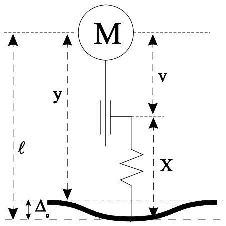
Chair *David Orin, The Ohio State Univ.*
Co-Chair *Andreas Hofmann, MIT*

17:00–17:18 WeE5.1

A Policy for Open-Loop Attenuation of Disturbances Caused by Uncertain Ground Properties in Running

Jonathan Hurst, Joel Chestnutt, and Alfred Rizzi
The Robotics Institute, Carnegie Mellon University, USA
Benjamin Morris
EECS Department, University of Michigan, USA

- Ground surface stiffness changes can cause disturbances to running robot gaits
- Humans adjust to ground surface changes faster than neural responses allow
- A position trajectory, v(t), in series with a spring can attenuate disturbances caused by ground stiffness changes

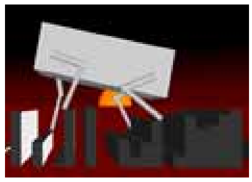


17:18–17:36 WeE5.2

Search-based Foot Placement for Quadrupedal Traversal of Challenging Terrain

Barrett Mitchell, Andreas G. Hofmann, and Brian C. Williams
CSAIL,Massachusetts Institute of Technology, USA

- Foot placement is one of the most challenging problems in legged locomotion over difficult terrain.
- Local, limited, receding horizon search over candidate foot placements and body poses
- Key heuristic: minimize deviation from nominal gait
- A significant percentage of terrain maps can be traversed using a small number of look ahead steps.



A quadruped can traverse difficult terrain that cannot be traversed by a wheeled vehicle of comparable size

17:36–17:54 WeE5.3

A Controller for the LittleDog Quadruped Walking on Rough Terrain

John R. Rebula, Peter D. Neuhaus, Brian V. Bonnlander, Matthew J. Johnson, Jerry E. Pratt
Institute for Human and Machine Cognition, FL, USA

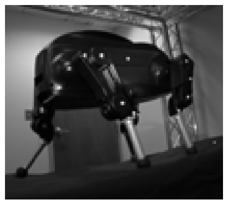
- A controller is developed for statically stable walking on known rough terrain
- Deliberative and reactive modules provide multiple gaits and omni directional walking
- Capable of negotiating obstacles up to 40% leg length

17:54–18:12 WeE5.4

A Robust Quadruped Walking Gait for Traversing Rough Terrain

Dimitris Pongas[1], Michael Mistry[1], and Stefan Schaal[1,2]
[1]Computer Science and Neuroscience, University of Southern California, USA
[2]ATR Computational Neuroscience Laboratory, Japan

- Quadruped locomotion with accurate foot placement for traversing rough terrain.
- Smooth walking pattern generator, adjusted for foot placement and stable COG trajectory plan.
- Continuous and smooth COG trajectory parameterized by position, velocity, and acceleration of robot feet.
- Robot's pitch, yaw, and ground clearance automatically adjusted for terrian condition.



Boston Dynamics LittleDog quadruped robot.

Parallel Kinematic Machines: Statics and Dynamics

Chair *Frank Chongwoo Park, Seoul National Univ.*
Co-Chair *François Pierrot, CNRS - LIRMM*

17:00–17:18 WeE6.1

Dynamics and control of actuated parallel structures as a constrained optimization problem through Gauss' principle and Appell's equations

G. Le Vey
IRCCyN/Ecole des Mines de Nantes
UMR-CNRS 6597 – Nantes, FRANCE

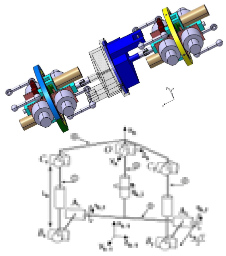
- Inverse and direct dynamical models for parallel structures
- Purely deductive method
- Founded on Gauss' principle and design constraints
- Possible use for other design problems

17:18–17:36 WeE6.2

Dynamic Modeling and Simulation of a 3-D Hybrid structure Eel-Like Robot

Guillaume Gallot, Ouarda Ibrahim and Wisama Khalil
IRCCyN, Ecole Centrale de Nantes, France

- Dynamic Modeling of a 3-D hybrid Eel-like robot using recursive Newton-Euler algorithms,
- Hybrid structure composed of 3 dof parallel modules connected in serie,
- Simple Fluid-Structure interaction Model,
- Simulation of a 36 dof robot with 12 parallel modules.

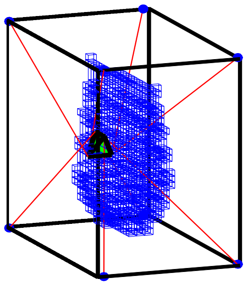


17:36–17:54 WeE6.3

Wrench-Feasible Workspace of Parallel Cable-Driven Mechanisms

Marc Gouttefarde, Jean-Pierre Merlet, and David Daney
COPRIN Research Team, INRIA, France

- Wrench-Feasible Workspace (WFW) of any *n*-dof cable-driven mechanism (*n* = 3 or 6)
- Numerical technique based on interval analysis
- Approximation of the WFW up to a chosen accuracy



WFW of a 6-dof mechanism

17:54–18:12 WeE6.4

Minimum-norm Solution for the Actuator Forces in Cable-based Parallel Manipulators based on Convex Optimization

Mahir Hassan and Amir Khajepour
Dept. of Mechanical and Mechatronics Engineering
University of Waterloo, Ontario, Canada

- Cable-based parallel manipulators are light-weight manipulators in which rigid links are replaced by cables.
- This paper presents for the first time a method to optimize the cable forces for a given load.
- This method is based on convex analysis and optimization using the Dykstra's alternating projection algorithm.

3-DOF translational cable-based manipulator for ultra fast pick and place operation

Force and Tactile Sensing

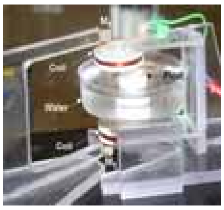
Chair *Craig Carignan, Georgetown Univ. ISIS Center*
Co-Chair *Makoto Kaneko, Osaka Univ.*

17:00–17:18	WeE7.1

Microforce sensor for microbiological applications based on a floating-magnetic principle

Ali Cherry, Joël Abadie and Emmanuel Piat
Laboratoire d'automatique de Besançon, UFC University & ENSMM, France

- Force measurement without deformation of the sensing element
- Measurement range between ± 100µN with a resolution of 20nN
- Mechanical stiffness close to 0.018 $N.m^{-1}$
- "No" weight limitation of the floating body



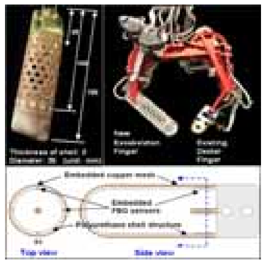
Floating mechanism equipped with two coils

17:18–17:36	WeE7.2

Force Sensing Robot Fingers using Embedded Fiber Bragg Grating Sensors and Shape Deposition Manufacturing

Yong-Lae Park[1], Kelvin Chau[2], Richard J. Black[2], and Mark R. Cutkosky[1]
[1]Center for Design Research, Stanford University, USA
[2]Intelligent Fiber Optic Systems Corporation, USA

- Force sensing is an essential requirement for dexterous robot manipulation.
- Exoskeletal force sensing robot fingers were developed using a new rapid-prototyping process.
- For sensing, EMI-immune, light-weight, multiplexable FBG sensors were embedded in a polymer structure.
- The sensorized robot finger was characterized using an FBG interrogator.

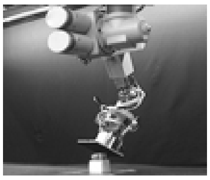


17:36–17:54	WeE7.3

Acquisition and Application of a Tactile Database

Matthias Schöpfer and Helge Ritter
Faculty of Technology, Neuroinformatics Group, Bielefeld University, Germany
Gunther Heidemann
Intelligent Systems Group, Stuttgart University, Germany

- Robot mounted tactile sensor probes different objects
- A broad variety of tactile views are stored in the database
- Database can be used to evaluate and test tactile algorithms offline
- First application: classification of objects using a neural approach



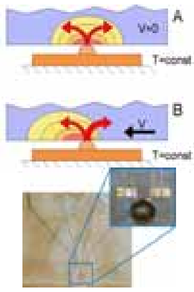
Robot mounted sensor probing object

17:54–18:12	WeE7.4

A Thermal Slip Sensor for Biorobotic Applications

Dino Accoto†, Francesco Damiani†, Ranjana Sahai†, Domenico Campolo‡, Eugenio Guglielmelli‡, and Paolo Dario†
†CRIM Lab, Scuola Superiore Sant'Anna, Pisa, Italy
‡Biomedical Robotics & EMC Lab, Università Campus Bio-Medico, Roma, Italy

- This paper describes a novel slip sensor that exploits thermal phenomenon accompanying slip.
- Tests with varying velocities and surfaces show low response times.
- The sensor is impervious to vibrations and can be mounted on fast moving objects, such as robotic arms.
- The sensor is microfabricated and has potential for further miniaturization.



Rehabilitation Robotics II

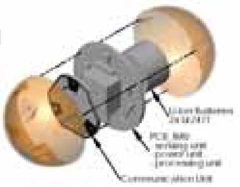
Chair *Rajiv Dubey, Univ. of South Florida*
Co-Chair *Christian Fleischer, Tech. Univ. Berlin*

17:00–17:18 WeE8.1

Design of a Sensorized Ball for Ecological Behavioral Analysis of Infants

D. Campolo[1], E. S. Maini[2], F. Patanè[2], C. Laschi[2], P. Dario[2], F. Keller[3], E. Guglielmelli[1]
[1]Biomedical Robotics, Campus Bio-Medico Univ., Roma - Italy
[2]ARTS Lab, Scuola Superiore Sant'Anna, Pisa - Italy
[3]Developmental Neuroscience Lab, Campus Bio-Medico Univ., Roma - Italy

- Design of a novel mechatronic toy (5 cm ball) small enough to be grasped with a single hand by a 1 year old child.
- *Sourceless* Orientation tracking via embedded inertial/magnetic sensing
- Distributed tactile sensing with approx. 3mm spatial resolution.
- Video clip of functional validation of an early prototype in a kindergarten



17:18–17:36 WeE8.2

Towards application of a mechatronic platform for whole-body isometric force-torque measurements to functional assessment in neuro-rehabilitation

Stefano Mazzoleni[1], Giuseppe Cavallo[3], Marko Munih[4], Justin Cinkelj[4], Mihaly Jurak[5], Jo Van Vaerenbergh[6], Domenico Campolo[3], Paolo Dario[12], Eugenio Guglielmelli[3]
[1] ARTS Lab and [2] CRIM Lab, Scuola Superiore Sant'Anna, Pontedera, Italy
[3] Laboratory of Biomedical Robotics & EMC, Università Campus Bio-Medico, Roma, Italy
[4] Laboratory of Robotics and Biomedical Engineering, Univ. Ljubljana, Slovenia
[5] Dept. Manufacturing Eng.,Budapest Univ. Technology and Economics, Hungary
[6] Arteveldehogeschool, Gent, Belgium

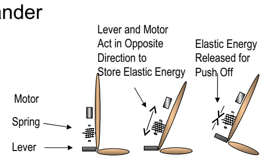
- Use of an innovative mechatronic platform during an extensive clinical trial in a neuro-rehabilitation setting
- Multidisciplinary approach to simplify the problem of handling the great amount of acquired raw data
- Identification of pre-processing parameters and onset detection methods
- Implementation and testing of the data pre-processing software

17:36–17:54 WeE8.3

Dynamically Controlled Ankle-Foot Orthosis (DCO) With Regenerative Kinetics: Incrementally Attaining User Portability

Joseph Hitt, A.Mehmet Oymagil, Thomas Sugar, Alex Boehler, Jennifer Fleeger
Mechanical and Aerospace Engineering and the Department of Engineering, Arizona State University, USA
Kevin Hollander
Augspurger-Komm Engineering, Inc, USA

- Development of a Robotic Tendon that has a high power/energy to weight ratio
- Uniquely tune the spring stiffness for walking
- Use a simple position controller to adjust the compliant spring
- Power amplification of 2.4 and higher



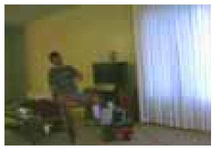
Motor and lever act in opposite directions to store the necessary elastic energy in the spring required for push off. The spring provides the majority of the peak power required for push off.

17:54–18:12 WeE8.4

Hands-Off Therapist Robot Behavior Adaptation to User Personality for Post-Stroke Rehabilitation Therapy

Adriana Tapus[1], Cristian Tapus[2], and Maja J. Matarić[1]
[1] Interaction Lab, University of Southern California, USA
[2] Mojave Lab, California Institute of Technology (Caltech), USA

- This paper describes a behavior adaptation system using a reinforcement learning algorithm.
- The adaptation system takes advantage of the user's personality and the number of exercises performed.
- The robot adapts to deliver customized post-stroke rehabilitation therapy.
- The experimental results demonstrate the robot's autonomous behavior adaptation to the user's personality and the resulting improvements of his/her exercise task performance.



Participant interacting with the therapist robot

Smart Actuators

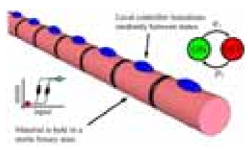
Chair *Shinichi Hirai, Ritsumeikan Univ.*
Co-Chair *Koichi Suzumori, Okayama Univ.*

17:00–17:18 WeE9.1

Stochastic Optimal Control Laws for Cellular Artificial Muscles

Lael Odhner, Jun Ueda, and H. Harry Asada
Mechanical Engineering Dept., Massachusetts Inst. of Technology, USA

- Active material artificial muscles are broken down into small binary units, or cells
- These cells are coordinated using a novel recruitment scheme to produce desired motion
- Cells are designed to respond stochastically to a single input, broadcast to all of the cells
- Dynamic programming is used to obtain a time-optimal response from the actuator



17:18–17:36 WeE9.2

How does the Time Delay of an ER Fluid's Response Affect Control Performance of Servo-systems?

Ken'ichi Koyanagi
Department of Intelligent Systems Design Engineering,
Toyama Prefectural University, Japan

- How does the time delay of a variable viscous damper affect damping performance and stability?
- This paper investigates this question by utilizing analysis, simulation, and experiment.
- The damper has a ER fluid, one of the functional materials.
- This paper also study on mathematical models of time delays of a ER fluid.

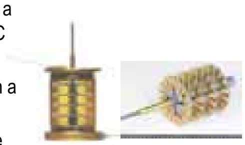
DD Motor and ER Damper

17:36–17:54 WeE9.3

DP-RE type Micromotor using Electro-conjugate Fluid

Shinichi Yokota, Hiroto Kozuki, Kenjiro Takemura and Kazuya Edamura
Precision and Intelligence Laboratory, Tokyo Institute of Technology, Japan
New Technology Management Co., Ltd, Japan

- An electro-conjugate fluid (ECF) generates a powerful jet flow when subjected to high DC voltage.
- A micromotor using ECF with electrodes on a disk plate rotor is proposed.
- Several kinds of electrode configuration are evaluated by experiments.
- A motor with saw-toothed electrode series showed the best performance.



ECF micromotor & disk plate rotor

17:54–18:12 WeE9.4

Hands-Off Therapist Robot Behavior Adaptation to User Personality for Post-Stroke Rehabilitation Therapy

Adriana Tapus[1], Cristian Tapus[2], and Maja J. Matarić[1]
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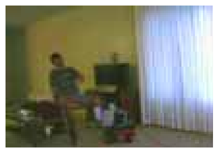


Participant interacting with the therapist robot

Logistic and production systems

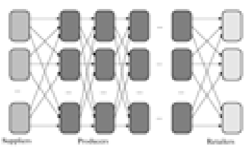
Chair *Maria Pia Fanti, Pol. di Bari*
Co-Chair *Luca Ferrarini, Pol. di Milano - Dip. di Elettronica e Informazione*

17:00–17:18 WeE10.1

Optimization of multi-product nodes in supply chains

Davide Giglio, Riccardo Minciardo,
Simona Sacone, and Silvia Siri
Dept. of Communication, Computer and System Sciences,
University of Genova, Italy

- A model for multi-product nodes in supply chain systems is defined
- It is a hybrid model, combining continuous and discrete-event dynamics
- The optimization of a production node is considered, for two classes of products
- A "one-step" optimization procedure is investigated, to be performed each time an event occurs



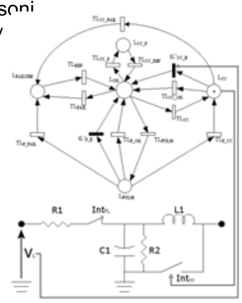
Schematic representation of a supply chain

17:18–17:36 WeE10.2

Dependability Analysis of Power System Protections using Stochastic Hybrid Simulation with Modelica

Luca Ferrarini, Juliano S. A. Carneiro, Simone Radaelli
Politecnico di Milano – Italy
Emanuele Ciapessoni
CESI, Milano Italy

- Dependability analysis of protection schemes of transmission grids
- Cascading effects and undesired trips have been modelled
- Stochastic hybrid model developed in Modelica/Dymola
- Hybrid = Extended PN + DAEs

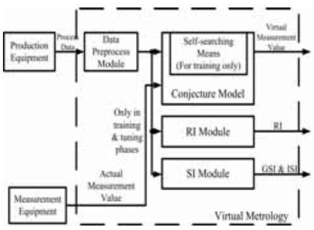


17:36–17:54 WeE10.3

Method for Evaluating Reliance Level of a Virtual Metrology System

Fan-Tien Cheng, Yeh-Tung Chen, & Deng-Lin Zeng
Institute of Manufacturing Engineering, NCKU, Tainan, Taiwan, R.O.C.
Yu-Chuan Su
Dept. of Computer Science & Information Engg., FEU, Tainan, Taiwan, R.O.C.

- This method calculates a reliance index (*RI*) value between 0 & 1 by analyzing the process data of production equipment.
- The method also proposes process data similarity indexes that are applied to assist *RI* in gauging the reliance level and locating the key parameters that cause major deviation.

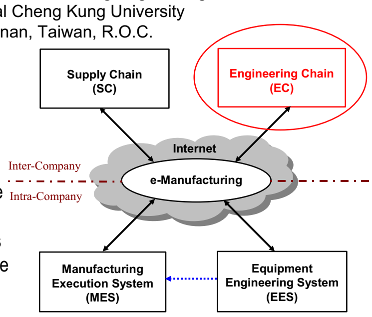


17:54–18:12 WeE10.4

Novel Semiconductor Business Model – Engineering Chain for the Semiconductor Industry

Jonathan Chang, Fan-Tien Cheng, & Tsung-Li Wang
Institute of Manufacturing Engineering
National Cheng Kung University
Tainan, Taiwan, R.O.C.

- A novel Engineering-Chain (EC) business model is proposed.
- An Engineering Chain Management System is also proposed to help achieve the goals of EC, such as improving IC design success rate, reducing IC design cycle time, lowing IC design costs, and increasing revenue.



Probabilistic Motion Planning

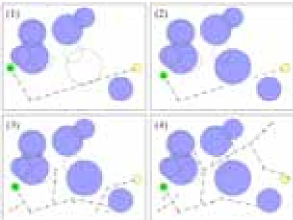
Chair *Stefano Panzieri, Univ. degli Studi*
Co-Chair *Herbert Tanner, Univ. of New Mexico*

17:00–17:18	WeE11.1

Multipartite RRTs for Rapid Replanning in Dynamic Environments

Matt Zucker and James Kuffner
The Robotics Institute, Carnegie Mellon University, USA
Michael Branicky
EECS Department, Case Western Reserve University, USA

- Novel variant of Rapidly-exploring Random Tree (RRT) algorithm
- Supports planning in unknown or dynamic environments
- Efficient computation via re-use of subtrees from prior RRT search
- Experimental data shows MP-RRT yields performance improvements over previous dynamic RRT variants



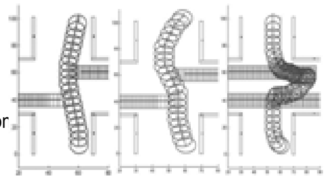
Replanning with MP-RRT after discovering previously unknown obstacles

17:18–17:36	WeE11.2

Dynamic Obstacle Avoidance in uncertain environment combining PVOs and Occupancy Grid

Chiara Fulgenzi, Anne Spalanzani, Christian Laugier
Laboratoire d'Informatique de Grenoble (LIG), INRIA Rhône Alpes, France

- Generalization of the Probabilistic Velocity Obstacles to a dynamic occupancy grid
- Probabilistic framework to take into account occlusions, nor observed space, uncertain estimation.
- Motion strategies adapting to the quality of perception



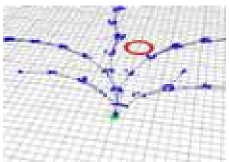
Simulated trajectories for different levels of perception

17:36–17:54	WeE11.3

Particle RRT for Path Planning with Uncertainty

Nik A. Melchior and Reid Simmons
Robotics Institute, Carnegie Mellon University, USA

- Rough terrain path planning for rovers
- Extends Rapidly-exploring Random Tree algorithm to explicitly account for uncertainty in perception or actuation
- Produces robust plans that can be executed accurately despite unpredictable conditions



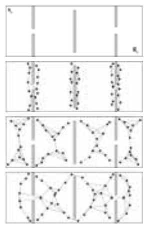
A pRRT planning tree with state distributions at each node.

17:54–18:12	WeE11.4

Biasing Samplers to Improve Motion Planning Performance

Shawna Thomas, Marco Morales,
Xinyu Tang, and Nancy M. Amato
Parasol Lab, Department of Computer Science, Texas A&M University, USA

- No sampling technique out-performs all others for all problems.
- Our framework exploits the strengths of existing techniques by biasing one sampler with another.
- We show that the resulting distribution can out-perform its parent distributions.
- No single combination works best, and we identify trends for different application domains.



The final distribution (bottom) performs better than its parent distributions (middle).

Teleoperation Control

Chair *Homayoun Seraji, California Inst. of Tech.*
Co-Chair *William R. Hamel, Univ. of Tennessee*

17:00–17:18 WeE12.1

A four-channel adaptive structure for high friction teleoperation systems in contact with soft environments

Thomas Delwiche and Michel Kinnaert
Dept. of Control Engineering and Systems Analysis, Université Libre de Bruxelles, Belgium

- A modified representation of the four-channel structure is proposed.
- It is shown that some parameters of this model are time varying in high friction devices
- In order to deal with these time varying parameters, an adaptive law is proposed which is based on position and force errors measurements.
- Finally, this adaptive control scheme is successfully applied to a high friction one degree of freedom teleoperation setup.

17:18–17:36 WeE12.2

A Framework for Quantitative Comparison of Bilateral Teleoperation Systems Using μ–Synthesis

Keehoon Kim[(1)], M. Cenk Cavusoglu[(2)], Wan Kyun Chung[(3)]
1: Mechanical Eng. Northwestern Univ. USA
2: Electrical Eng. and Computer Sci., Case Western Reserve Univ., USA
3: Mechanical Eng., Pohang Univ. of Science and Technology, Korea

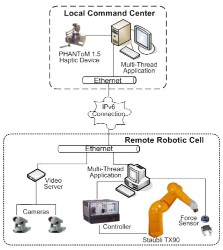
- Quantitative comparison framework for bilateral teleoperation systems
- Evaluate and compare systems with different dynamic characteristics and sensory configurations
- User specified Task Dependant Performance Objective
- μ–Synthesis based formulation for modeling uncertainty in manipulator, human operator and environment dynamics

17:36–17:54 WeE12.3

Passive Bilateral Teleoperation Framework for Assisted Robotic Tasks

Emmanuel Nuño and Luis Basañez
Institute of Industrial and Control Engineering (IOC), UPC, Spain
Romeo Ortega
Laboratoire des Signaux et Systèmes (LSS), CNRS-SUPÈLEC, France

- This paper addresses the problem of position-drift in a time-delayed bilateral teleoperation system
- The proposed scheme encodes position and integral of force to render passive the communication channel
- The operator can easily define motion restrictions to improve his ability to perform complex tasks



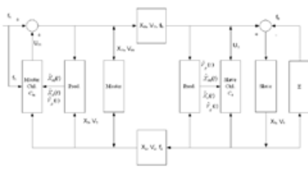
Physical Scheme

17:54–18:12 WeE12.4

Bilateral Teleoperation of Robotic Systems with Predictive Control

[1]Ya-Jun Pan, [2,3]Jason Gu, and [2]Jayaprashanth Jayachandran
{[1]Mech., [2]Elec.} Engineering, Dalhousie University, Canada
[3]Shandong University, Shenzhen Institute of Advanced technology, China
Max Meng
Chinese University of Hong Kong, Hong Kong

- A new control approach to minimize the effects of time delays
- A new scheme to stabilize the teleoperation system
- A novel design of two predictors at slave and master side
- An experiment to verify the design and algorithm


A bilateral teleoperation system with the predictive control strategy