

Lecture Notes in Control and Information Sciences 271

Editors: M. Thoma · M. Morari

Springer

Berlin

Heidelberg

New York

Barcelona

Hong Kong

London

Milan

Paris

Singapore

Tokyo

Engineering  **ONLINE LIBRARY**

<http://www.springer.de/engine/>

Daniela Rus, Sanjiv Singh (Eds)

Experimental Robotics VII



Springer

Series Advisory Board

A. Bensoussan · P. Fleming · M.J. Grimble · P. Kokotovic ·
A.B. Kurzhanski · H. Kwakernaak · J.L. Massey

Editors

Professor Daniela Rus
Dartmouth College
Department of Computer Science
Hanover, NH 03755
USA

Dr. Sanjiv Singh
Carnegie Mellon University
Robotics Institute
Pittsburgh, PA 15213
USA

Cataloging-in-Publication Data applied for
Die Deutsche Bibliothek – CIP-Einheitsaufnahme
Experimental robotics VII
Berlin; Heidelberg; New York; Barcelona; Hong Kong; London; Milano; Paris; Singapore; Tokyo:
Springer, 2001
(Lecture Notes in control and information sciences; 271)
ISBN 3-540-42104-1

ISBN 3-540-42104-1 Springer-Verlag Berlin Heidelberg New York

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilm or in other ways, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer-Verlag. Violations are liable for prosecution act under German Copyright Law.

Springer-Verlag Berlin Heidelberg New York
a member of BertelsmannSpringer Science + Business Media GmbH

<http://www.springer.de>

© Springer-Verlag Berlin Heidelberg 2001
Printed in Germany

The use of general descriptive names, registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

Typesetting: Digital data supplied by author. Data-conversion by PTP-Berlin, Stefan Sossna
Cover-Design: design & production GmbH, Heidelberg
Printed on acid-free paper SPIN 10796506 62/3020Rw - 5 4 3 2 1 0

Preface

Experimental Robotics is at the core of validating robotics research for both its systems science and theoretical foundations. Because robotics experiments are carried out on physical, sometimes complex, machines whose controllers are subject to uncertainty, devising meaningful experiments and collecting statistically significant results pose important and unique challenges in robotics. Robotics experiments serve as a unifying theme for robotics system science and algorithmic foundations. These observations have led to the creation of the International Symposia on Experimental Robotics in 1989. The meetings are bi-annual and focus on research where theories and principles have been validated by experiments.

The Seventh International Symposium on Experimental Robotics (ISER 2000) brought together a group of about 80 researchers to discuss recent results and relevant trends in experimental robotics. Held in Waikiki, Hawaii on December 11–13, the symposium was chaired by Prof. Daniela Rus (Dartmouth College) and Prof. Sanjiv Singh (Carnegie Mellon University). Prof. Song Choi from the University of Hawaii chaired the local arrangements committee. The meeting consisted of three invited talks, one invited panel, and fifty-seven contributed presentations in a single track. Each paper was refereed by the program chairs plus at least two members of the program committee. The program committee consisted of: Vincent Hayward (Canada), Oussama Khatib (USA), Herman Bruyninckx (Belgium), Alicia Casals (Spain), Raja Chatila (France), Peter Corke (Australia), Eve Coste-Maniere (France), John Craig (USA), Paolo Dario (Italy), Gerd Hirzinger (Germany), Jean-Pierre Merlet (France), Yoshihiko Nakamura (Japan), Daniela Rus (USA), Kenneth Salisbury (USA), Sanjiv Singh (USA), Tsuneo Yoshikawa (Japan), and Alex Zelinsky (Australia).

Topics reported at ISER 2000 included humanoids and human-robot interactions, perception systems, assembly and manipulation, medical and field applications, locomotion, multi-robot systems, modeling and motion planning, control, and navigation and localization. Several research projects presented at ISER 2000 are clearly breakthroughs in the field and will likely have a big impact in the future. Representatives include the three talks given by our invited speakers. Russell Taylor (Johns Hopkins University) presented an impressive medical robot system and argued a great case for how the impact of Computer-Integrated Surgery on medicine in the next 20 years will be as great as that of Computer-Integrated Manufacturing on industrial production over the past 20 years. Hirochika Inoue (University of Tokyo) described an amazing suite of humanoid robots and their tasks and presented a research agenda for a human-centered robotized society. Ralf Koeppel (DLR, Germany) described their progress with light-weight robotic manipulators and advocated an exciting range of applications to personal and service robotics.

We are very grateful to Dartmouth College and to Carnegie Mellon University for their generous financial support of ISER 2000. We would like to thank all the participants and their contributions, which made our meeting exciting and inspiring. We also thank David Bellows, Alan Guisewite, Monica Hopes, Catherine LaTouche, Dot Marsh and Alison Sartonov for their help with coordinating the meeting and producing the proceedings.

March 2001

Daniela Rus
Sanjiv Singh

Contents

1. Humanoids and Human-Robot Interaction

Haptically Augmented Teleoperation	1
<i>N. Turro and O. Khatib</i>	
Bilateral Teleoperation: Towards Fine Manipulation with Large Time Delay	11
<i>Y. Yokokohji, T. Imaida, Y. Iida, T. Doi, M. Oda, and T. Yoshikawa</i>	
Virtual Exoskeleton for Telemanipulation	21
<i>J. Amat, M. Frigola, and A. Casals</i>	
Design of Programmable Passive Compliance for Humanoid Shoulder	31
<i>M. Okada, Y. Nakamura, and S. Ban</i>	
Design, Implementation, and Remote Operation of the Humanoid H6	41
<i>S. Kagami, K. Nishiwaki, J.J. Kuffner Jr., T. Sugihara, M. Inaba, and H. Inoue</i>	
Cooperative Human and Machine Perception in Teleoperated Assembly	51
<i>T. Debus, J. Stoll, R.D. Howe, and P. Dupont</i>	
Regulation and Entrainment in Human-Robot Interaction	61
<i>C. Breazeal</i>	

2. Perception

Advancing Active Vision Systems by Improved Design and Control	71
<i>O. Sutherland, H. Truong, and S. Rougeaux, A. Zelinsky</i>	
S-NETS: Smart Sensor Networks	81
<i>Y. Chen and T.C. Henderson</i>	
Six Degree of Freedom Sensing for Docking Using IR LED Emitters and Receivers	91
<i>K. Roufas, Y. Zhang, D. Duff, and M. Yim</i>	
Height Estimation for an Autonomous Helicopter	101
<i>P. Corke, P. Sikka, and J. Roberts</i>	
Ladar-Based Discrimination of Grass from Obstacles for Autonomous Navigation	111
<i>J. Macedo, R. Manduchi, and L. Matthies</i>	
Reality-Based Modeling with ACME: A Progress Report	121
<i>D.K. Pai, J. Lang, J.E. Lloyd, and J.L. Richmond</i>	

3. Assembly and Manipulation

Grasp Strategy Simplified by Detaching Assist Motion (DAM)	131
<i>M. Kaneko, T. Shirai, K. Harado, and T. Tsuji</i>	
Force-Based Interaction for Distributed Precision Assembly	141
<i>R.T. DeLuca, A.A. Rizzi, and R.L. Hollis</i>	
Design and Implementation of a New Discretely-Actuated Manipulator	151
<i>J. Suthakorn and G.S. Chirikjian</i>	
Design and Experiments on a Novel Biomechatronic Hand	159
<i>P. Dario, M.C. Carrozza, S. Micera, B. Massa, and M. Zecca</i>	
Autonomous Injection of Biological Cells Using Visual Servoing	169
<i>S. Yu and B.J. Nelson</i>	

4. Medical, Space, and Field Applications

An Active Tubular Polyarticulated Micro-System for Flexible Endoscope	179
<i>J. Szewczyk, V. de Sars, Ph. Bidaud, and G. Dumont</i>	
Towards Semi-autonomy in Laparoscopic Surgery through Vision and Force Feedback Control	189
<i>A. Krupa, C. Doignon, J. Gangloff, M. de Mathelin, L. Soler, and G. More</i>	
Optimized Port Placement for the Totally Endoscopic Coronary Artery Bypass Grafting Using the da Vinci Robotic System	199
<i>È. Coste-Manière, L. Adhami, R. Severac-Bastide, A. Lobontiu, J.K. Salisbury Jr., J.-D. Boissonnat, N. Swarup, G. Guthart, É. Mousseaux, and A. Carpentier</i>	
ETS-VII Flight Experiments for Space Robot Dynamics and Control; Theories on Laboratory Test Beds Ten Years Ago, Now in Orbit	209
<i>K. Yoshida</i>	
Experimental Demonstrations for a New Design Paradigm in Space Robotics	219
<i>M.D. Lichter, V.A. Sujan, and S. Dubowsky</i>	
A First-Stage Experiment of Long Term Activity of Autonomous Mobile Robot—Result of Repetitive Base-Docking Over a Week	229
<i>Y. Hada and S. Yuta</i>	

5. Locomotion

Comparing the Locomotion Dynamics of the Cockroach and a Shape Deposition Manufactured Biomimetic Hexapod	239
<i>S.A. Bailey, J.G. Cham, M.R. Cutkosky, and R.J. Full</i>	

Super Mechano-System: New Perspective for Versatile Robotic System	249
<i>S. Hirose</i>	
Using Modular Self-Reconfiguring Robots for Locomotion	259
<i>K. Kotay, D. Rus, and M. Vona</i>	
Open-Loop Verification of Motion Planning for an Underwater Eel-Like Robot	271
<i>K.A. McIsaac and J.P. Ostrowski</i>	
Quadruped Robot Running With a Bounding Gait	281
<i>S. Talebi, I. Poulakakis, E. Papadopoulos, and M. Buehler</i>	
Evidence for Spring Loaded Inverted Pendulum Running in a Hexapod Robot ...	291
<i>R. Altendorfer, U. Saranlı, H. Komsuoğlu, D. Koditschek H.B. Brown Jr. M. Buehler, N. Moore, D. McMordie, and R. Full</i>	

6. Multi-robot Systems

A Framework and Architecture for Multirobot Coordination	303
<i>R. Alur, A. Das, J. Esposito, R. Fierro, G. Grudic, Y. Hur, V. Kumar, I. Lee, J.P. Ostrowski, G. Pappas, B. Southall, J. Spletzer, and C.J. Taylor</i>	
Motion Control of Distributed Robot Helpers Transporting a Single Object in Cooperation with a Human	313
<i>Y. Hirata, K. Kosuge, H. Asama, H. Kaetsu, and K. Kawabata</i>	
First Results in the Coordination of Heterogeneous Robots for Large-Scale Assembly	323
<i>R. Simmons, S. Singh, D. Hershberger, J. Ramos, and T. Smith</i>	
Towards A Team of Robots with Repair Capabilities: A Visual Docking System	333
<i>C. Bererton and P.K. Khosla</i>	
Merging Gaussian Distributions for Object Localization in Multi-robot Systems	343
<i>A.W. Stroupe, M.C. Martin, and T. Balch</i>	
Principled Communication for Dynamic Multi-robot Task Allocation	353
<i>B.P. Gerkey and M.J. Mataric</i>	
Progress in RoboCup Soccer Research in 2000	363
<i>M. Asada, A. Birk, E. Pagello, M. Fujita, I. Noda, S. Tadokoro, D. Duhaut, P. Stone, M. Veloso, T. Balch, H. Kitano, and B. Thomas</i>	

7. Modeling and Motion Planning

View Planning via C-Space Entropy for Efficient Exploration with Eye-in-Hand Systems	373
<i>Y. Yu and K.K. Gupta</i>	
Motion Planning for a Self-Reconfigurable Modular Robot	385
<i>E. Yoshida, S. Murata, A. Kamimura, K. Tomita, H. Kurokawa, and S. Kokaji</i>	
Experimental Comparison of Techniques for Localization and Mapping Using a Bearing-Only Sensor	395
<i>M. Deans and M. Herbert</i>	
Robot Navigation for Automatic Model Construction Using Safe Regions	405
<i>H. González-Baños and J.-C. Latombe</i>	
Simulation and Experimental Evaluation of Complete Sensor-Based Coverage in Rectilinear Environments	417
<i>Z.J. Butler, A.A. Rizzi, and R.L. Hollis</i>	
An Interactive Model of the Human Liver	427
<i>F. Boux de Casson, D. d'Aulignac, and C. Laugier</i>	

8. Control

The Biomechanical Fidelity of Slope Simulation on the Sarcos Treadport Using Whole-Body Force Feedback	437
<i>R. Mills, J.M. Hollerbach, and W.B. Thompson</i>	
A New Approach to the Control of a Hydraulic Stewart Platform	447
<i>M.R. Sirouspour and S.E. Salcudean</i>	
Design of Life-Size Haptic Environments	461
<i>Y. Matsuoka and B. Townsend</i>	
Micro Nafion Actuators for Cellular Motion Control and Underwater Manipulation	471
<i>M.Y.F. Kwok, W. Zhou, W.J.Li, and Y. Xu</i>	
Control of an Under Actuated Unstable Nonlinear Object	481
<i>N.A. Andersen, L. Skovgaard, and O. Ravn</i>	
Singularity Handling on Puma in Operational Space Formulation	491
<i>D. Oetomo, M.H. Ang Jr., and S.Y. Lim</i>	

9. Navigation and Localization

Autonomous Rover Navigation on Unknown Terrains Functions and Integration	501
<i>S. Lacroix, A. Mallet, D. Bonnafous, G. Bauzil, S. Fleury, M. Herrb, and R. Chatila</i>	
Map Building and Localization for Underwater Navigation	511
<i>S. Majumder, J. Rosenblatt, S. Scheding, and H. Durrant-Whyte</i>	
Visually Realistic Mapping of a Planar Environment with Stereo	523
<i>L. Iocchi, K. Konolige, and M. Bajracharya</i>	
Incorporation of Delayed Decision Making into Stochastic Mapping	533
<i>J.J. Leonard and R.J. Rikoski</i>	
Tele-Autonomous Watercraft Navigation	543
<i>R. Jarvis</i>	
An Underwater Vehicle Monitoring System and Its Sensors	551
<i>S.K. Choi and O.T. Easterday</i>	
Real Time Obstacle Detection for AGV Navigation Using Multi-baseline Stereo	561
<i>H. Wang, J. Xu, J.I. Guzman, R.A. Jarvis, T. Goh, and C.W. Chan</i>	
A new Generationacle of Light-Weight Robot Arms and Multifingered Hands ...	569
<i>G. Hirzinger, J. Butterfaß, M. Fischer, M. Grebenstein, M. Hähnle H. Liu, I. Schaefer, N. Sporer, M. Schedl, R. Koeppe</i>	