

CISM COURSES AND LECTURES

Series Editors:

The Rectors of CISM
Sandor Kaliszky – Budapest
Mahir Sayir – Zurich
Wilhelm Schneider – Wien

The Secretary General of CISM
Giovanni Bianchi – Milan

Executive Editor
Carlo Tasso – Udine

The series presents lecture notes, monographs, edited works and proceedings in the field of Mechanics, Engineering, Computer Science and Applied Mathematics.

Purpose of the series is to make known in the international scientific and technical community results obtained in some of the activities organized by CISM, the International Centre for Mechanical Sciences.

INTERNATIONAL CENTRE FOR MECHANICAL SCIENCES

COURSES AND LECTURES - No. 422



ROMANSY 13

THEORY AND PRACTICE OF ROBOTS AND MANIPULATORS

PROCEEDINGS OF THE THIRTEENTH
CISM-IFT_oMM SYMPOSIUM

EDITED BY

ADAM MORECKI
WARSAW UNIVERSITY OF TECHNOLOGY

GIOVANNI BIANCHI
POLYTECHNIC OF MILAN

CEZARY RZYMKOWSKI
WARSAW UNIVERSITY OF TECHNOLOGY



Springer-Verlag Wien GmbH

This volume contains 292 illustrations

This work is subject to copyright.

All rights are reserved,

**whether the whole or part of the material is concerned
specifically those of translation, reprinting, re-use of illustrations,
broadcasting, reproduction by photocopying machine
or similar means, and storage in data banks.**

© 2000 by Springer-Verlag Wien

Originally published by Springer-Verlag Wien New York in 2000

Softcover reprint of the hardcover 1st edition 2000

SPIN 10796360

**In order to make this volume available as economically and as
rapidly as possible the authors' typescripts have been
reproduced in their original forms, This method unfortunately
has its typographical limitations but it is hoped that they in no
way distract the reader.**

ISBN 978-3-7091-2500-7

ISBN 978-3-7091-2498-7 (eBook)

DOI 10.1007/978-3-7091-2498-7

PREFACE

The CISM-IFTOMM Ro.Man.Sy Symposia have played a dynamic role in the development of the theory and practice of robotics. The proceedings of the thirteenth symposia present world view of the state of the art.

Ro.Man.Sy 2000 held July 3-6, 2000 in Zakopane, Poland was attended by 74 participants from 15 countries.

The proceedings of this thirteenth edition of Ro.Man.Sy focus mainly on problems of mechanical engineering and control.

In his opening lecture B. Roth presented an overview of the theoretical basis for the mechanical aspects of robot design.

In his general lecture M. Vukobratovič discussed theory and practice of new frontiers of robotics.

The 50 regular papers included in this volume illustrate significant contribution in mechanics (13 papers), motion control (7), synthesis and design (8), legged locomotion (11), sensing and machine intelligence (2), applications (5) and biomechanical aspects of robots and manipulators (4). They appear here in the order and form in which they were presented during the symposium.

The next Ro.Man.Sy will be held in Udine, Italy in July 2002.

*Adam Morecki
Giovanni Bianchi
Cezary Rzymkowski*

CONTENTS

Page

Preface

OPENING LECTURE:

The Theoretical Basis for the Mechanical Aspects of Robot Design
by *B. Roth* 3

GENERAL LECTURE:

New Frontiers in Robotics
by *M. Vukobratovič* 15

CHAPTER I: Mechanics

Coordination of Parallel Arrays of Binary Actuators
by *P.-H. Yang and K.J. Waldron* 43

A Formal-Numerical Approach to Determine the Accuracy of a Parallel Robot
in a 6D Workspace
by *J-P. Merlet* 51

Symbolic Calculation of Robot's Base Reaction-Force/Torque Equations
with Minimal Parameter Set
by *M. Grotjahn and B. Heimann* 59

Mechanics of the New UWA Robot
by *K. Miller* 67

On Kinematic Singularities of Nonholonomic Robotic Systems
by *K. Tchoń* 75

Experimental Determination of Robot Workspace by Means of CATRASYS
(Cassino Tracking System)
by *M. Ceccarelli, E. Ottaviano and M. Toti* 85

A Pantograph Mechanism with Large-Deflective Hinges for Miniature
Surface Mount Systems
by *M. Horie, T. Uchida and D. Kamiya* 93

Adaptive λ - Tracking for Rigid Manipulators by <i>A. Mazur and C. Schmidt</i>	103
Mobility Analysis of the 3-PSP Mechanism by <i>R. Di Gregorio and V. Parenti-Castelli</i>	113
Detaching and Grasping Strategy Inspired by Human Behavior by <i>M. Kaneko, T. Shirai and T. Tsuji</i>	121
Cross-Country Capabilities of a Walking Robot: Geometrical, Kinematic and Dynamic Investigation by <i>V.E. Pavlovsky and A.K. Platonov</i>	131
Optimization of Robot Gripper Parameters Using Genetic Algorithms by <i>S. Krenich and A. Osyczka</i>	139
Design of Spatial Fixed-Sequence Manipulator for Precise and Approximate Reproduction of Gripper Predetermined Positions by <i>V. Arakelian and M. Dahan</i>	147

CHAPTER II: Control of Motion

A Powered-Caster Holonomic Robotic Vehicle for Mobile Manipulation Tasks by <i>R. Holmberg and O. Khatib</i>	157
Motion Coordination and Hybrid Position/Force Control of a Mobile Micromanipulator Actuated by Direct-Drive Vibromechanisms by <i>A. Ferreira and P. Minotti</i>	169
Coordination Control of a Human/Manipulator System by <i>J.H. Chung and S.A. Velinsky</i>	179
Stability of Cooperating Manipulators with Symmetric Position/Force Control and Time Delay by <i>A. Schneider, I. Zeidis and K. Zimmermann</i>	187
Remote Control of Periodic Robot Motion by <i>T. Insperger and G. Stépán</i>	197
Dynamic Control of Multiple Joint Manipulators Interacting with Dynamic Environment by <i>A. Tuneski and M. Vukobratovič</i>	205
A Comparison between PD-Controls in Terms of Normalized and Unnormalized Quasi-Velocities by <i>K. Kozłowski and P. Herman</i>	215

CHAPTER III: Synthesis and Design

The Modular Design of a Long-Reach, 11-Axis Manipulator <i>by J. Angeles, A. Morozov, L. Slutski, O. Navarro and L. Jabre</i>	225
Structure Synthesis of Parallel Manipulators <i>by V. Glazunov, A. Kraynev, G. Rashoyan, A. Trifonova and M. Esina</i>	235
Design of Manipulators Under Dynamic and Kinematic Performances <i>by S. Guerry and F.B. Ouezdou</i>	241
Influence of Leg Flexibilities on the Trajectory Planning of a 3-DOF Spherical Parallel Manipulator <i>by J. Knapczyk and G. Tora</i>	249
Study on the Specific Characteristics of Various Actuators <i>by T. Hayashi</i>	257
Micro-Manipulation and Adhesion Forces <i>by D.S. Haliyo, Y. Rollot, S. Regnier and J.C. Guinot</i>	265
Universal Dental Robot — 6-DOF Mouth Opening and Closing Training Robot WY-5 <i>by H. Takanobu, T. Maruyama, A. Takanishi, K. Ohtsuki and M. Ohnishi</i>	275
Development of the Design of POLYCRANK Manipulator Without Joint Limits <i>by K. Nazarczuk, K. Mianowski and S. Łuszczak</i>	285

CHAPTER IV: Legged Locomotion

Emotion-based Walking for a Biped Humanoid Robot <i>by Hun-ok Lim, A. Ishii and A. Takanishi</i>	295
Design and Control of the Humanoid Robot ARMAR <i>by K. Berns, T. Asfour and R. Dillmann</i>	307
On Dynamics of Movement of Walking Machines with Gears Made on the Basis Cycle Mechanisms of Walking <i>by E.S. Briskin, V.V. Chernyshev, A.V. Maloletov and S.V. Sherstobitov</i>	313
Development of Walking Machines: Novel Leg Drive Design and Control <i>by T. Zielińska and J. Heng</i>	323
Autonomous Locomotion of Walking Machines in Rough Terrain <i>by M. Frik, A. Buschmann, M. Guddat, M. Karataş and D.C. Losch</i>	331

Design and Control of a Biped Robot by <i>K. Löffler, M. Gienger and F. Pfeiffer</i>	339
Six Link Mechanisms for the Legs of Walking Machines by <i>A.P. Bessonov, N.V. Umnov, V.V. Korenovsky, E.E. Silvestrov and S.V. Khoborkov</i>	347
Design, Analysis and Measurements Problems of Mili-Walking Machines Using Multi-Body System Formulation by <i>J. Frączek and A. Morecki</i>	355
Modeling, Simulation and Nonlinear Control of a Combined Legged and Wheeled Vehicle by <i>J. Müller and M. Hiller</i>	363
A New Local Path Planner for a Nonholonomic Wheeled Mobile Robot in Cluttered Environments by <i>G. Ramirez and S. Zegloul</i>	371
Three-Dimensional Simulation of Walk of Anthropomorphic Biped by <i>F. Gravez, O. Bruneau and F.B. Ouezdou</i>	379

CHAPTER V: Sensing and Machine Intelligence

Cooperative Micro Object Handling by Dual Micromanipulators Under Vision Control by <i>A. Ferreira and S. Hirai</i>	391
A Comparative Study of Torque Control Using a Wrist or a Base Force/Torque Sensor by <i>F. Geffard, C. Andriot and G. Morel</i>	401

CHAPTER VI: Applications

Quality Feature Based Adjustment of Robot Programs Exemplified for the Welding Process – MAGROB by <i>R.D. Schraft, J. Neugebauer and W. Schaaf</i>	411
Application of the RNT Robot to Milling and Polishing by <i>K. Mianowski, K. Nazarczuk, M. Wojtyra, W. Szykiewicz, C. Zieliński and A. Woźniak</i>	421
Path Planning in Complex Environments for Industrial Robots with Additional Degrees of Freedom by <i>F. Valero, V. Mata and M. Ceccarelli</i>	431
Robotic Deburring Using a Fuzzy Force Controller by <i>R. Bicker and K. Burn</i>	439

A Distributed SMA Actuator System and Associated Self-Guiding Control Strategy for a Scalable Endoscope Steering Device <i>by Ph. Bidaud, J. Szewczyk, N. Troisfontaine and J.-C. Guinot</i>	447
--	-----

CHAPTER VII: Biomechanical Aspects

Low Energy Biped Locomotion <i>by S. Gruber and W. Schiehlen</i>	459
Jumping Motion of an Object Controlled by a Muscle Contraction <i>by J. Viba, I. Tipans, O. Kononova and J.-G. Fontaine</i>	467
Inverse Simulation Study of Trampoline-Performed Somersaults <i>by W. Blajer and A. Czaplicki</i>	479
Functional Biomechanics of Human Grasping and Sensory Requirements for Simple Robotic End-Effectors <i>by R.B. Addis and B. Ravani</i>	489

APPENDIX A

Programme and Organizing Committee	503
--	-----

APPENDIX B

List of Participants	507
----------------------------	-----