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Vincent Padois
Philippe Bidaud
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Romansy 19 – Robot Design, Dynamics and Control

Proceedings of the 19th CISM-IFtomm Symposium

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Editors

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PREFACE

The first CISM-IFToMM Symposium on Theory and Practice of Robots and Manipulators was held on September 5-8, 1973 at CISM in Udine, Italy. The Symposium has been called RoManSy for Robot and Manipulator Systems. Indeed, RoManSy has been the very first international symposium dedicated to the Robotics field. The chairman of the first RoManSy was Professor A.E. Kobrinsky, and personalities such as Professors M. Konstantinov, I.I. Artobolevski, G. Bianchi, A. Morecki, B. Roth, M. Vukobratovic, were members of the Program Committee.

For over 35 years now, the RoManSy symposia provided a framework for fruitful exchanges between researchers around the world on modelling and design of complex robotic systems, design of control systems and interactions induced in challenging applications of robotic systems. The RoManSy has been and remains the place where scientific questions such as those related to the kinematic analysis and synthesis of complex mechanisms, the design of advanced robotic systems, the analysis of the dynamic behaviour of robotic systems and their applications in order to achieve a certain level of autonomy or adapt to changes in physical and human environment are specifically discussed.

Modelling issues of robotic systems, their physical and cognitive interactions with the environment and humans, and their dynamic control have been the core of the exchanges among attendees during RoManSy 2012. They took place based on a set of technical sessions that have involved contributions in a number of fundamental and applied aspects related the design and the control of parallel manipulators for challenging applications with a particular focus on cable-driven machines, human-robot interfaces including those for physical interactions such as those useful for physical rehabilitation, human modelling and humanoid control as well as the design of integrated perception devices, mobile robots navigation on natural terrains, etc.

Each session was introduced by a presentation placing the state of the art in the field and defining a number of scientific challenges. In

addition, the invited speakers (Professor A. Bicchi and A. Edsinger, co-founder of Meka Robotics) offered a unique perspective on particularly rich topics of research: design of bio-inspired dexterous hands and design of human friendly robots.

Future researches on the various topics covered by the 2012 RoManSy are obviously particularly important. Clearly, by considering their impact on the development of next-generation robotic systems, they will be subject to numerous investigations in the coming years and will be major topics for future editions of RoManSy to which we wish a great success.

Philippe Bidaud, Université Pierre et Marie Curie
Oussama Khatib, Stanford University
Vincent Padois, Université Pierre et Marie Curie

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Inverse Static Analysis of Massive Parallel Arrays of Three-State Actuators via Artificial Intelligence

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Abstract Massive parallel arrays of discrete actuators are force-regulated robots that undergo continuous motions despite being commanded through a large but finite number of states only. Real-time control of such systems requires fast and efficient methods for solving their inverse static analysis, which is a challenging problem. Artificial intelligence methods are investigated here for the on-line computation of the inverse static analysis of a planar parallel array featuring eight three-state force actuators and possessing one degree of revolute motion.

1 Introduction

Discrete-State Manipulators (DSM) are a special kind of mechanisms whose actuators can be made switching among a finite number of states only. Introduced in the early 1970's [1] in an attempt to conceive sensor-less robots as well as to reduce the complexity of control systems and computer interfacing, nowadays DSM can be classified into two different groups depending on whether their actuators act as either discrete displacement generators [2-5] or discrete force generators [6]. This work deals with the latter type of DSM, usually referred to as Massively Parallel Robots (MPR). In essence, MPR are dynamically constrained mechanisms employing a large number of on-off actuators that exert either a constant force (active state) or no force (inactive state) irrespective of their arbitrary kinematically unconstrained configuration. To achieve high force capabilities (both in terms of variation range and accuracy), the architecture of these MPR practically requires a large number of actuators (typically 4-10 times greater than the number

brute-force method, two Neuro-Fuzzy methods and two Recurrent Neural Network methods for the solution of the inverse static analysis. Thanks to the partitioned and spatially distributed actuator architecture, the considered discrete robot features rather ample, uniform and accurate torque generation capabilities. Comparison among the considered inverse static analysis methods highlighted that Elman type Recurrent Neural Network model is best suited for real-time control applications.

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