

## PREFACE

It was early September 1995. I took part in the Second International Symposium on *Methods and Models in Automation and Robotics* in Mi/edzyzdroje, Poland. During one of the conference breaks Prof. J. Korbicz, Editor-in-Chief, and I were struggling with big waves at the Baltic Sea and all of a sudden he introduced the idea to me preparing a special issue on robotics for *Applied Mathematics and Computer Science*. I found this idea very interesting since robotics is a complex interdisciplinary field which uses several classical disciplines such as mechanics, mathematics, physics up to computer science and control engineering it deserves a special attention for this journal.

One and a half year later I take great pleasure in realizing this idea and presenting the Reader with the special issue entitled *Recent Developments in Robotics*. This issue gathers papers written by prominent roboticists from all over the world. We received 20 very good papers for this issue but unfortunately due to a limited number of papers (in spite of that this issue is thicker than the regular one) we were able to publish only 12 papers.

In order to characterise the contents of the special issue we make the following comments. All contributions have very strong mathematical background and present nontrivial solutions to the control, kinematics, dynamics, and trajectory planning problems encountered in robotics. The first eight papers are devoted to control problems in robotics. The first paper written by A. De Luca, R. Mattone, and G. Oriolo uses a partial feedback linearization control scheme for a kinematically redundant robot driven by forces/torques imposed on the end-effector. Authors use nonlinear controllability tools to derive conditions under which it is possible to move the robot between two given configurations using end-effector commands. Interesting simulation results illustrate the proposed control scheme. The second paper written by T. Lin and A.A. Goldenberg addresses motion and force control problem of a flexible joint robot in constrained motion. Authors propose a two-stage control scheme, consisting of a constrained motion controller and a joint torque controller. Both adaptive and robust control algorithms are developed based on the Lyapunov stability theory. Simulation results illustrate the effectiveness of the proposed control method. The next paper by B. Armstrong, J. McPherson and Y. Li is an interesting study on how to construct a nonlinear PD-controller which applies an increased control effort when the system is moving away from its desired value and a reduced effort when the output is moving toward the goal point. Authors present a rigorous stability proof of the nonlinear PD controller. Design, and implementation issues are addressed and interesting design examples are presented. The fourth paper written by S. Chiaverini, B. Siciliano, and L. Villani proposes an adaptive control scheme for controlling both the force

and position of a robot manipulator in contact with a compliant surface. Stability of the systems is formally proved in two cases: known and unknown stiffness. Simulation results illustrate the proposed method. The following paper written by J. Ostrowski and J. Burdick derives accessibility and controllability tests for a large class of mechanical systems characterised by nonholonomic constraints and symmetries which are based on their reduced geometrical structure. Several interesting examples are discussed. A method of finding optimal controls for both kinematically non-redundant and redundant manipulators is discussed in the next paper written by M. Galicki, G. Paj/ak, and I. Paj/ak. It is shown in the paper that the optimal controls converge to a bang-bang solution. A simple numerical example of a three degree of freedom robot illustrate the proposed method.

The seventh paper written by Th. Meitingner and F. Pfeiffer is devoted to force contact analysis during the assembly process. Dynamics of the manipulator and models of the mounting processes are included in this analysis. This interesting compliant analysis is illustrated by numerical and experimental results. The paper by C. Schmidt and M. Prüfer discusses various practical issues of robot dynamics identification such as bias estimates and poor identifiability conditions or problems of measurement noise. This discussion is widely illustrated by simulation and experimental results.

The successive paper written by K. Tcho/n deals with avoidability and unavoidability conditions of singular configurations for redundant manipulators. These conditions are derived by examining the stability of the Hamiltonian vector fields. An example derived based on *Mathematica* illustrates the proposed approach. G. Rodriguez and A. Jain introduced a new factorization method of the mass matrix for free-flying robots. This factorization corresponds to the optimal combination of the covariance of two independent spatially recursive random processes. Computational aspects of the new method are widely discussed in the paper.

The last two papers deal with optimal trajectory planning. The first one written by P. Fiorini, and Z. Shiller presents a direct method for computing the time optimal trajectory for a robot among stationary and moving obstacles, subject to robots dynamics and actuator constraints. The motion planning problem is first formulated as an optimisation problem and then solved numerically using a gradient descent. The method is illustrated by an example of planar manipulator moving in static and dynamic environments. The other paper written by Y. Bestaoui, P. Plédel, and M. Gautier solves a trajectory planning problem in the Cartesian space taking into account actuators limitations on voltages and currents, in order to minimise the arrival time. Simulation results illustrate the proposed method.

At the end of this preface the Guest Editor wishes to express his gratitude to all the authors who have contributed to this special issue. It was a pleasure for me to cooperate with them. Special thanks are directed to Prof. J. Korbicz, the Editor-in-Chief, for his invitation to prepare this issue and active assistance in the final publication process. This special issue would not come to life without authors' and Editor's-in-Chief relentless effort.

*Krzysztof Kozłowski*