PREFACE

The idea of creating a special section devoted to theoretical robotics within one of the issues of the *International Journal of Applied Mathematics and Computer Science* emerged in the discussions during the 10-th National Conference on Robotics organized by the Division of Fundamentals of Cybernetics and Robotics of the Wrocław University of Technology (Piechowice, Poland, September 2008). This conference showed that the Polish robotics community had produced significant theoretical results and thus the Program Committee decided that it would be beneficial to put together those achievements within one publication, so that they can complement each other. Hence a selected group of authors working on formal methods in robotics was approached to submit papers describing their achievements concerning the mathematical foundations of robot control. It should be underscored that the papers contained in this section are by no means a simple translation of the conference papers. Here the reported results are described more comprehensively and in a wider context. Moreover, they have been subject to the regular *AMCS* review procedure. Gratitude should be expressed to all of the reviewers, who provided indepth comments enabling many clarifications and overall improvement of the contents of the papers.

This special section of *AMCS* is devoted to selected algorithms utilized in robot control. Five papers compose this section. They have two common features that enable us to treat them as a single thematic group. All of them heavily rely on advanced mathematical formulation of the problems considered and all focus on mobile robots. Having said that, it should be noted that some of the obtained results are more general in nature and so can be applied to manipulator control as well.

The paper entitled *Approximation of Jacobian inverse kinematics algorithms*, by Tchoń, Karpińska and Janiak, focuses on the derivation of the inverse Jacobian for mobile robots and redundant manipulators. The Jacobian relates the velocities of a mobile robot platform or a manipulator end-effector expressed in the configuration and task spaces. Thus it is fundamental to control those devices. For that purpose, any trajectory specified in the task space must be converted into a trajectory expressed in the configuration space, and thus an inverse of the Jacobian is necessary. As in the case of redundant manipulators or non-holonomic mobile robots, the Jacobian is usually not a square matrix, and thus it is directly non-invertible, so that some form of a pseudoinverse has to be computed. Usually a Jacobian pseudoinverse is utilized, although this solution is not repeatable due to the freedom of choosing the solution from within the null space. The authors propose an approximation of the inverse Jacobian that they term an extended Jacobian. It is derived by utilizing two approaches: variational and differential geometric. The theoretical developments are illustrated with two numerical examples showing the performance of the extended Jacobian inverse kinematics algorithm for a redundant manipulator and a unicycle.

The next two papers, *Motion planning and feedback control for a unicycle in a way point following task: The VFO approach*, by Michałek and Kozłowski, and *Trajectory tracking for a mobile robot with skid-slip compensation in the vector-field-orientation control system*, by Michałek, Dutkiewicz, Kiełczewski and Pazderski, form a pair dealing with control synthesis using the concept of Vector Field Orientation (VFO). The former paper introduces the idea of VFO and formulates the motion task for a non-holonomic mobile robot in terms of a sequence of way-points that this robot has to pass through. This formulation simplifies the motion planning stage by avoiding interpolation procedure between the way-points. The motion task is solved by synthesizing a VFO feedback controller. This paper presents both the stability analysis and proof of finite-time convergence of the proposed control algorithm. The theoretical discussion is illustrated with the simulation of the behaviour of the robot under the influence of the proposed control scheme. The latter paper extends the concept of VFO onto a situation when skid or slip of the vehicle occurs, although retaining the kinematic nature of the algorithm. Skid and slip are treated as a velocity disturbance. The benefit of utilizing a purely kinematic approach is that the determination of wheel-ground friction coefficients is avoided, which is inherent in the issues involving dynamics. In the experiments the authors used a fast vision system and Kalman filtering for skid-slip estimation.

The paper *On path following control of nonholonomic mobile manipulators*, by Mazur and Szakiel, delves into the problem of control law synthesis for devices consisting of a nonholonomic platform combined with either a holonomic or a nonholonomic manipulator. Here the solution of the problem is based on the dynamics model of such a device. The motion task is split into two subtasks: the end-effector following a geometric path expressed in relation to its base and the mobile platform following a curve defined on the supporting plane. Here again theoretical investigations are supported by simulations presenting the performance of the control algorithm.

The last paper of the section, *Simultaneous localization and mapping: A feature-based probabilistic approach*, by Skrzypczyński, presents the field of probabilistic SLAM and shows a solution of this problem based on an extended Kalman filter and its extensions. They are aimed at improving computational efficiency and effectiveness of pairing observations and features in the obtained images, as well as creating perceptually rich environment representations by using cameras.

All of the above topics are at the forefront of the currently ongoing research into robot control. Each of the papers gives a valuable insight into a particular problem, providing its formal definition and solution. This selection of papers makes us realize the diversity of the field of robot control.

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