Robot modelling, perception, and motion synthesis

This issue of the *Journal of Automation, Mobile Robotics and Intelligent Systems* is devoted to three complementary aspects of current robotics research: modelling of robots, robot perception, and motion synthesis for different types of robots. The main theme is robot motion synthesis, however it takes into account robot perception and diverse aspects of modelling. This complementarity encouraged us to put those topics together into a single issue of JAMRIS, enabling its readers to enjoy wider context of the presented subject.

The idea of publishing an issue of JAMRIS devoted to the mentioned topics emerged in the discussions during the 14th National Conference on Robotics organized by the Department of Fundamental Cybernetics and Robotics, Electronics Faculty, Wrocław University of Technology in Polanica Zdrój, Poland, held from 14th till 18th of September 2016. The conference showed that the Polish robotics community has produced significant results pertaining to the mentioned subject, and thus the Program Committee decided that it would be of benefit, if those achievements were gathered within one publication. Hence, a selected group of authors of the most insighting achievements was invited to submit papers describing their research results. It should be stressed that the papers put together in this issue of JAMRIS are by no means a simple translation into English of the conference papers. The results reported here have been updated, described more comprehensively and in a wider context. The new papers were subjected to the regular JAMRIS review procedure. Gratitude should be expressed to all of the reviewers who provided in depth comments enabling many clarifications and overall improvement of the contents of the papers. Below we make a brief overview of the contents of this issue.

The paper entitled *Modeling and Simulation of a Tracked Mobile Inspection Robot in Matlab and V-Rep Software*, authored by Michał Ciszewski, Łukasz Mitka, Tomasz Buratowski and Mariusz Giergiel, introduces a novel in-pipe inspection robot. The robot contains two track modules that propel it inside the pipe. These tracks, mounted around the modules containing motors, are pressed onto the inner side of the pipe by arms (called pedipulators), so that the resulting friction is able to provide adequate support and traction. The article presents the mechanical structure of the robot, including the mechanism that enables it to adapt to varying diameters of the inspected pipes, the simulation of its motion, and the tests performed on the prototype of the device.

Magdalena *Żurawska*, Maksymilian Szumowski and Teresa Zielińska authored the paper *Reconfigurable Double Inverted Pendulum Applied to Modelling Human Robot Motion*, which delves into the motion of humanoids. A simplified model of the humanoid body is introduced. A 15-segment anthropomorphic model is divided into two parts: upper and lower, hence the concept of a double inverted pendulum could be employed. Trajectories of the centres of mass of the two parts have been subjected to the analysis in terms of correlation coefficients. The simplified model was compared with the model allowing free arm movement, showing the influence of arm motions on the overall humanoid movement.

The article: *A Kinetostatics-Based Study of Uniqueness of Reactions and Drives in Robotics*, autored by Marcin Pękal and Janusz Frączek, focuses on the problem of non-uniqueness of driving and reaction forces in robots. The kinetostatics-based analysis, unlike the previously used methods, which detected only non-uniqueness of reaction forces, enables concurrent detection of both types of uniqueness deficiency. The method is based on the concept derived from linear algebra, i.e. the null space of a coefficient matrix containing the geometry-related parameters of joints and links.

Azimuth Angle Determination for the Arrival Direction for an Ultrasonic Echo Signal, by Bogdan Kreczmer, looks into the problem of how to measure the angle of echo arrival from an ultrasonic signal produced by a piezoelectric sonar. The proposed method assumes that the echo is reflected from a single object. The theoretical considerations have been validated by experiments performed using the constructed rotary sonar system.

Agnieszka Kobierska, Leszek Podsędkowski, Paweł Poryzała and Piotr Rakowski in their work entitled *The Measurement of Displacement with the Use of MEMS Sensors: Accelerometer, Gyroscope and Magnetometer* present a method of determining the orientation of manipulator links with respect to a global reference frame by relating the vectors associated with the links to the vectors of the gravitational and magnetic fields. For this purpose each link was equipped with low-cost inertial sensors and a magnetometer. The measurements obtained from those sensors are processed by an Extended Kalman Filter.

The paper: *A Set of Depth Sensor Processing ROS Tools for Wheeled Mobile Robot Navigation*, by Michał Drwięga and Janusz Jakubiak, presents a ROS based toolset facilitating the implementation of robot navigation. The presented toolset contains software for: converting 3D depth images into 2D polar scans, removing the ground plane, projecting obstacles, compensation of sensor tilt angle, detection of holes in the ground, and estimation of the height

and the orientation of the sensor. The utility of the created software was validated on a mobile platform equipped with a Kinect sensor.

The work entitled *On the Application of RGB-D SLAM Systems for Practical Localization of Mobile Robots*, written by Aleksander Kostusiak, Michał Nowicki and Piotr Skrzypczyński, delves into practical problems encountered when localizing mobile robots using RGB-D SLAM techniques. The work concentrates on the influence of different classes of mobile robots and the environments they operate in, and on the quality of the estimated trajectory obtained from measurements provided by an RGB-D sensor mounted on a mobile platform. The paper concludes that not all RGB-D SLAM architectures presented in the literature perform robustly when applied to physical robots and environments. Moreover, it provides an insight as to why they fail.

Wojciech Dudek, Wojciech Szynkiewicz and Tomasz Winiarski present *Cloud Computing Support for the Multi-Agent Robot Navigation System*. The paper discloses how to distribute navigation software between the on-board robot computer and the computational cloud. Thus computationally demanding modules can be located in the cloud supporting many mobile robots. In-cloud robot path planning and global localization have received particular attention.

The paper authored by Paweł Joniak and Robet Muszyński, entitled *Path Following for Two HOG Wheels Mobile Robot*, describes a mobile robot composed of two hemispheres. It focuses on the kinematics of the device for the purpose of its control along a predefined path. A full kinematics model of the device and its simplification are considered.

The team composed of: Krzysztof Arent, Mateusz Cholewiński, Łukasz Chojnacki, Wojciech Domski, Michał Drwięga, Janusz Jakubiak, Mariusz Janiak, Bogdan Kreczmer, Adam Kurnicki, Bartłomiej Stańczyk and Dorota Szczęśniak-Stańczyk presents *Selected Topics in Design and Application of a Robot for Remote Medical Examination with the Use of Ultrasonography and Ascultation from the Perspective of the REMEDI Project*. The aim of this project is to construct a robot that is able to subject a patient to a medical examination by a remotely located doctor. The fundamental aspect of this system is robot perception, providing remote sensing to the doctor. The physician, by using the robot, is able to conduct an interview and observe the patient, as well as subject him/her to an auscultation and an ultrasound examination, including echocardiography. The paper describes the overall system structure and its components. Moreover it presents the system evaluation by the users.

The paper entitled: *2D Microgravity Test-Bed for the Validation of Space Robot Control Algorithms*, was written by the team consisting of: Jakub Oleś, Jan Kindracki, Tomasz Rybus, Łukasz Mężyk, Przemysław Paszkiewicz, Radosław Moczydłowski, Tomasz Barciński, Karol Seweryn and Piotr Wolański. It describes problems encountered when removing debris by space robots (satellites) equipped with manipulators. Prior to their launch they must be thoroughly tested on Earth under microgravity conditions. Autonomous operation of such robots is a necessity, as the acquisition of debris requires quick reactions. In such systems the perception component, based on vision, is of paramount importance. The paper presents the dynamics of a satellite-manipulator system, which is subsequently used for simulation and control of such systems. The vision system supplies the information on the pose of the debris with respect to the satellite.

All of the topics addressed in the papers contained in this issue of JAMRIS, and briefly characterized above, are the subject of current deliberations of the scientific community conducting research concerned with robot modelling, perception and motion synthesis. Each of the papers gives a valuable insight into a particular problem, providing its formulation and deriving its solution. This selection of papers reveals the wide scope and diversity of contemporary robotics.

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