Smart Innovation, Systems and Technologies 329

Andrey Ronzhin
Viacheslav Pshikhopov *Editors*

Frontiers in Robotics and Electromechanics

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Andrey Ronzhin · Viacheslav Pshikhopov
Editors

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Editors
Andrey Ronzhin
St. Petersburg Federal Research Center
of the Russian Academy of Sciences
St. Petersburg, Russia

Viacheslav Pshikhopov
Research Institute of Robotics and Control
Systems
Southern Federal University
Rostov-on-Don, Russia

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Preface

Digital transformation of society and declining cost of robots open up new areas of application of robotic technology. A retrospective analysis of the development of robotics allows us to assess the future development of the industry and highlight the most promising research areas for the development of intelligent control systems and electromechanics of heterogeneous robots.

The book presents solutions and notes of the problems of individual robotic devices, as well as heterogeneous groups of robots when performing technological tasks that require information, physical or energy interaction with people, the environment and other robots, including service-charging platforms. The book examines the models, algorithms and software, hardware control of ground, water and underwater robots, unmanned aerial vehicles, as well as their built-in and attached equipment, including video cameras, sensors, repeaters, manipulators, grippers, and other actuators.

Examples of bioinspired insectomorphic and four-legged robots, unmanned aerial vehicles with flapping wings, which allow them to move in an aggressive environment with moving obstacles and changing weather conditions, are considered.

Multilink systems for manipulating objects and exoskeletons for enhancing the physical capabilities of a person and rehabilitation of the patient's musculoskeletal system have been analyzed. Due to the observance of the correct angles of the patient's hip and foot, as well as their precise positioning in the exoskeleton, rehabilitation is much faster.

To implement manipulators, various kinematic schemes are used, including those with a pyramidal structure, and their control systems are tuned through algorithms for learning an artificial neural network, reinforcement learning, an adaptive forecasting strategy, and a semi-Markov model.

Decomposition of tasks in collaborative robotic systems is discussed. For complex and lengthy composite operations in the control system, it is possible to take into account the requirements for providing time to the rest of the participating people (depending on their current productivity and taking into account the drop in the efficiency of completing tasks on time) and periodic maintenance of collaborative robots.

Approaches to the calculation of trajectories of movement of robots in two-dimensional and three-dimensional environments with obstacles are considered. When constructing the trajectory of unmanned aerial vehicles of an aircraft type, the location of take-off and landing points is taken into account, which ensures a decrease in the number of maneuvers while driving. Simulation of labyrinthine environments is performed in the Gazebo simulator and other computer platforms.

The robotic solutions of authors from Azerbaijan, Japan, Mexico, Russia, and Taiwan, considered in the book, are implemented for practical tasks of monitoring power lines, water resources, agricultural resources, hazardous radioactive territories, the movement of ships on the coastal territory, airfield transport, the formation of dynamic communication systems, and construction production.

St. Petersburg, Russia — Andrey Ronzhin
Rostov-on-Don, Russia — Viacheslav Pshikhopov

Contents

Performance Evaluation of Multigrid Brute-Force Solutions of Inverse Kinematics Problem for the Robotis OP2 Humanoid Hand

Linar Zagidullin, Tatyana Tsoy, Kuo-Hsien Hsia, Edgar A. Martínez-García & Evgeni Magid

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Abstract

Humanoid robots target to remove human labor from multiple working environments including the ones that were initially constructed for a human. Robot limbs operation requires solving an inverse kinematics problem, and a standard solution could involve algebraic, geometric, or numerical approaches. This paper presents two brute-force off-line approaches for a Robotis OP2 humanoid upper limb positioning via forward kinematics. Both approaches calculate and structure all possible solutions for an end-effector pose within a robot workspace in advance using a powerful PC, in the off-line mode. Several levels of workspace and joint space discretization allow a user to select a required for his/her task level of the solution precision considering available onboard resources of the robot. Different discretization levels were evaluated at an offboard PC and at an onboard computer of the Robotis OP2 humanoid. The solutions with different discretization levels were compared in terms of memory consumption and precision. The solutions were initially obtained in the Gazebo simulation and then successfully validated with a real Robotics OP2 humanoid. The presented analysis might be useful for a discretization level selection under onboard memory limitations while dealing with manipulator kinematics.

Keywords

Humanoid | Gazebo | Robotics