Advanced Technologies in Modern Robotic Applications

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Preface

Today's digital lifestyle is born from the revolutions of personal computer (PC) and Internet. Moving forward, it seems inevitable that robots will find their ways into our daily lives, integrating seamlessly into the fields of manufacturing, construction, household duties, services, medical operations, health care, etc. A new era of Industry 4.0 is coming, and robots will play significant roles in the new waves of technological revolutions. Unfortunately, most of the existing robot technologies are designed for traditional industrial applications for which the robots operate behind safeguarding and for predefined routine tasks, and thus are not able to perform varying tasks in unknown, complex, and dynamic environments. And modern robots are expected to co-habit with our humans and work closely with us in the fields such as manufacturing and health care as well as in other aspects of our daily lives, and are thus inevitably subject to unpredictable and uncertain external disturbances. Therefore, on the one side we focus on advanced control techniques for robots to deal with various uncertainties, and on the other side we pay much attention to visual servoing techniques which enable robot to autonomously operate in a dynamic environment.

In the recent decades, there is a significant trend in the robotic research community to develop advanced technologies that would enable robots to collaborate with humans friendly and naturally. Therefore, human–robot interaction is another important topic to be covered in this book. Much effort has been devoted to human–robot shared control in teleoperation, and advanced techniques involved in human–robot interfaces. Most of the techniques presented in this book have been tested by either simulations or experiments, preferably on human-like robot platforms such as Baxter robot, because humanoid robots are very popular and have been widely accepted by human users due to their appearances. In summary, the objective of this book is to present in a systematic manner the advanced technologies used for various modern robot applications. By bringing fresh ideas, new concepts, novel methods, and tools into robot control, human–robot interaction, robotic teleoperation, and multiple robot collaboration, we are to provide a

state-of-the-art and comprehensive treatment of the advanced technologies for a wide range of robotic applications.

This book starts with an introduction to the robot platforms and tools used in this book in Chap. 1, including some popularly used humanoid robot platforms, visual sensors and haptic devices, and the simulation platforms such as MATLAB Robotics Toolbox, Virtual Robot Experiment Platform (V-REP) simulator, and Robot Operating System (ROS). Since robotic kinematics and dynamics are essential for describing the position, orientation, joints motion as well as analyzing and synthesizing the dynamic behavior of a robot, Chap. 2 discusses the robotic kinematics and dynamics modeling procedure of the commercialized Baxter robot and provides a case study of robot modeling. In Chap. 3, we introduce a number of novel intelligent control methods which are useful to deal with the uncertainties associated with the robot manipulators, such as model mismatch, changing of the external environment, and uncertain loads. These control methods include dual adaptive control, optimized model reference control, and discrete-time adaptive control. Machine vision and image processing are very important for advanced robots as they provide comprehensive and abundant information of surrounding environment. To realize the key functions for robots in understanding the surrounding environment, Chap. 4 focuses on vision-based object detection and tracking using pattern recognition and state estimation. And Chap. 5 investigates visual servoing based human–robot interaction which allows users just to perform in the front of the sensor devices without wearing or operating any control devices to achieve their control purposes. Human–robot collaboration is regarded as a key character of next generation robots which allows human and robot to interact physically with guaranteed safety and compliance. In Chap. 6, we investigate a number of robot teleoperation techniques which can be regarded as a straightforward way to achieve human–robot interaction, such as teleoperation using body motion tracking, teleoperation based on adaptive control approach and human–robot interaction using haptic feedback devices. These technologies are further investigated in Chap. 7, with establishment of a human–robot shared control framework in which the automatic obstacle avoidance can be achieved without affecting the intended teleoperation task. Chapter 8 studies several state-of-art techniques for human–robot interfaces, which are key elements for human–robot interactions, such as hand gesture based robot control, Emotiv neuroheadset in the controlling of mobile robot and the EEG signals based robot manipulator control. Robot localization is essential for a wide range of applications, such as navigation, autonomous vehicle, intrusion detection, and so on. Chapter 9 focuses on indoor/outdoor localization of robot, which is crucial for most tasks demanding accuracy. Chapter 10 is dedicated to the theoretical study of multiple robot cooperation in the framework of multi-agents system, including optimal multi-robot formation, hunting activities of a multi-robot system, and multi-robot cooperative lifting control. Finally, some useful technologies developed for other popular robot applications are presented in Chap. 11, including some theoretical and practical results of robot kicking, and reference trajectory adaptation algorithm for motion planning.

This book is featured with a number of attractive and original research studies, including the robot control design in a biomimetic manner, the teleoperation method in a human–robot shared control manner, the novel human–robot interaction interface based on hand gesture recognition and on electromyography (EMG). The publication of this book will systematically bring new knowledge created by the authors to the robotic communities, especially in the topics of biomimetic control, human–robot interaction and teleoperation. The book is primarily intended for researchers and engineers in the robotic and control community. It can also serve as complementary reading for robotics at both graduate and undergraduate levels. The book will help to consolidate knowledge and extend skills of robotic researchers. This book will be extremely useful for early career researchers to be equipped with a comprehensive knowledge of technologies in modern robot applications. This book will also bring fresh new ideas into education, and will benefit students by exposing them to the very forefront of robotics research; preparing them for possible future academic or industrial careers in robotics or robot applications.

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