Part D

Multimedia Contents

Manipu

Part D Manipulation and Interfaces

Ed. by Makoto Kaneko

Part D, Manipulation and Interfaces, is separated into two subparts; the first half is concerned with manipulation where frameworks of modeling, motion planning, and control of grasp and manipulation of an object are addressed, and the second half is concerned with interfaces where physical human–robot interactions are handled. Humans can achieve grasping and manipulation of an object dexterously through hand–arm coordination. An optimum control skill for such a redundant system is naturally and gradually acquired through experience in our daily life. Especially, fingers play an important role for expressing human dexterity. Without dexterous fingers, it is hard for us to handle any daily tool, such as a pencil, keyboard, cup, knife, or fork. This dexterity is supported with active and passive compliance as well as the multiple sensory organs existing at the fingertip. Such dexterous manipulation enables us to clearly differentiate humans from other animals. Thus, manipulation is one of the most important functions for humans. We eventually acquired the current shape of finger, the sensory organs, and skill for manipulation, through a long history of evolution, over more than six million years. While humans and robots are largely different in terms of actuators, sensors, and mechanisms, achieving dexterous manipulation like that of a human in a robot is a challenging subject in robotics. As we overview current robot technology, however, we observe that the dexterity of robots is still far behind that of humans. With this overview, we now provide a brief synopsis of each chapter in the first half of Part D.

Chapter 36, Motion for Manipulation Tasks, discusses algorithms that generate motion for manipulation tasks at the arm level, especially in an environment, by using the configuration space formalism. While in previous chapters (6 and 7) the focus was on specific algorithmic techniques for robot motion, this chapter is focused on a specific application for robot manipulation. The important example of assembly motion is discussed through the analysis of contact states and compliant motion control.

Chapter 37, Contact Modeling and Manipulation, provides the contact modeling on rigid contact with and without friction, and also the modeling on soft contact, such as elastic and viscoelastic contact interfaces. Kinematics and mechanics with friction are precisely handled under rigid-body contact. The selection matrix **H** is introduced to understand the force and velocity constraints at the contact interface. Pushing manipulation is also addressed by using the concept of the friction limit surface.

Chapter 38, Grasping, discusses based on the closure property, grasping with many examples, supposing multifingered robotic hands. A strong constraint for grasping is the unilateral characteristic,where a fingertip can push but not pull an object through a contact point. The rigid-body model is further extended for considering compliance in grasping with robotic hands having a low number of degrees of freedom (DOFs). Kinematics and closure issues are also addressed under this unilateral constraint.

Chapter 39, Cooperative Manipulators, addresses the strategies for controlling both the motion of cooperative system and the interaction forces between the manipulators and the grasped object when two manipulator arms firmly grasp a common object. It should be noted that this chapter allows the bilateral constraint where both directional force and moment are permissible. A general cooperative task-space formulation is introduced for different classes of multiarm robotic systems.

Chapter 40, Mobile Manipulation, focuses on research conducted on an experimental platform that combines capabilities in mobility and manipulation. Furthermore, it involves the interaction between the robots and real-world environment, unstructured environments. The main research objective here is to maximize task generality of autonomous robotic systems, under minimizing the dependence on task-specific, hard-coded, or narrowly-relevant information.

Chapter 41, Active Manipulation for Perception, covers perceptual methods in which manipulation is an integral part of perception. There are advantages to use manipulation rather than vision for perception. For example, manipulation can be used to sense in poor-visibility conditions, and also to determine properties that require physical interaction. This chapter includes the methods that have been developed for inference, planning, recognition, and modeling in sensing-via-manipulation approaches are cover.

Without dexterity like that of humans, future robots will not be able to work instead of humans in environments where human cannot enter. In this sense, the implementation of dexterity into robots is one of the highlights of future robot design. Chapters 36–41 provide a good hint for enhancing dexterity for robots.

The second half of Part D addresses interfaces where humans control a robot or multiple robots through direct or indirect contact with robot(s).We now provide a brief synopsis of each chapter in the second half of Part D.

Chapter 42, Haptics, discusses robotics devices that allow human operators to experience the sense of touch in remote or virtual environment. Two classes of force feedback haptic devices are discussed. One is an admittance device that senses the force applied by the operator and constrains the operator's position to match the appropriate deflection of a simulated object or surface; the other is an impedance haptic device that senses the position of the operator and then applies a force vector to the operator according to the computed behavior of the simulated object or surface. Haptic rendering from real time three-dimensional (3-D) image is also introduced in this chapter.

Chapter 43, Telerobotics, starts with a discussion on the classification of three different concepts: direct control where all slave motions are directly controlled by the user via the master interface, shared control where task execution is shared between direct control and local sensory control, and supervisory control where the user and slave are connected loosely with strong local autonomy. Various control issues such as lossy communication with Internet and operation with mobile robots, are also addressed.

Chapter 44, Networked Robots, focuses on the framework of computer networks which offer extensive computing, memory, and other resources that can dramatically improve performance. The chapter covers a wide span from the history of networked robots as it evolves from teleoperation to cloud robotics to how to build a networked robot. The very recent progress on cloud robotics and potential topics for future research are included later in the chapter.

In Haptics (Chap. 42) direct contact between human and robot is made, while in both Telerobotics (Chap. 43) and Networked Robots (Chap. 44), an appropriate distance between the human and robot is kept. One of the main issues is how to maintain appropriate control performance of the system in the presence of humans or a time lag between humans and robots.