Part G

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Part G Human-Centered and Life-Like Robotics

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Part G Human-Centered and Life-Like Robotics, covers some of the most recent advances concerned with human–robot interaction, ranging from designing biologically inspired robots, to programming and safety issues for human–robot interaction, and ethical issue brought forth by robotics. Our field's future vision for technology is the leap from personal computers to personal robots, in a world where robots exist pervasively and work side by side with humans. Over the past 50 years we have made great strides in robotics, as the previous parts of this Handbook show. However, there are still new capabilities that need to be developed and existing capabilities that need to be improved to create a world in which robots and humans work together. Robot bodies should be easily integrated into our living environments. Robots should be safe to be around. Robots should take commands from human users easily. Robots should be functionally capable. Robots should engage humans to help mitigate error states and task uncertainties. Meeting these challenges will bring robots closer to our vision of pervasive robotics.

The topics in Part G are essential for creating robots that operate in human-centered environments. The chapters cover organically human-centered and life-like robots and include hardware design, control (of locomotion, manipulation, and interaction), perception, user interfaces, and social and ethical implications for robotics. As such, Part G builds on all of the Handbook's previous parts. The connection with the chapters in Robot Foundations (Part A) and Robot Structures (Part B), particularly Mechanisms and Actuation (Chap. 3), Sensing and Estimation (Chap. 4), Motion Planning (Chap. 5), Robot Systems Architectures and Programming (Chap. 8), AI Reasoning Methods for Robotics (Chap. 9), Robot Hands (Chap. 15), Legged Robots (Chap. 16), and Wheeled Robots (Chap. 17) are essential. There is also an important dependency on Sensing and Perception (Part C), Manipulation and Interfaces (Part D), and Mobile and Distributed Robotics (Part E) as these chapters cover some of the basic algorithms and technologies required by robots operating in human-centered environments.

Today's approach to computation has progressed naturally from desktop computing, to mobile computing, to pervasive computing, ultimately leading to computation for interaction with the physical world, in other words, robotics. Part G presents a snapshot of the field's advances for creating machines in our own image that are smart and obedient.

With this overview of Part G, we now provide a brief synopsis of each chapter.

Chapter 56, Humanoids, provides a concise overview of the state of the art in creating human-like machines, starting with a historical and philosophical discussion on the human example and understanding intelligence. These machines are capable of bipedal locomotion and manipulation. In addition, humanoid robots can take advantage of their entire body (e.g., lifting objects while moving the body to compensate for the load). Control issues specific to humanoids include static and dynamic stability during a mobile manipulation action. Humanoid robots interact with humans via perception systems which should be capable of interring behavior and mood as well as via speech systems for interpreting human language.

Chapter 57, Safety for Physical Human–Robot Interaction, discusses what happens when humans and robots share the same workspace and come into contact with one another. Safety can be jeopardized by mechanical failures, operator errors, or software problems. Designing and controlling robots with safety guarantees is a very important precondition for physical human–robot interaction (pHRI) . The chapter discusses safety standards for pHRI and surveys several approaches to safety.

Chapter 58 , Social Robots that Interact with People, discusses the creation of robots designed to interact with people in a social and emotional way for applications in education, entertainment, health care, etc. These robots' embodiment is life-like and they are capable of multimodal communication. The chapter uses a case study of the Kismet robot to illustrate the idea of a machine capable of projecting emotion. The chapter surveys some basic approaches to giving robots sociocognitive skills such as shared attention, emotional empathy, and mental perspective tasking.

Chapter 59, Robot Programming by Demonstration, is an important approach to teaching robots what to do by providing either good or bad examples. This is an intuitive approach to robot control and learning of tasks with the potential of opening robot applications to nonexpert users. The chapter starts by discussing what it means for a robot to learn a new skill and surveys several learning approaches for this. Biologically oriented learning approaches such as conceptual models of imitation learning and neural models of imitation learning are also introduced. The chapter concludes with several open issues in robot programming by demonstration.

Chapter 60, Biologically Inspired Robots, starts with a discussion of the difference between bio-inspired and biomimetic robots. Bio-inspired robots seek to reproduce a natural phenomenon but not necessarily the underlying means. Biomimetic robots reproduce both the natural phenomenon and the means. The chapter starts with a survey of bio-inspired morphologies. A survey of bio-inspired sensors from vision to audio, touch, smell, and taste is then presented. Bio-inspired actuators include locomotion topics such as crawling, legged locomotion, climbing swimming, flying, and manipulation. The chapter also examines bio-inspiration in the context of control and planning. This includes behavior-based architectures, learning robots, evolving robots, and developing robots. Finally, the chapter examines how to make machines self-sustaining from an energy point of view.

Chapter 61, Evolutionary Robotics, discusses a method for creating robots that is inspired by the Darwinian principle of selective reproduction of the fittest captured by evolutionary algorithms. The chapter describes the basic method and presents several case studies. Because the evolutionary method requires intensive computation, it is often run in simulation and the final result is transferred to the robot platform. However, in the recent past there were several successes with running evolutionary algorithms in real time on physical platforms to achieve complex behaviors such as learning to walk.

Chapter 62 , Neurorobotics: From Vision to Action, looks at how neuroethology, the study of brain mechanisms for animal behavior, inspires the creation of a central nervous system for a machine. The chapter presents several case studies that sample this bio-inspired design of robot controllers structurally and functionally: the optic flow in bees and robots, visually guided behaviors in frogs and robots, and navigation in rats and robots. The chapter then examines the role of the cerebellum in motion control and the role of mirror systems. The chapter concludes by observing the the brain has evolved to serve as action-oriented perception, which is a useful guiding principle for building robot controllers.

Chapter 63 , Perceptual Robotics, discusses principles derived from high-level cognitive processing in vision in the human brain that have led to results in robotics and computer vision. The chapter is focused on the technical realization of perceptual functions in robots by examining relationships between biological perception and robotics systems. Object recognition is used as an exemplary task and issues such as representation, structural description models, neural representations, as well as recognition and learning algorithms are discussed. Next, example-based movement representations are examined to establish the connection between the functionality of the visual cortex and a class of computer vision algorithms.

Chapter 64 , Roboethics: Social and Ethical Implications of Robotics, discusses the social and ethical implications in a society where robots coexist with humans. Starting with a philosophical introspection into the dangers of unlimited use of technology, the chapter argues for the need for a new ethics of robots. Many other factors, including the cultural differences in societies ready to accept robots, define this need. The chapter surveys the code of ethics, privacy, accuracy, intellectual property, and access which could be adopted by robotics. A taxonomy of robots, along with socio-ethical issues for each robot type is then presented.