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Abstract

Human–Robot Interaction (HRI) has recently received considerable attention in the academic community, in government labs, in technology companies, and through the media. Because of this attention, it is desirable to present a survey of HRI to serve as a tutorial to people outside the field and to promote discussion of a unified vision of HRI within the field. The goal of this review is to present a unified treatment of HRI-related problems, to identify key themes, and discuss challenge problems that are likely to shape the field in the near future. Although the review follows a survey structure, the goal of presenting a coherent "story" of HRI means that there are necessarily some well-written, intriguing, and influential papers that are not referenced. Instead of trying to survey every paper, we describe the HRI story from multiple perspectives with an eye toward identifying themes that cross applications. The survey attempts to include papers that represent a fair cross section of the universities, government efforts, industry labs, and countries that contribute to HRI, and a cross section of the disciplines that contribute to the field, such as human, factors, robotics, cognitive psychology, and design.

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1

Introduction

Human–Robot Interaction (HRI) is a field of study dedicated to understanding, designing, and evaluating robotic systems for use by or with humans. Interaction, by definition, requires communication between robots and humans. Communication between a human and a robot may take several forms, but these forms are largely influenced by whether the human and the robot are in close proximity to each other or not. Thus, communication and, therefore, interaction can be separated into two general categories:

- Remote interaction — The human and the robot are not co-located and are separated spatially or even temporally (for example, the Mars Rovers are separated from earth both in space and time).
- Proximate interaction — The humans and the robots are co-located (for example, service robots may be in the same room as humans).

Within these general categories, it is useful to distinguish between applications that require mobility, physical manipulation, or social interaction. Remote interaction with mobile robots is often referred

to as teleoperation or supervisory control, and remote interaction with a physical manipulator is often referred to as telemanipulation. Proximate interaction with mobile robots may take the form of a robot assistant, and proximate interaction may include a physical interaction. Social interaction includes social, emotive, and cognitive aspects of interaction. In social interaction, the humans and robots interact as peers or companions. Importantly, social interactions with robots appear to be proximate rather than remote. Because the volume of work in social interactions is vast, we present only a brief survey; a more complete survey of this important area is left to future work.

In this review, we present a survey of modern HRI. We begin by presenting key developments in HRI-related fields with the goal of identifying critical technological and scientific developments that have made it possible for HRI to develop as a field of its own. We argue that HRI is not simply a reframing and reformulation of previous work, but rather a new field of scientific study. To support this argument, we identify seminal events that signal the emergence of HRI as a field. Although we adopt a designer-centered framing of the review, work in the field requires strong interdisciplinary blends from various scientific and engineering fields.

After surveying key aspects in the emergence of HRI as a field, we define the HRI problem with an emphasis on those factors of interaction that a designer can shape. We then proceed to describe the application areas that drive much of modern HRI. Many of these problems are extremely challenging and have strong societal implications. We group application areas into the previously mentioned two general categories, remote and proximate interactions, and identify important, influential, or thought-provoking work within these two categories. We follow this by describing common solution concepts and barrier problems that cross application domains and interaction types. We then briefly identify related work from other fields involving humans and machines interacting, and summarize the review.

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