Mapping the Field of Human-Robot Interaction

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I. Introduction

The field of Human-Robot Interaction is extremely diverse: researchers from Engineering, Computer Science, and Psychology must all work together to produce strong research. This diversity produces difficulties, as researchers struggle to find common ground for methods and language, often prompting the question of whether the field of HRI is a "field" at all, and whether there is enough commonality to hold together the research community.

We argue here that HRI *is* a field, but without a universal set of common characteristics. Instead HRI should be viewed in terms of three major areas which contribute strongly to the research and methods used.

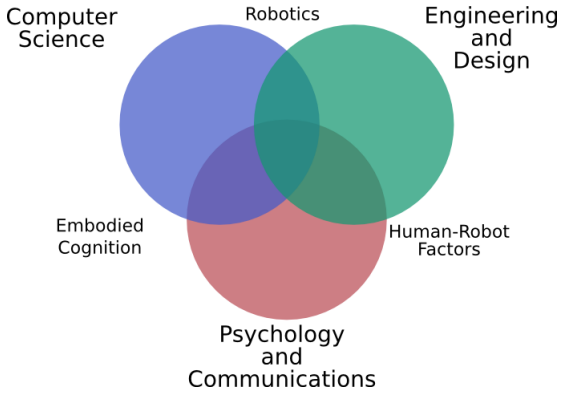

Fig. 1. A Venn diagram representation of HRI

II. Research Areas

HRI can be viewed as the intersection of Engineering, Computer Science, and Psychology[1]. What makes HRI distinct is that all HRI research involves at least two of these general fields. The development of complete systems requires integration of work from each of the fields, but most work occurs within specific intersections.

a) Embodied Cognition (Computer Science & Psychology): One major area of HRI focuses on building computational systems which mimic the cognitive and affective facilities of people. Examples include the intelligence in affective robots which are capable of showing emotion and social robots which are capable of recognizing the emotions and mental states of the people they interact with. Research in this area uses results from Psychology regarding how people understand one another, and also on computational methods for modeling these cognitive facilities. It uses many tools from artificial intelligence and machine learning, but with a stronger emphasis on the embodied nature of the systems (which provides stronger constraints on the inputs of the system, as well as appropriate failure modes and other issues).

An example of work in embodied cognition is that of El Kaliouby [3] and also Rani [8] in estimating cognitive and affective mental states. Another example is that of Gold and Scassellati [6] in developing a robot which recognizes its own body motion.

[1]This is not, of course, a complete list, but the most typical of the areas that compose HRI.

b) Human-Robot Factors (Psychology & Engineering): The Human-Robot Factors area of HRI focuses on designing robotic systems and understanding how people respond to them. This includes the physical design of robots (such as humanoid vs. non-humanoid designs) as well as the design of control software for robots (as in interfaces for search and rescue robots or military robots). This area may make heavy use of methods from Communications and Human-Computer Interaction studies.

One key application in Human-Robot Factors is Urban Search & Rescue [2]. Much of USAR research aims to develop better interfaces for controlling robots. Also in Human-Robot Factors are human response studies such as those of Broadbent et. al. [1]. Human-response studies look to discover what types of robot behavior and design elicit the most desirable social responses from people.

c) Robotics (Engineering & Computer Science): The final area is traditional Robotics, focusing on developing new tools for robot platforms, including both hardware and software capabilities. There is clearly less emphasis on the human (though many robot designs are inspired by people), as the focus is on building the robot and the control software which researchers in other areas of HRI can use. Some common types of Robotics research involve the design of controllers for complex motion (such as walking for legged robots or control of robotic appendages) and development of localization and mapping algorithms.

d) Integrated Systems: There is a fourth area of intersection, where all three areas come together. The goal for HRI is ultimately to develop complete cognitive robotic systems, informed by the principles of Human-Robot Fac-

tors, from the ground up. To build these systems requires co-operation between all areas of HRI.

III. Community

Are there unifying characteristics of HRI research beyond the human and the robot? We believe that, given its diversity, HRI should not be viewed as a monolithic field, and therefore we should not look for a monolithic set of characteristics.

Instead, we should look to where the fields overlap. Many researchers will come from one of the larger fields, and work in more than one of these intersections. The Embodied Cognition and Human-Robot Factors areas both rely on human subjects studies and tools from Psychology. Embodied Cognition and Robotics share tools from Computer Science, and Human-Robot Factors and Robotics rely on Engineering and Design methods.

This abstraction of HRI can provide some specific concrete suggestions to improve the current state of the community and education of researchers.

A. Curriculum

While most graduate students and experienced researchers will enter HRI from one of the three major fields, undergraduates may enter HRI from a general background. Introductory courses in an HRI curriculum should be developed to provide background in the research tools of each area. Courses in computer programming, Engineering and Design principles, and experimental design in Psychology would provide valuable introductory material. A general HRI course would aim to provide an overview of the different areas of HRI and the types of research which take place in each. More advanced courses would focus on specific areas, and final projects could bring students specializing in each area together for an integration task.

Even without specific HRI courses, students can improve their understanding of the field by taking introductory courses in the fields with which they are unfamiliar. Graduate students in Computer Science, for example, will find that courses in Cognitive Psychology or experimental design can greatly aid research.

B. HRI Texts

There has been some discussion about the need for a handbook for HRI which would provide information about how to undertake research in HRI [5]. This task is particularly daunting given the diversity of the field. A simpler approach would be to focus on specific areas of HRI, and present useful methods for each. A series of handbooks focusing on narrow areas of HRI would be easier to write. Robotics texts are already available, while Embodied Cognition benefits from existing work in Cognitive Science. Human-Robot Factors handbooks are the greatest challenge, as existing experimental methods are not directly applicable to user studies involving robots.

IV. Conclusion

Human-Robot Interaction is not a monolithic field with a set of universal characteristics and methods. We should not expect all researchers to use the same methodology. HRI is a cohesive field, though, and we should make use of the overlaps in research and methods where they exist.

The HRI community would be best served by recognizing that the research occurring in the field *is* very diverse, and communicating with other researchers in the field may require some research in itself. To many researchers in robotics, the acronyms used by researchers coming from a background in HCI may sound foreign. Likewise, a researcher in Embodied Cognition may have very little understanding of the control algorithms required for keeping a bi-pedal robot on its feet.

A curriculum for HRI would do very well to include an introduction to the research methods and the basic language of each area. It is not necessary (or possible!) to provide a full education in every field related to HRI, but some background in each will make communication across the field more tractable.

Finally, one of the largest issues in the community is not just the diversity in research, but the diversity in robots. Only the largest research groups will have the resources to develop a full system from hardware to software, and then perform studies with people. Common operating platforms are needed, from both a hardware and software perspective. A number of community-developed platforms are emerging (such as the RobotCub [7]) and numerous software platforms including Player [4], but there is more work to be done. In addition, some groups may have very few resources in certain areas, so it is vitally important that the community share resources between institutions.

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