Human–robot interaction

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Human–robot interaction is the study of interactions between humans and robots. It is often referred as HRI by researchers. Human–robot interaction is a multidisciplinary field with contributions from human–computer interaction, artificial intelligence, robotics, natural language understanding, design, and social sciences.

Contents

Origins

Human–robot interaction has been a topic of both science fiction and academic speculation even before any robots existed. Because HRI depends on a knowledge of (sometimes natural) human communication, many aspects of HRI are continuations of human communications topics that are much older than robotics per se.

The origin of HRI as a discrete problem was stated by 20th-century author Isaac Asimov in 1941, in his novel *I, Robot*. He states the Three Laws of Robotics as,

> 1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
> 2. A robot must obey any orders given to it by human beings, except where such orders would conflict with the First Law.
> 3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

These three laws of robotics determine the idea of safe interaction. The closer the human and the robot get and the more intricate the relationship becomes, the more the risk of a human being injured rises. Nowadays in advanced societies, manufacturers employing robots solve this issue by not letting humans and robots share the workspace at any time. This is achieved by defining safe zones using liar sensors or physical cages. Thus the presence of humans is completely forbidden in the robot workspace while it is working.

With the advances of artificial intelligence, the autonomous robots could eventually have more proactive behaviors, planning their motion in complex unknown environments. These new capabilities keep safety as the primary issue and efficiency as secondary. To allow this new generation of robot, research is being conducted on human detection, motion planning, scene reconstruction, intelligent behavior through task planning and compliant behavior using force control (impedance or admittance control schemes).

The goal of HRI research is to define models of humans' expectations regarding robot interaction to guide robot design and algorithmic development that would allow more natural and effective interaction between humans and robots. Research ranges from how humans work with remote, tele-operated unmanned vehicles to peer-to-peer collaboration with anthropomorphic robots.

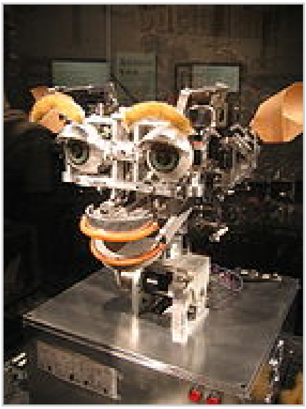
Many in the field of HRI study how humans collaborate and interact and use those studies to motivate how robots should interact with humans.

The goal of friendly human–robot interactions

Robots are artificial agents with capacities of perception and action in the physical world often referred by researchers as workspace. Their use has been generalized in factories but nowadays they tend to be found in the most technologically advanced societies in such critical domains as search and rescue, military battle, mine and bomb detection, scientific exploration, law enforcement, entertainment and hospital care.

These new domains of applications imply a closer interaction with the user. The concept of closeness is to be taken in its full meaning, robots and humans share the workspace but also share goals in terms of task achievement. This close interaction needs new theoretical models, on one hand for the robotics scientists who work to improve the robots utility and on the other hand to evaluate the risks and benefits of this new "friend" for our modern society.

With the advance in AI, the research is focusing on one part towards the safest physical interaction but also on a socially correct interaction, dependent on cultural criteria. The goal is to build an intuitive, and easy communication with the robot through speech, gestures, and facial expressions.



Kismet can produce a range of facial expressions.

Dautenhan refers to friendly Human–robot interaction as "Robotiquette" defining it as the "social rules for robot behaviour (a ‘robotiquette’) that is comfortable and acceptable to humans"[1] The robot has to adapt itself to our way of expressing desires and orders and not the contrary. But every day environments such as homes have much more complex social rules than those implied by factories or even military environments. Thus, the robot needs perceiving and understanding capacities to build dynamic models of its surroundings. It needs to categorize objects, recognize and locate humans and further their emotions. The need for dynamic capacities pushes forward every sub-field of robotics.

On the other end of HRI research the cognitive modelling of the "relationship" between human and the robots benefits the psychologists and robotic researchers the user study are often of interests on both sides. This research endeavours part of human society.

General HRI research

HRI research spans a wide range of field, some general to the nature of HRI.

Methods for perceiving humans

Most methods intend to build a 3D model through vision of the environment. The proprioception sensors permit the robot to have information over its own state. This information is relative to a reference.

Methods for perceiving humans in the environment are based on sensor information. Research on sensing components and software lead by Microsoft provide useful results for extracting the human kinematics (see Kinect). An example of older technique is to use colour information for example the fact that for light skinned people the hands are lighter than the clothes worn. In any case a human modelled a priori can then be fitted to the sensor data. The robot builds or has (depending on the level of autonomy the robot has) a 3D mapping of its surroundings to which is assigned the humans locations.

A speech recognition system is used to interpret human desires or commands. By combining the information inferred by proprioception, sensor and speech the human position and state (standing, seated).

Methods for motion planning

Motion planning in dynamic environment is a challenge that is for the moment only achieved for 3 to 10 degrees of freedom robots. Humanoid robots or even 2 armed robots that can have up to 40 degrees of freedom are unsuited for dynamic environments with today's technology. However lower-dimensional robots can use potential field method to compute trajectories avoiding collisions with human.

Cognitive models and theory of mind

A lot of data has been gathered with regards to user studies. For example, when users encounter proactive behaviour on the part of the robot and the robot does not respect a safety distance, penetrating the user space, he or she might express fear. This is dependent on one person to another. Only intensive experiment can permit a more precise model.

It has been shown that when a robot has no particular use, negative feelings are often expressed. The robot is perceived as useless and its presence becomes annoying.

In another experiment, it has occurred that people tend to attribute to the robot personality characteristics that were not implemented.

Application-oriented HRI research

In addition to general HRI research, researchers are currently exploring application areas for human-robot interaction systems. Application-oriented research is used to help bring current robotics technologies to bear against problems that exist in today's society. While human-robot interaction is still a rather young area of interest, there is active development and research in many areas.

Search and rescue

First responders face great risks in search and rescue (SAR) settings, which typically involve environments that are unsafe for a human to travel. In addition, technology offers tools for observation that can greatly speed-up and improve the accuracy of human perception. Robots can be used to address these concerns . Research in this area includes efforts to address robot sensing, mobility, navigation, planning, integration, and tele-operated control.

SAR robots have already been deployed to environments such as the Collapse of the World Trade Center.[2]

Other application areas include:

- Entertainment
- Education
- Field robotics
- Home and companion robotics
- Hospitality
- Rehabilitation and Elder Care
- Robot Assisted Therapy (RAT)

See also

Robotics

- Autonomous robots
- Gesture recognition
- Humanoid robots
- Human-robot collaboration

- Mobile robots
- Motion planning
- Personal robot
- Robot simulations
- Robot teams
- Social robot

Technology

- Artificial intelligence
- Automatic speech recognition
- Computer supported collaborative work
- Dialog management
- Haptic technology
- Human–computer interaction
- Interactive Systems Engineering
- Linguistics
- fusion
- Telematics
- Face recognition

Psychology

- Anthropomorphism and the uncanny valley

Properties

Bartneck and Okada[3] suggest that a robotic user interface can be described by the following four properties:

Tool – toy scale

- Is the system designed to solve a problem effectively or is it just for entertainment?

Remote control – autonomous scale

- Does the robot require remote control or is it capable of action without direct human influence?

Reactive – dialogue scale

- Does the robot rely on a fixed interaction pattern or is it able to have dialogue — exchange of information — with a human?

Anthropomorphism scale

- Does it have the shape or properties of a human?

Conferences

International Conference on Social Robotics

The International Conference on Social Robotics is a conference for scientists, researchers, and practitioners to report and discuss the latest progress of their forefront research and findings in social robotics, as well as interactions with human beings and integration into our society.

- ICSR2009, Incheon, Korea in collaboration with the FIRA RoboWorld Congress
- ICSR2010 (http://www.icsr2010.org/), Singapore
- ICSR2011 (http://icsr2011.org/), Amsterdam, Netherlands

International Conference on Human-Robot Personal Relationships

- HRPR2008, Maastricht
- HRPR 2009 (http://hrpr.uvt.nl), Tilburg. Keynote speaker was Hiroshi Ishiguro.
- HRPR2010 (http://hrpr.liacs.nl), Leiden. Keynote speaker was Kerstin Dautenhahn.

International Symposium on New Frontiers in Human-Robot Interaction

This symposium is organized in collaboration with the Annual Convention of the Society for the Study of Artificial Intelligence and Simulation of Behaviour.

- 2010 (http://homepages.feis.herts.ac.uk/~comqkd/HRI-AISB2010-Symposium.html), Leicester, United Kingdom
- 2009 (http://homepages.feis.herts.ac.uk/~comqkd/HRI-AISB2009-Symposium.html), Edinburgh, United Kingdom

IEEE International Symposium in Robot and Human Interactive Communication

The IEEE International Symposium on Robot and Human Interactive Communication (http://www.ro-man.org/) (RO-MAN) was founded in 1992 by Profs. Toshio Fukuda, Hisato Kobayashi, Hiroshi Harashima and Fumio Hara. Early workshop participants were mostly Japanese, and the first seven workshops were held in Japan. Since 1999, workshops have been held in Europe and the United States as well as Japan, and participation has been of international scope.

ACM/IEEE International Conference on Human-Robot Interaction

This conference is amongst the best conferences in the field of HRI and has a very selective reviewing process. The average acceptance rate is 26% and the average attendance is 187. Around 65% of the contributions to the conference come from the USA and the high level of quality of the submissions to the conference becomes visible by the average of 10 citations that the HRI papers attracted so far.[4]

- HRI 2006 (http://www.hri2006.org/) in Salt Lake City, Utah, USA, Acceptance Rate: 0.29
- HRI 2007 (http://www.hri2007.org/) in Washington DC, USA, Acceptance Rate: 0.23
- HRI 2008 (http://www.hri2008.org/) in Amsterdam, Netherlands, Acceptance Rate: 0.36 (0.18 for oral presentations)
- HRI 2009 (http://www.hri2009.org/) in San Diego, CA, USA, Acceptance Rate: 0.19
- HRI 2010 (http://www.hri2010.org/) in Osaka, Japan, Acceptance Rate: 0.21
- HRI 2011 (http://www.hri2011.net/) in Lausanne, Switzerland, Acceptance Rate: 0.22 for full papers
- HRI 2012 (http://hri2012.org/) in Boston, Massachusetts, USA, Acceptance Rate: 0.25 for full papers
- HRI 2013 (http://humanrobotinteraction.org/2013/) in Tokyo, Japan, Acceptance Rate: 0.24 for full papers
- HRI 2014 (http://humanrobotinteraction.org/2014/) in Bielefeld, Germany, Acceptance Rate: 0.24 for full papers

Related conferences

There are many conferences that are not exclusively HRI, but deal with broad aspects of HRI, and often have HRI papers presented.

- IEEE-RAS/RSJ International Conference on Humanoid Robots (Humanoids)
- Ubiquitous Computing (UbiComp)
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
- Intelligent User Interfaces (IUI)
- Computer Human Interaction (CHI)
- American Association for Artificial Intelligence (AAAI)
- INTERACT

Related journals

There are currently two dedicated HRI Journals

- International Journal of Social Robotics (http://www.springer.com/engineering/robotics/journal/12369)
- The open access Journal of Human-Robot Interaction (http://humanrobotinteraction.org/journal/)

and a new dedicated HRI Journal

and there are several more general journals in which one will find HRI articles.

- International Journal of Humanoid Robotics
- Entertainment Robotics Section (http://www.elsevier.com/locate/inca/717010) of the Entertainment Computing Journal

- Interaction Studies Journal (http://benjamins.com/#catalog/journals/is)
- Artificial Intelligence
- Systems, Man and Cybernetics

Footnotes

1. ^ Dautenhan, Kerstin (29 April 2007). "Socially intelligent robots: dimensions of human–robot interaction" (http://rstb.royalsocietypublishing.org/content/362/1480/679.full.pdf) (pdf). *Phil. Trans. R. Soc.* b **362** (1480): 679–704. doi:10.1098/rstb.2006.2004 (http://dx.doi.org/10.1098%2Frstb.2006.2004).
2. ^ Casper, J.; Murphy, R. (June 2003). "Human-robot interactions during the robot-assisted urban search and rescue response at the World Trade Center" (http://ieeexplore.ieee.org/iel5/3477/27019/01200160.pdf?tp=&isnumber=&arnumber=1200160). *IEEE Transactions on Systems, Man, and Cybernetics* **33** (3): 367–385. doi:10.1109/tsmcb.2003.811794 (http://dx.doi.org/10.1109%2Ftsmcb.2003.811794).
3. ^ Bartneck, Christoph; Michio Okada (2001). "Robotic User Interfaces" (http://bartneck.de/publications/2001/roboticUserInterfaces/bartneckHC2001.pdf) (PDF). *Proceedings of the Human and Computer Conference*. pp. 130–140.
4. ^ Bartneck, Christoph (February 2011). "The end of the beginning: a reflection on the first five years of the HRI conference". *Scientometrics* **86** (2): 487–504. doi:10.1007/s11192-010-0281-x (http://dx.doi.org/10.1007%2Fs11192-010-0281-x).

External links

- Human interaction with the robot J2B2 (http://www.hakenberg.de/automation/j2b2_human_interaction.htm): Algorithms, graphics, and video material
- Carnegie Mellon University's People and Robots Research Group (http://www.peopleandrobots.org/): Experimental and ethnographic studies of human-robot interaction
- Carnegie Mellon University's Human-Robot Interaction research group (http://www.ri.cmu.edu/research_lab_group_detail.html?type=personnel&lab_id=73&menu_id=263): Design and development of robotic systems for human use
- Bilge Mutlu's research on human-robot interaction (http://www.bilgemutlu.com/research): Design of social behavior, understanding the social impact of human-robot interaction
- NASA project on peer-to-peer human-robot interaction (http://www.nasa.gov/multimedia/podcasting/p2p_robot_vod_transcript.html): Developing tools and methods for human-robot teamwork
- Takayuki Kanda's research on human-robot interaction (http://www.irc.atr.jp/~kanda/research.html): Experimental research on human-robot communication, field experiments, laboratory studies
- Institute of Robotics and Mechatronics (http://www.dlr.de/rm/en/desktopdefault.aspx/tabid-5471/)

Germany's national research centre for aeronautics and space

- CHRIS project (http://164.11.131.110/) Cooperative Human Robot Interaction Systems is a European project on HRI research
- Interactions and Communication Design Lab (ICD), Toyohashi University of Technology (http://www.icd.tutkie.tut.ac.jp/en/profile.html): ICD has been developing a variety of futuristic sociable artifacts, robots, and creatures in human-centric applications and conducting research on the next generation robot which aims to establish a communication between people and robots in social interactions.
- The European Aliz-E research project focusing on robot-child interaction (http://www.aliz-e.org): Aliz-E focuses on the interactions robots can have with children in the long run and in real-life environments, especially in paediatrics departments.
- The European LOCOBOT research project that is focused on an autonomous robot assistant, capable of speech and gesture interaction for the industrial environment. (http://www.locobot.eu/)
- Ulrich Hottelet: Albert is not happy - How robots learn to live with people (http://african-times.com/index.php?option=com_content&view=article&id=2478%3Aalbert-is-not-happy&catid=73%3Ajune-2009-business&Itemid=63), African Times (http://african-times.com/), June 2009

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Categories: Human communication | Multimodal interaction | Robotics

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