SEMINARS IN ARTIFICIAL INTELLIGENCE

HUMAN ROBOT INTERACTION INTRODUCTION

Marc Hanheide

with material from Feil-Seifer, Mataric, Goodrich, Schultz, Breazeal, and many other colleagues

UNIVERSITY OF LINCOLN

SAPIENZA UNIVERSITÀ DI ROMA

L-CAS

WHAT IS HRI?

Human-robot interaction (HRI) is the interdisciplinary study of **interaction dynamics** between humans and robots. Researchers and practitioners specialising in HRI come from a **variety of fields**, including **engineering** (electrical, 1 mechanical, industrial, and design), computer science (**human-computer interaction**, **artificial intelligence**, **robotics**, natural language understanding, and computer vision), **social sciences** (psychology, cognitive science, communications, anthropology, and human factors), and **humanities** (ethics and philosophy).

David Feil-Seifer
Maja J Mataric, 2009

WHAT IS HRI?

HRI regards the analysis, design, modeling, implementation and evaluation of robots for human use.

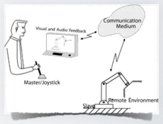
"The study of the humans, robots and the ways they influence each other"
(definition by the 10th International Symposium of Robotics Research, November 2001, Australia).

HRI represents an interdisciplinary effort that addresses the need to integrate social informatics, human factors, cognitive science and usability concepts into the design and development of robotic technology.

CO-LOCATION

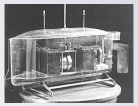
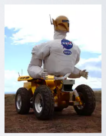
- Remote interaction — The human and the robot are not co-located and are separated spatially or even temporally (for example, the Mars Rovers are separated from earth both in space and time).





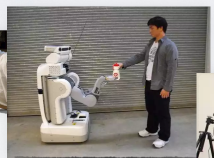
ONE SLIDE ON HISTORY OF TELEPRESENCE

- In 1898, Nicola Tesla demonstrated a radio-controlled boat
- The Naval Research Laboratory's "Electric Dog" robot from 1923, attempts to remotely pilot bombers during World War II, the creation of remotely piloted vehicles, and mechanical creatures designed to give the appearance of life.
- Robonaut is a well-known example of successful teleoperation of a humanoid robot

CO-LOCATION

- Proximate interaction — The humans and the robots are co-located (for example, service robots may be in the same room as humans).


WHAT DEFINES AN HRI PROBLEM?

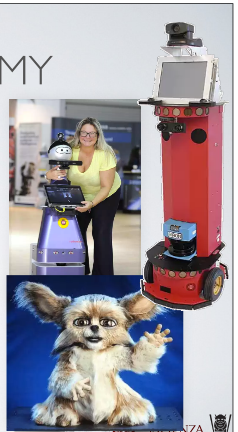
WHAT DEFINES AN HRI PROBLEM?

- **Level and behaviour of autonomy,**
- **Nature of information exchange,**
- **Structure of the team,**
- **Adaptation, learning, and training of people and the robot, and**
- **Shape of the task.**

Interaction, the process of **working together** to accomplish a **goal**, emerges from the confluence of these factors. The designer attempts to **understand** and **shape** the interaction itself, with the objective of making the exchange between humans and robots **beneficial in some sense**.

AUTONOMY

- robots act autonomously
- they are not just mediated embodiment for a (tele-)present human
- A breakthrough in autonomous robot technology occurred in the mid 1980s with work in behaviour-based robotics
- A second important break-through for autonomy as it applies to HRI is the emergence of hybrid architectures



AUTONOMY

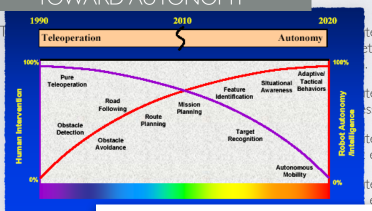
- A system with a high level of autonomy is one that can be neglected for a long period of time without interaction.
- Autonomy is not an end in itself in the field of HRI, but rather a means to **supporting productive interaction**.
  - Indeed, autonomy is only useful insofar as it supports beneficial interaction between a human and a robot.

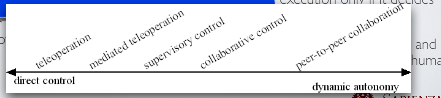
LEVELS OF AUTONOMY

- Tom Sheridan:
  - 1. Computer offers no assistance; human does it all.
  - 2. Computer offers a complete set of action alternatives.
  - 3. Computer narrows the selection down to a few choices.
  - 4. Computer suggests a single action.
  - 5. Computer executes that action if human approves.
  - 6. Computer allows the human limited time to veto before automatic execution.
  - 7. Computer executes automatically then necessarily informs the human.
  - 8. Computer informs human after automatic execution only if human asks.
  - 9. Computer informs human after automatic execution only if it decides too.
  - 10. Computer decides everything and acts autonomously, ignor- ing the human.

LEVELS OF AUTONOMY

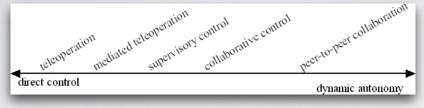
Department of Defense (DOD) PATH TOWARD AUTONOMY





- T
  - 5. Computer human appro
  - ter allows the human limited eto before automatic
  - ter executes automatically ssarily informs the human.
  - ter informs human after execution only if human asks.
  - ter informs human after execution only if it decides
  - and human.

LEVELS OF AUTONOMY



Dynamic Autonomy: changing goal-directed action in the light of new goals or changed circumstances.

15/04/16: Human-Robot Spatial Interaction

This session focuses on mobile robots and how they should be moving among humans. We will look at implicit signalling from motion, social- or human-aware navigation approaches, balancing (perceived) safety and effectiveness of navigation.

Paper	Presented by	Discussed by
3-0 Dondrup, C. et al., 2015. Real-time multisensor people tracking for human-robot spatial interaction. In Workshop on Machine Learning for Social Robotics at International Conference on Robotics and Automation (ICRA). ICRA / IEEE. Available at: http://eprints.lincoln.ac.uk/17545/1/dondrup.pdf [Accessed February 1, 2016].	Ali Youssef	?
3-1 Lichtenthäler, C. et al., 2012. Increasing perceived value between human and robots - Measuring legibility in human aware navigation. In Proceedings of IEEE Workshop on Advanced Robotics and its Social Impacts, ARSO. pp. 89–94.	Lorenzo Steccanella	Wilson Villa
3-2 Lu, D. V, Hershberger, D. & Smart, W.D., 2014. Layered costmaps for context-sensitive navigation. In Intelligent Robots and Systems (IROS 2014), 2014 IEEE/RSJ International Conference on. pp. 709–715.	riccardo rinaldi	Daniele Evangelista
3-3 Trautman, P. & Krause, A., 2010. Unfreezing the robot: Navi… interacting crowds. In Intelligent Robots and Systems (IROS), 2… International Conference on. IEEE, pp. 797–803. Available at: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5654369 … 2011].		

22/04/16: Human-Robot Collaboration

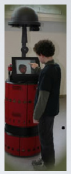
Here we are going to look into ways humans and robot can effectively collaborate in tasks, focusing on physical interaction and task coordination.

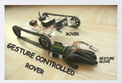
Paper	Presented by	Discussed by
4-2 (*moved here due to unavailability of presenter next week*) Lang, C. et al., 2009. Feedback interpretation based on facial expressions in human-robot interaction. In RO-MAN 2009 - The 18th IEEE International Symposium on Robot and Human Interactive Communication. Toyama, Japan: IEEE, pp. 189–194.	Wilson Villa	Harold Agudelo
5-1 St. Clair, A. & Mataric, M., 2011. Task coordination and assistive opportunity detection via social interaction in collaborative human-robot tasks. In Proc. Int. Conf. on Collaboration Technologies and Systems (CTS). IEEE, pp. 168–172. Available at: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5928682 [Accessed December 10, 2012].	Gabriele Angeletti	riccardo rinaldi
5-3 Sisbot, E.A. & Alami, R., 2012. A human-aware manipulation planner. IEEE Transactions on Robotics, 28(5), pp.1045–1057.	Paolo Russo	Ahmad Irjoob

---

INFORMATION EXCHANGE / SIGNALLING

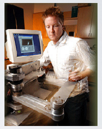
- visual displays, typically presented as graphical user interfaces or augmented reality interfaces
- gestures, including hand and facial movements and by movement-based signalling of intent
- speech and natural language, which include both auditory speech and text-based responses, and which frequently emphasise dialog and mixed-initiative interaction

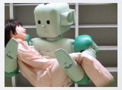




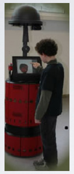
INFORMATION EXCHANGE / SIGNALLING

- non-speech audio, frequently used in alerting
- physical interaction and haptics, frequently used remotely in augmented reality or in teleoperation to invoke a sense of presence especially in tele-manipulation tasks and also frequently used proximately to promote emotional,
- social, and assistive exchanges

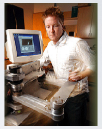


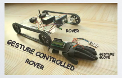


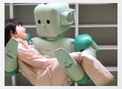
INFORMATION EXCHANGE / SIGNALLING



The modalities, specifics, flexibility, and requirements for information exchange vary a lot between tasks







SIGNALLING

29/04/16: Social Signals

This session will focus on the ways humans and robots can communicate with one another, focusing on implicit signalling.

Paper	Presented by	Discussed by
4-1 Fischer, K. et al., 2013. The impact of the contingency of robot feedback on HRI. In Proceedings of the 2013 International Conference on Collaboration Technologies and Systems, CTS 2013. pp. 210–217.	Mirco Colosi	Irvin Aloise
4-3 Moon, Aj. et al., 2013. Design and Impact of Hesitation Gestures during Human-Robot Resource Conflicts. International Journal of Human-Robot Interaction (IJHR), 2(3), pp.18–40. Available at: http://hri-journal.org/index.php/HRI/article/view/49.	Ahmad irjoob	Gabriele Angeletti
There is a free slot here as one presentation had to be moved		

STRUCTURE OF THE TEAM

- who has the authority to make certain decisions?
  - robot
  - interface software
  - or human (direct user or maintainer?)
- who has the authority to issue instructions or commands to the robot and at what level:
  - strategic
  - tactical
  - operational

STRUCTURE OF THE TEAM

- How can **conflicts** be resolved, especially when robots are placed in peer-like relationships with multiple humans.
- How are **roles** defined and supported: is the robot
  - a peer,
  - an assistant,
  - or a slave;
- does it report to another robot, to a human, or is it fully independent?

ADAPTATION, LEARNING, AND TRAINING

- Minimising Operator Training.
  - Efforts to Train Humans.
- Training Designers.
- Training Robots.
- Technical questions:
  - How to achieve adaptation?
  - What signals govern the learning (supervised, semi-supervised, reinforcement)

TASK-SHAPING

- Task-shaping is a term that emphasises the importance of considering **how the task should be done** and will be done when new technology is introduced.
  - like in Human-human interaction
  - maybe human and robot should better complement each other
  - and maybe their specific interaction is very different to HHI

PROBLEM DOMAINS OF HRI

PROBLEM DOMAINS

- Scholtz & Goodrich provided a taxonomy of roles that robots can assume in HRI:
  - Supervisor,
  - Operator,
  - Mechanic,
  - Peer,
  - Bystander,
  - Information Consumer,
  - Mentor.

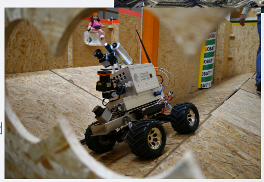
Application area	Remote/ Proximate	Role	Example
Search and rescue	Remote	Human is supervisor or operator	Remotely operated search robots
	Proximate	Human and robot are peers	Robot supports unstable structures
Assistive robotics	Proximate	Human and robot are peers, or robot is tool	Assistance for the blind, and therapy for the elderly
	Proximate	Robot is mentor	Social interaction for autistic children
Military and police	Remote	Human is supervisor	Reconnaissance, de-mining
	Remote or Proximate	Human and robot are peers	Patrol support
	Remote	Human is information consumer	Commander using reconnaissance information
Edutainment	Proximate	Robot is mentor	Robotic classroom assistant
		Robot is mentor	Robotic museum tour guide
		Robot is peer	Social companion
Space	Remote	Human is supervisor or operator	Remote science and exploration
	Proximate	Human and robot are peers	Robotic astronaut assistant
Home and industry	Proximate	Human and robot are peers	Robotic companion
	Proximate	Human is supervisor	Robotic vacuum
	Remote	Human is supervisor	Robot construction

Application area	Remote/ Proximate	Role	Example
Search and rescue	Remote	Human is supervisor or operator	Remotely operated search robots
	Proximate	Human and robot are peers	Robot supports unstable structures
Assistive robotics	Proximate	Human and robot are peers, or robot is tool	Assistance for the blind, and therapy for the elderly
Space			
	Proximate	Human and robot are peers	Robotic astronaut assistant
Home and industry	Proximate	Human and robot are peers	Robotic companion
	Proximate	Human is supervisor	Robotic vacuum
	Remote	Human is supervisor	Robot construction

If you work in HRI, be clear about the roles of human and robot and the application area

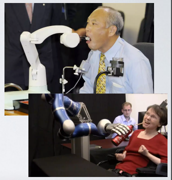
SEARCH AND RESCUE

- Urban Search and Rescue challenges
- mostly remote controlled
- shared autonomy
- A wide variety of interface concepts, autonomy designs, sensor-processing, robot morphologies, field studies, and human factors analyses and experiments have been created in the name of robot-assisted USAR.



ASSISTIVE AND EDUCATIONAL ROBOTICS

- age- & ability-related challenges
- ethical considerations that arise by delegating a companionship
- big fields: autistic children, assisted living
- physical therapy (close proximity)



Lessons learned from the deployment of a long-term autonomous robot as companion in physical therapy for older adults with dementia

A Mixed Methods Study

11TH ACM/IEEE INTERNATIONAL CONFERENCE ON HUMAN-ROBOT INTERACTION (HRI 2016) MARCH 7-10, 2016 NEW ZEALAND

SAPIENZA UNIVERSITÀ DI ROMA

L-CAS

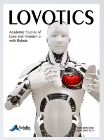
MILITARY AND POLICE

- operational, tactical and strategical support
- ethical considerations
- telepresence *and* close proximity
- military claims the would never let a robot shoot a weapon without human intervention…

SAPIENZA UNIVERSITÀ DI ROMA

L-CAS

ENTERTAINMENT

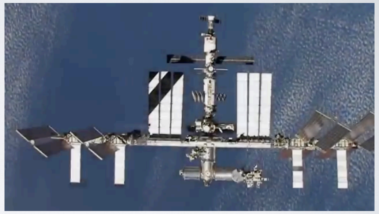


- robotic story tellers
- robotic dance partners
- robotic pets
- dance
- "Lovotics"
- you name it

SAPIENZA UNIVERSITÀ DI ROMA

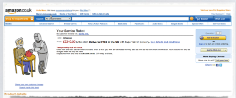
L-CAS

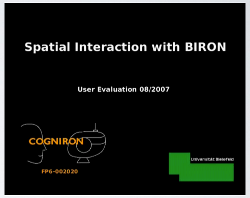
SPACE



- Mars rovers (high level of autonomy)
- Robonaut for human-robot collaboration

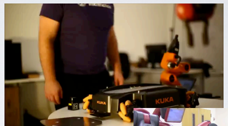
HOME

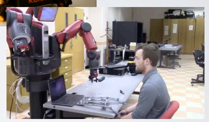




- several applications:
  - assisted living
  - everyday chores
    - cooking
    - cleaning
    - …

HOME AND INDUSTRY





- several applications:
  - assembly
  - palletising
  - warehouses
- often close collaboration, also physical

RESEARCH CHALLENGES

- Multi-Modal Perception
- Design and Human Factors
- Developmental/Epigenetic Robotics
- Robot (shared/adaptive) Autonomy
- Measuring HRI

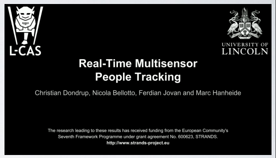
David Feil-Seifer
Maja J Mataric, 2009

MULTI-MODAL PERCEPTION

- Real-time perception and dealing with uncertainty in sensing are some of the most enduring challenges of robotics.
- range of sensor inputs for human interaction is huge (added on to the general challenges of robot perceiving environments):
  - Vision and speech, major challenges for real-time data processing.
  - Computer vision methods: facial expression, gestures
  - Language understanding and dialog systems, prosody
  - truly multimodal perception: connection between visual and linguistic data

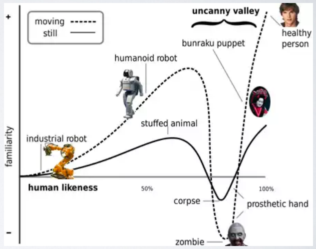
MULTI-MODAL PERCEPTION

- Real-time perception and dealing with uncertainty in sensing are some of the most enduring challenges of robotics.
- range of sensor inputs for human interaction is huge (added on to the general challenges of robot perceiving environments):
  - Vision and speech, major challenges for real-time data processing.
  - Computer vision methods: facial expression, gestures
  - Language understanding and dialog systems, prosody
  - truly multimodal perception: connection between visual and linguistic data



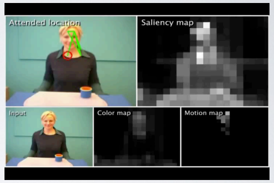
DESIGN AND HUMAN FACTORS

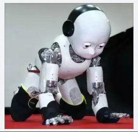
- Embodiment
- Anthropomorphism (How human-like do you want your robot to be?)
  - uncanny valley
- Appearance
- Expectations



DEVELOPMENTAL/ EPIGENETIC ROBOTICS

- Humans as tutors
- understanding how learning form interaction works
- emulate the learning process in children





ROBOT (SHARED/ADAPTIVE) AUTONOMY

- understanding user's goals and intentions
- dynamic re-planning and fluent interaction
- uncertain worlds (and uncertain humans even)
- adaptation and life-long learning

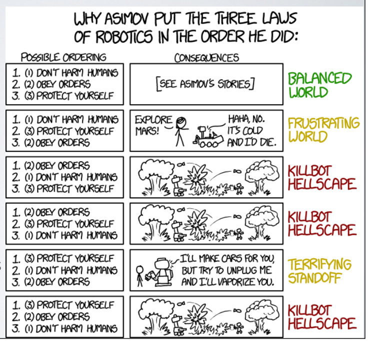
BENCHMARKS FOR HRI

- Robot Evaluation
- Social Interaction Evaluation
- Task-Oriented Benchmarks
- Assistive Evaluation

What to measure?

ROBOT EVALUATION

- Safety:
  - how safe is the robot to use (actually)
  - how safe to people feel using the robot (perceived safety)
  - even goes towards implementing Asimov's Laws of robotics



ROBOT EVALUATION

- Scalability:
  - How well will such HRI systems perform outside of the lab?
  - How well does a robot perform with users from the general population?
  - How many people can be helped by such a robot?
  - Can the robot operate in the most relevant environments for the user?

SOCIAL INTERACTION EVALUATION

- Autonomy (again)
  - non-Wizard of Oz
- Imitation
  - Turing test
- Privacy
  - "presence": The presence of a robot inherently affects a user's sense of privacy

TASK-ORIENTED BENCHMARKS

- Social Success: Does the robot successfully achieve the desired social identity?
- Understanding of Domain:
  - emotion recognition, and integration of vocalisations, speech, language, motor acts, and gestures for effectively modeling user state.
- Abilities: Do users understand the abilities (and limitations) intuitively?

ASSISTIVE/TASK EVALUATION

- Success Relative to Task
- *Usability*: How useful is the robot perceived?
- Cost/Benefit Analysis
- Impact on Task
- Satisfaction With Outcome
- Existing Quality of Life Measures
- Impact on the Role in Community/Society

GODSPEED QUESTIONNAIRE

- Godspeed key concepts: "A series of questionnaires to measure the user's perception of robots" combines five consistent and validated questionnaires based on 5-point semantic differential scales as a standardised metric for the "five key concepts in HRI":
- Anthropomorphism: rates the user's impression of the robot on five semantic differentials.
- Animacy: rates the user's impression of the robot on six semantic differentials.
- Likeability: rates the user's impression of the robot on five semantic differentials.
- Perceived Intelligence: rates the user's impression of the robot on five semantic differentials.
- Perceived Safety: rates the user's emotional state on three semantic differentials.


Measuring the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots.

Christoph Bartneck
Department of Industrial Design
Eindhoven University of Technology
Den Dolech 2, 5600MB Eindhoven
The Netherlands
Phone +31 40 247 5175
c.bartneck@tue.nl

Dana Kulic
Nakamura & Yamane Lab
Department of Mechano-Informatics
University of Tokyo
7-3-1 Hongo, Bunkyo-ku
Tokyo 113-8656, Japan
dana@ynl.t.u-tokyo.ac.jp

Elizabeth Croft
Department of Mechanical Engineering
University of British Columbia
6250 Applied Science Lane
Room 2054, Vancouver
Canada V6T 1Z4
ecroft@mech.ubc.ca

SOLUTION PARADIGMS

SOLUTION PARADIGMS

- **Dynamic Autonomy, Mixed-Initiative Interaction, and Dialog.**
- Because most interesting applications of human–robot interaction include rich information exchanges in dynamic and complex environments, it is imperative that interactions and resulting behaviours can accommodate complexity.
- Involve the human to find solutions to problems

SOLUTION PARADIGMS

- **Telepresence and Information Fusion in Remote Interaction.**
  - advances in robot morphology, sensor processing, and communications make it is necessary to find new ways to fuse information to provide humans an operational presence with the robot.
  - Obstacles to achieving this include bandwidth limitations, communications delays and drop-outs, mismatches in frames of reference, communicating intent and trusting autonomy

SOLUTION PARADIGMS

- **Cognitive Modeling.**
- Common ground creates realistic expectations and forms the basis communications.
- Create rich enough models either
  - (a) to allow the robot to identify a human's cognitive state and adjust information exchange accordingly or
  - (b) to allow the robot's behaviour to be generated by models that are interpretable by a human.

SOLUTION PARADIGMS

- **Team Organisations and Dynamics.**
  - multiple robots and multiple humans to interact with each other.
  - shape team interactions and dynamics by establishing organisational structures, communications protocols, and support tools.
  - team organisations necessarily subsume different and dynamic roles
  - leverage lessons from research on mixed initiative and dialog.

SOLUTION PARADIGMS

- **Interactive Learning.**
- it is impossible to anticipate every conceivable problem and generate scripted responses
- Interactive learning is the process by which a robot and a human work together to incrementally improve perceptual ability, autonomy, and interaction.

Towards A Framework for Human-Robot Interaction

Sebastian Thrun

The goal of this article is to introduce the reader to the rich and vibrant field of robotics, in hopes of laying out an agenda for future research on human robot interaction. Robotics is a field in change; the meaning of the term "robot" today differs substantially from the term just a decade ago. The primary purpose of this article is to provide a comprehensive description of past and present-day robotics. It identifies the major epochs of robotic technology and systems—from industrial to service robotics—and characterizes the different styles of human robot interaction paradigmatic for each epoch. To set an agenda for research on human robot interaction, the article articulates some of the most pressing open questions pertaining to modern-day human robot interaction.

Maurizio Maisto

Lorenzo Steccanella

TIME FOR A BREAK

SOCIAL == SOCIABLE == INTERACTIVE?

Is every interactive robot a social or sociable robot?

SOCIAL == SOCIABLE == INTERACTIVE?

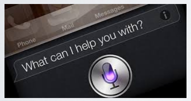
Is very interactive robot a social or sociable robot?

Cynthia Breazeal (2002: 1) writes:

...a **sociable robot** is able to communicate and **interact** with us, understand and even relate to us, in a personal way. It should be able to understand itself and us in **social terms**. We, in turn, should be able to understand it in the **same social terms** – to be able to relate to it and to **empathize** with it. Such a robot must be able to **adapt** and **learn** throughout its **lifetime**, incorporating shared experiences with other individuals into its **understanding of self**, of others, and of the relationships they share. In short, a sociable robot is **socially intelligent** in a **human-like** way, and interacting with it is like interacting with another person. At the pinnacle of achievement, they could **befriend us**, as we could them.

PEOPLE TREAT COMPUTERS LIKE PEOPLE

- Social and natural responses to media are not conscious
- Even simplest of media can activate rich social responses in humans




PEOPLE TREAT COMPUTERS LIKE PEOPLE

- Social and natural responses to media are not conscious
- Even simplest of media can activate rich social responses in humans
- All people automatically and unconsciously respond socially and naturally to media.
  - Can reason around it, but takes a lot of effort to do so!
  - Difficult to "think around" when people are tired, other things compete for attention --- it is difficult to sustain

APPEARANCE

Findings: Affect of Appearance

- People willing to cede more responsibility to human-like robot
- People willing to attribute more credit to human-like robot
- Little difference in attributing blame
- Little difference in people's willingness to rely on a robot

QUESTIONS TO YOU

- What makes robots that are sociable potentially useful?
- What are the potential problems?
- What are the particular challenges with sociable robots?

IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS—PART C: APPLICATIONS AND REVIEWS, VOL. 34, NO. 2, MAY 2004 181

Social Interactions in HRI: The Robot View

Cynthia Breazeal

Andrea Gigli

Matteo Bordoni

IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS—PART C: APPLICATIONS AND REVIEWS, VOL. 34, NO. 2, MAY 2004 181

Social Interactions in HRI: The Robot View

Cynthia Breazeal

Abstract—This paper explores the topic of human–robot interaction (HRI) from the perspective of designing sociable autonomous robots—robots designed to interact with people in a human-like way. There are a growing number of applications for robots that people can engage as capable creatures or as partners rather than tools, yet little is understood about how to best design robots that interact with people in this way. The related field of human-computer interaction (HCI) offers important insights, however autonomous robots are a very different technology from desktop computers. In this paper, we look at the field of HRI from an HCI perspective, pointing out important similarities yet significant differences that may ultimately make HRI a distinct area of inquiry. One outcome of this discussion is that it is important to view the design and evaluation problem from the robot's perspective as well as that of the human. Taken as a whole, this paper provides a framework with which to design and evaluate sociable robots from a HRI perspective.

Index Terms—Human–robot interaction (HRI), socially guided learning, social or sociable robot partner.

Andrea Gigli

Matteo Bordoni

HRI: A SUB-DISCIPLINE OF HCI

Disclaimer: Prepared with input from an actual HCI researcher: Dr Kathrin Gerling

SAPIENZA UNIVERSITÀ DI ROMA L-CAS

DISCLAIMER II: HRI == HCI ???

- HRI is **strongly related** to Human-Computer Interaction (HCI) and Human-Machine Interaction (HMI).
- HRI, however, **differs** from both HCI and HMI because it concerns systems (robots) which have **complex**, **dynamic control systems**, which exibit **autonomy** and **cognition** and which operate in changing, **real-world environments**.

SAPIENZA UNIVERSITÀ DI ROMA L-CAS

HUMAN FACTORS / ERGONOMICS

- Understanding the human element in design of technology
  - Designing equipment and devices that fit the human body and its cognitive abilities
- NASA and IBM pioneered this work
- A lot of the concepts and methods in HCI are borrowed from engineering

	IBM Computer Usability Satisfaction Questionnaire
1	Overall, I am satisfied with how easy it is to use this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
2	It was simple to use this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
3	I can effectively complete the tasks using this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
4	I am able to complete my work quickly using this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
5	I feel comfortable using this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
6	It was easy to learn to use this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
7	Whenever I make a mistake using the system, I recover easily and quickly
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
8	The organization of information on the system screens is clear
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
9	The interface of this system is pleasant
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
10	I like using the interface of this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
11	Overall, I am satisfied with how easy it is to use this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree

TORS /
ICS
design of technology
fit the human body and
HCI are borrowed from

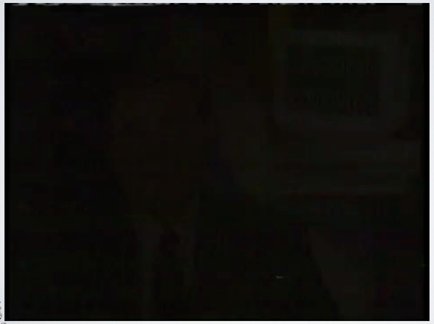
USABILITY & ACCESSIBILITY

- Started with the era of desktop computing, suddenly “usability” becomes a billion dollar industry
- The design of interfaces that allow people to do their work without being massively frustrated
- Based on cognitive psychology – understanding what people are capable of and comfortable with in terms of perception & memory

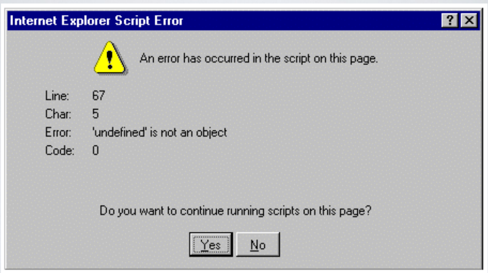
USER EXPERIENCE

- Putting the user at the centre of everything
  - Requirements, design, prototyping, dev & evaluation
  - Cognitive abilities, subjective experience, narratives, cultural impact
- Dialogue is the key - constant, constructive dialogue between designers, users and communities

USABILITY (FROM KATHRIN)

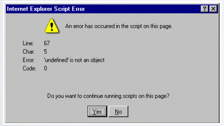


WHAT IS USABILITY?



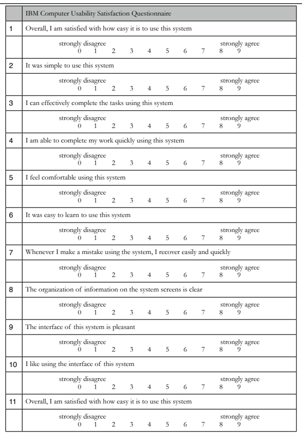
WHAT IS USABILITY?

- "The effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments." ISO 9241



WHAT IS USABILITY?

- Lots of different ways of considering / measuring this
- It depends on what the software is supposed to do
- Efficiency
  - Time taken to do task
  - Errors
- Effectiveness
  - Number of tasks completed in a given time
- Satisfaction
  - Questionnaires



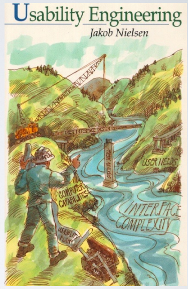
	IBM Computer Usability Satisfaction Questionnaire
1	Overall, I am satisfied with how easy it is to use this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
2	It was simple to use this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
3	I can effectively complete the tasks using this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
4	I am able to complete my work quickly using this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
5	I feel comfortable using this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
6	It was easy to learn to use this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
7	Whenever I make a mistake using the system, I recover easily and quickly
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
8	The organization of information on the system screens is clear
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
9	The interface of this system is pleasant
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
10	I like using the interface of this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree
11	Overall, I am satisfied with how easy it is to use this system
	strongly disagree 0 1 2 3 4 5 6 7 8 9 strongly agree

BILITY?

ring this

d to do

USABILITY



- Nielsen (1993): Usability Engineering
- There are vast amounts of usability research – progress in instruments, procedures, specialised for different user groups / devices
- It is inherent in the design of most software / devices

WHAT ARE USABILITY HEURISTICS?

- Essentially rules-of-thumb that "experts" use to ensure that their software follows established usability principles
- They are used primarily because they have been found useful.
- Applied before software is exposed to real people.
- There are a few different versions
  - Nielsens (1993) 10 usability heuristics
  - Schneidermans (1998) 8 golden rules

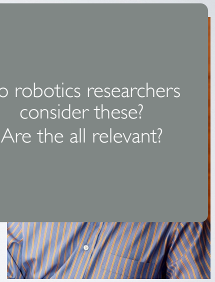
NIELSEN'S 10 USABILITY HEURISTICS

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help recognise, diagnose, and recover from errors
10. Help and documentation

http://www.useit.com/papers/heuristic/heuristic_list.html

NIELSEN'S 10 USABILITY HEURISTICS

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help recognise, diagnose, and recover from errors
10. Help and documentation



Do robotics researchers consider these?
Are the all relevant?

http://www.useit.com/papers/heuristic/heuristic_list.html

SAPIENZA UNIVERSITÀ DI ROMA

SHNEIDERMAN'S 8 GOLDEN RULES

1. Strive for consistency.
2. Enable frequent users to use shortcuts.
3. Offer informative feedback.
4. Design dialog to yield closure.
5. Offer simple error handling.
6. Permit easy reversal of actions.
7. Support internal locus of control.
8. Reduce short-term memory load.

http://lncn.eu/dtu

SAPIENZA UNIVERSITÀ DI ROMA

SHNEIDERMAN'S 8 GOLDEN RULES

1. Strive for consistency.
2. Enable frequent users to use shortcuts.
3. Offer informative feedback.
4. Design dialog to yield closure.
5. Offer simple error handling.
6. Permit easy reversal of actions.
7. Support internal locus of control.
8. Reduce short-term memory load.

Use these as tick boxes when designing HRI!

http://lncn.eu/dtu

SAPIENZA UNIVERSITÀ DI ROMA

WHAT IS GOOD DESIGN?

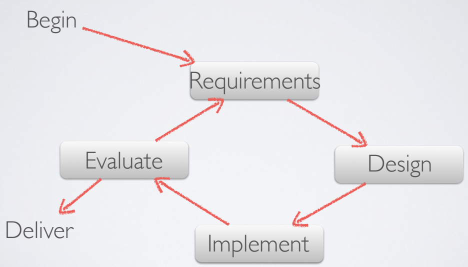
What makes digital products appeal to people?

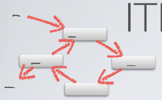
What are the requirements of different user groups?

OVERVIEW

- **Iterative and experience-centred** design process
- Introduction to methods for **requirement establishment** in HCI
- Focus on approaches that can help us understand users:
  - **Requirements analysis**: Focus groups and interviews
  - **Design phase**: Participatory design and personas

ITERATIVE DESIGN





ITERATIVE DESIGN

- **Cyclic** (software development) process that starts with requirements establishment, leads over to the design and implementation of solutions which are then evaluated
- After **evaluation**, either exit, or enter new iteration in which requirements are adapted and design and implementation are updated
- System **evolves** throughout development

EXPERIENCE-CENTRED DESIGN

- Experience-centred design = **commitment to dialogue** with users and communities of interest
- At each stage of the iterative process there are different methodologies that have been found useful for informing design
- Lots of overlap – use the most appropriate one to find out the information you need to improve your design at each stage of the process

EXPERIENCE-CENTRED DESIGN

- Requirements establishment
  - **Ethnography**
  - Probes (cultural, experiential, evocative)
  - **Diary** studies
  - **Focus** groups
  - Card sorting tasks
  - **Interviews**
  - **Drama** / Role Play
  - Fictional Inquiry

EXPERIENCE-CENTRED DESIGN

- Design
  - Participatory design (focus groups)
  - Personas
  - Scenarios
  - Paper prototyping

EXPERIENCE-CENTRED DESIGN

- Evaluation
  - Early stages
    - Paper prototyping
    - Experience prototyping (Wizard of Oz)
- Later stages
  - Working prototype – lab usability study
  - Diary study
  - Analysis of data log files
  - Interviews

EXPERIENCE-CENTRED DESIGN

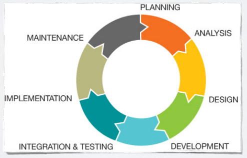
- The point of all of these is to "*invite participants to creatively express something about themselves, their values, their relationships, and the ways they make sense of experience*" (Wright & McCarthy, 2010, p.84).
- "*…to elicit personally meaningful reflections… to understand how people experience and make sense of situations, relationships and life events.*" (Wright & McCarthy, 2010, p.84).

EXPERIENCE-CENTRED DESIGN

- …Because understanding that, is what will lead you to design useful, interesting, successful technology
- ….and (more engineeringly) it's the best way to avoid costly errors in the development process
- A poor requirements phase can cost 100 times more to fix later in a project (Boehm & Basili, 2001).

REQUIREMENTS ANALYSIS

- Functional & Non-functional requirements
- These are software engineering practices
  - HCI is part of the SDLC, not an extra thing



FUNCTIONAL REQUIREMENTS

- Functional requirements are "a statement about an intended product that specifies what it should do" (Sharp, Rogers, & Preece, 2010)
- Put simply: Tangible system features

NON-FUNCTIONAL REQUIREMENTS

- Describe product or system characteristics with respect to performance – not just efficiency, but also softer qualities such as user experience
- Describe how a system is supposed to act

where does this stem from in HRI?

- Ideally need to be measurable so project progress and success can be assessed

REQUIREMENTS: QUICK GUIDE

- Identify what is **important** to stakeholders
  - This will allow you understand what is not acceptable (e.g., getting fired from my job because I need to play game during office hours)
- Involve the **stakeholder**
  - And more than one of them
- Be **prepared** – use props, examples, prototypes to support discussion

REQUIREMENTS: SUMMARY

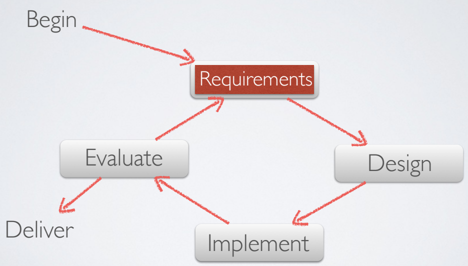
- **Functional and non-functional requirements go hand in hand** – define system features and execution
- Revisit throughout development process, reassess, ensure that nothing went wrong along the way

most users are novices when it comes to robots

- Understand that users may have different takes on requirements, show behaviours that were not anticipated, …

USER-CENTRED DESIGN

ITERATIVE DESIGN



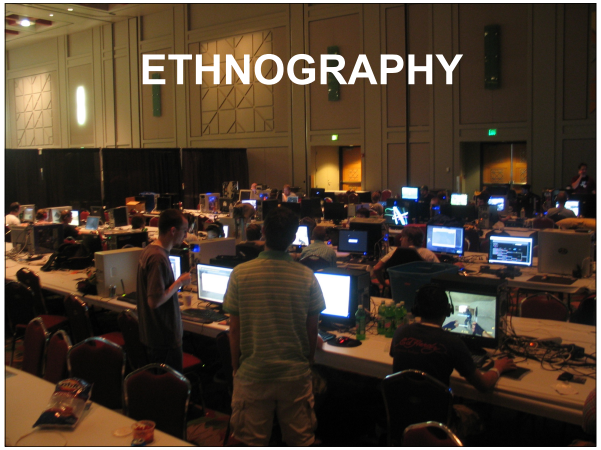
REQUIREMENTS ESTABLISHMENT

- Ethnography
- Focus groups
- Interviews

- There are many other approaches – this is just a selection to give you tools to use for this class!


ETHNOGRAPHY


ETHNOGRAPHY


ETHNOGRAPHY

ETHNOGRAPHY

- Everything is viewed naively – viewed as strange
- No theoretical framework in advance
- Gives a detailed and nuanced understanding of peoples lives
  - Other methods may be difficult - people may not answer questionnaires or interviews 100% honestly

many lessons learned in care home!

Ethnography =
Direct observations of how people actually live, work etc., allows the designer to gain understanding of how technology will fit intuitively into their lives.

FOCUS GROUPS

- Discussing ideas with target audience to elicit their feedback on developers'/designers' thoughts – not just observing, but also interacting!
- These are very commonly used
  - Designers meet stakeholders
  - Social, personal interaction
  - Public discussion
  - Highlights agreement, disagreement
  - People express their understanding

FOCUS GROUPS

- The designer has a plan…
  - They have a rough idea of the information they want to elicit
    - Functional requirements
  - They provide props, materials, some guidance on discussion
  - They record participant responses

INTERVIEWS

- Interviews are a common method for establishing requirements
- Different types
  - Structured
  - Unstructured
  - Semi Structured

STRUCTURED INTERVIEWS

- The interviewer asks pre-determined questions
  - Similar to a questionnaire
- Exactly same questions used with every participant
- Closed questions
  - Require an answer from a pre-determined set of alternatives
  - Works if the range of possible answers is known
  - And people are in a rush
- Only useful if goals are very well understood

UNSTRUCTURED INTERVIEWS

- Exploratory conversations around a particular topic
- Questions are open
  - No expectation of the format or content of answers
  - Useful when you want to explore the range of possible opinions
- But you still need a plan – you need to be aware of what information you need to find out.
- Results in rich, unstructured data

SEMI-STRUCTURED INTERVIEWS

- Use both open and closed questions
- Basic script so that the same topics are covered
- Begin with pre-planned questions, then probe participant to expand upon that point
- Don't lead people to conclusions
  - "as an older person you probably like tea…"
- Probe – "Is there anything else you'd like to tell me"

REQUIREMENTS ESTABLISHMENT

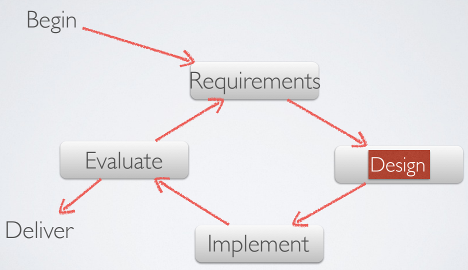
A. Ethnography – good to observe persons in natural environment without interfering with their activities, but no insights into personal opinions and ideas

B. Focus groups – good to get input from groups of people and their discussion of your ideas, will lead to interesting insights, but are hard to manage

C. Interviews – a way of obtaining individual feedback, but need to make sure you are not leading participants on

SAPIENZA UNIVERSITÀ DI ROMA

ITERATIVE DESIGN



SAPIENZA UNIVERSITÀ DI ROMA

DESIGN

- Participatory Design
- Personas

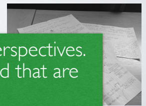
- There are many other approaches – this is just a selection to give you tools to use for this class!

SAPIENZA UNIVERSITÀ DI ROMA

L-CAS

PARTICIPATORY DESIGN

- The involvement of end-users in the development process; not just in the testing phase, but as actual designers
- Goal: "[…] increase the public's engagement with research, facilitate learning and change, ensure that technologies are aligned to people's needs and remove designer subjectivity." (Khaled & Vasalou, 2014)



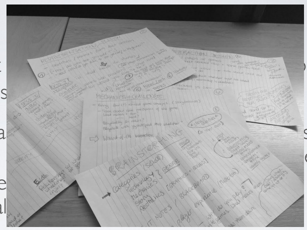
Allows you to gain new insights into the user's perspectives. They may have insights that you do not have, and that are impossible to imagine!

SAPIENZA UNIVERSITÀ DI ROMA

L-CAS

PARTICIPATORY DESIGN

- The involvement process; not just in the tes
- Goal: "[…] increa search, facilitate learning es are aligned to people subjectivity." (Khal



Allows you to gain new insights into the user's perspectives. They may have insights that you do not have, and that are impossible to imagine!

SAPIENZA UNIVERSITÀ DI ROMA

L-CAS

PERSONAS

- Alternative to directly involving end-users in design
- Fictional characters that are created by designers to represent target audience
- Still requires insights into needs and wishes of target audience, but does not require direct contact
- Can be based off literature, own experiences, group discussions, observations (ethnography!)
- Still subjective, so a bit tricky – keep that in mind when playing through scenarios

PERSONAS: EXAMPLE

- Sarah, 70 years old, widow, lives alone
- Has Arthritis but otherwise healthy and active
- Enjoys reading, going for walks, spending time with her children and grandchildren
- Little experience using computers, children bought her a tablet so they can Skype her
- Arthritis sometimes makes it hard to use tech, but also other things in daily life

PERSONAS: EXAMPLE

- Marcus, 21 years old, girlfriend lives in same town
- Student
- In his second year and a bit worried about finishing uni soon – thinking about what to do next
- Likes going out, seeing friends
- Wishes he could go home to see family more
- Uses phone all the time to text people

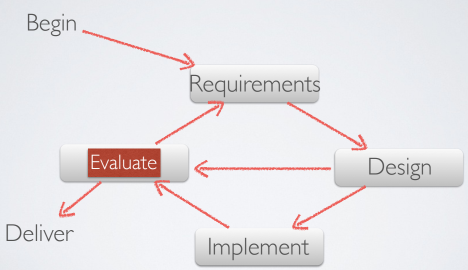
PERSONAS: QUICK GUIDE

- Include 'hard facts' about person
- Talk about strengths and weaknesses
- Try to create a 'full' image – include hobbies, interests, whatever makes the person unique
- Don't focus too much on the software you're trying to design – this will follow later
- When in doubt, read up about topics
- Sometimes you'll need to create several personas

REMEMBER: QUICK GUIDE

- Identify what is important to stakeholders
  - This will allow you understand what is not acceptable (e.g., getting fired from my job because I need to play video game during office hours)
- Involve the stakeholder
  - And more than one of them
- Be prepared – use props, examples, prototypes to support discussion

ITERATIVE DESIGN



DESIGN! EVALUATION

- Wizard-of-Oz
- (Paper) Prototype
- There are many other approaches – this is just a selection to give you tools to use for this class!

WIZARD-OF-OZ

- "The phrase Wizard of Oz has come into common usage to describe a testing or iterative design methodology wherein an experimenter (the "wizard"), […] simulates the behavior of a theoretical intelligent computer application."
- Long version: http://deepblue.lib.umich.edu/bitstream/handle/2027.42/174/71952.0001.001.pdf

REMEMBER

- The point of user-centred and participatory design is to "invite participants to creatively express something about themselves, their values, their relationships, and the ways they make sense of experience" (Wright & McCarthy, 2010, p.84).
- Not all people are the same!
- Make no assumptions, or at least try the best to stop your brain from getting ahead of you!

The bottom line:

sit down with your target audience and find out about their preferences.

Test your stuff.

Test it a lot.

HUMAN-CENTRED DESIGN APPLIED TO SOCIAL ROBOTS

- Human mind is exquisitely suited to make sense of the world and people
- Use Natural Cues
  - Indicate what parts to operate and how
  - The mapping between intended and actual operations is intuitive
  - The effects of the operations are apparent
- Just the right things need be visible to avoid gadget overload

---

What do staff in eldercare want a robot for? An assessment of potential tasks and user requirements for a long-term deployment.

***Abstract*— Robotic aids could help to overcome the gap between rising numbers of older adults and at the same time declining numbers of care staff. Assessments of end-user requirements, especially focusing on staff in eldercare facilities are still sparse. Contributing to this field of research this study presents end-user requirements and task analysis gained from a methodological combination of interviews and focus group discussions. The findings suggest different tasks robots in eldercare could engage in such as “fetch and carry” tasks, specific entertainment and information tasks, support in physical and occupational therapy, and in security. Furthermore this paper presents an iterative approach that closes the loop between requirements-assessments and subsequent implementations that follow the found requirements.**

Francesco Sapio

SALVATORE GIGLIO

HRI IN RESEARCH

6.1 Human-Robot Interaction-Specific Conferences

- **Conference on Human Robot Interaction (HRI):** This conference, created in 2006, is focused specifically on HRI research. Attendees and submissions to this conference are mostly from engineering (electrical engineering and computer science) with contributions from allied fields, such as psychology, anthropology, and ethics.
- **International Workshop on Robot and Human Interactive Communication (RO-MAN):** RO-MAN provides a forum for an interdisciplinary exchange for researchers dedicated to advancing knowledge in the field of human-robot interaction and communication. Importantly, RO-MAN has traditionally adopted a broad perspective encompassing research issues of human-machine interaction and communication in networked media as well as virtual and augmented tele-presence environments. RO-MAN is somewhat longer-standing than HRI.
- **International Conference on Development and Learning (ICDL):** This conference brings together the research community at the convergence of artificial intelligence, developmental psychology, cognitive science, neuroscience, and robotics, aimed at identifying common computational principles of development and learning in artificial and natural systems. The goal of the conference is to present state-of-the-art research on autonomous development in humans, animals and robots, and to continue to identify new interdisciplinary research directions for the future of the field.
- **Computer/Human Interaction (CHI) Conference:** CHI is an established conference in Human-Computer Interaction (HCI). Every year, it is a venue for 2000 HCI professionals, academics, and students to discuss HCI issues and research and make lasting connections in the HCI community. HRI representation in this meeting is small, but the two fields (HRI and HCI) have much to learn and gain from each other.

HRI IN RESEARCH

6.2 General Robotics and AI Conferences

- **Association for the Advancement of Artificial Intelligence (AAAI):** AAAI's annual conference affords participants a setting where they can share ideas and learn from each other's artificial intelligence (AI) research. Topics for the symposia change each year, and the limited seating capacity and relaxed atmosphere allow for workshoplike interaction.
- **AAAI Spring and Fall Symposia:** These annual symposia cover a broad range of focused topics. With the rapid growth of HRI, the topic and related areas (e.g., service robotics, socially assistive robotics, etc.) symposia are held in each session.
- **Epigenetic Robotics (EpiRob):** The Epigenetic Robotics annual workshop has established itself as an opportunity for original research combining developmental sciences, neuroscience, biology, and cognitive robotics and artificial intelligence is being presented.
- **International Conference on Robotics and Automation (ICRA):** This is one of two most major robotics conferences, covering all areas of robotics and automation. In recent years, the themes of the conference have included many areas of HRI research, such as "Humanitarian Robotics," "Ubiquitous Robotics," and "Human-Centered Robotics", reflecting the rapid growth in the field.
- **International Conference on Intelligent Robots and Systems (IROS):** This is the other major international robotics conference, featuring a very large number of papers, with a growing representation of HRI. Tutorials and workshops, as well as organized/special sessions in HRI are featured regularly.
- **International Symposium on Experimental Robotics (ISER):** ISER is a single-track symposium featuring around 50 presentations on experimental research in robotics. The goal of these symposia is to provide a forum dedicated to experimental robotics research with principled foundations. HRI topics have become a regular part of this venue.