SEMINARS IN ARTIFICIAL INTELLIGENCE

HUMAN ROBOT INTERACTION INTRODUCTION

Marc Hanheide

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

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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, 1mechanical, 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.

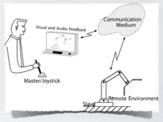
"The study of the humans, robots and the ways they influence each other"
(definition by the 10th International Symposium of Robotics Research, November 2001, Australia).

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

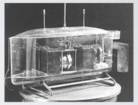
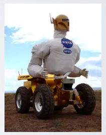
- Remote interaction — The human and the robot are not co-located and are separated spatially or even temporally (for example, the Mars Rovers are separated from earth both in space and time).





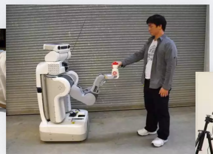
ONE SLIDE ON HISTORY OF TELEPRESENCE

- 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

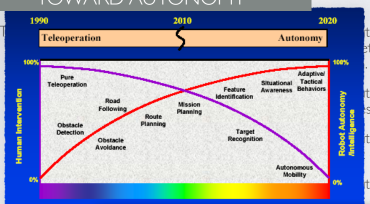
- A system with a high level of autonomy is one that can be neglected for a long period of time without interaction.
- Autonomy is not an end in itself in the field of HRI, but rather a means to **supporting productive interaction**.
  - Indeed, autonomy is only useful insofar as it supports beneficial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

LEVELS OF AUTONOMY

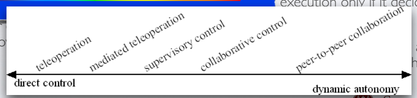
- Tom Sheridan:
  - 1. Computer offers no assistance; human does it all.
  - 2. Computer offers a complete set of action alternatives.
  - 3. Computer narrows the selection down to a few choices.
  - 4. Computer suggests a single action.
  - 5. Computer executes that action if human approves.
  - 6. 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

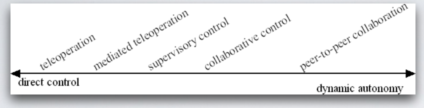
Department of Defense (DOD) PATH TOWARD AUTONOMY



- T
  - 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
  - 5. Computer
    human appro
  - 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

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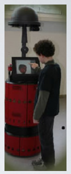
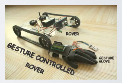
INFORMATION EXCHANGE / SIGNALLING

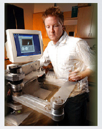


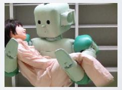
- visual displays, typically presented as graphical user interfaces or augmented reality interfaces
- gestures, including hand and facial movements and by movement-based signalling of intent
- speech and natural language, which include both auditory speech and text-based responses, and which frequently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



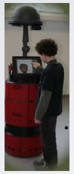
INFORMATION EXCHANGE / SIGNALLING

- 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

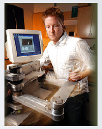


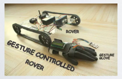


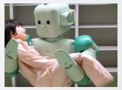
INFORMATION EXCHANGE / SIGNALLING



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

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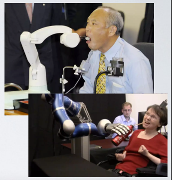
			interaction for tic children
Military and p			issance, ning
			upport
			nder using naissance nation
Edutainment			classroom ant
			museum tour
			companion
Space		operator	exploration
	Proximate	Human and robot are peers	Robotic astronaut assistant
Home and industry	Proximate	Human and robot are peers	Robotic companion
	Proximate	Human is supervisor	Robotic vacuum
	Remote	Human is supervisor	Robot construction

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)

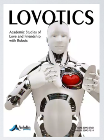
Lessons learned from the deployment of a long-term autonomous robot as companion in physical therapy for older adults with dementia

A Mixed Methods Study

MILITARY AND POLICE

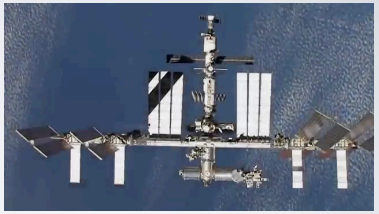
- operational, tactical and strategical support
- ethical considerations
- telepresence *and* close proximity
- military claims the would never let a robot shoot a weapon without human intervention…

ENTERTAINMENT



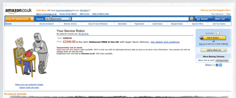
- robotic story tellers
- robotic dance partners
- robotic pets
- dance
- "Lovotics"
- you name it

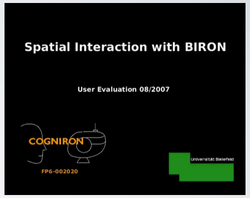
SPACE



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

HOME





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

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INDUSTRY

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

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RESEARCH CHALLENGES

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

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

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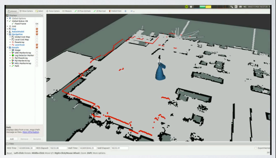
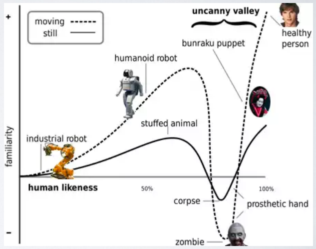


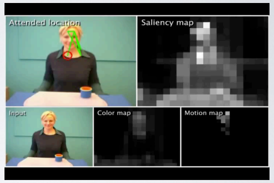
DESIGN AND HUMAN FACTORS

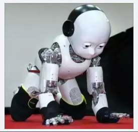
- Embodiment
- Anthropomorphism (How human-like do you want your robot to be?)
  - uncanny valley
- Appearance
- Expectations



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

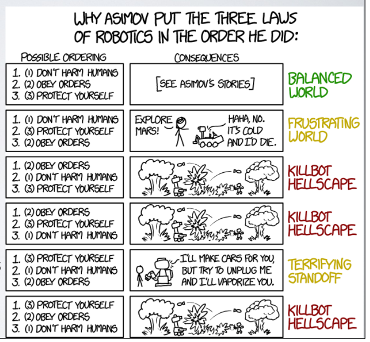
BENCHMARKS FOR HRI

- 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.

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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.

SOCIAL == SOCIABLE == INTERACTIVE?

Is every interactive robot a social or sociable robot?

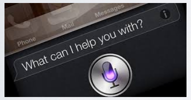
SOCIAL == SOCIABLE == INTERACTIVE?

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?

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Social Interactions in HRI: The Robot View

Cynthia Breazeal

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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

SAPIENZA UNIVERSITÀ DI ROMA L-CAS

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

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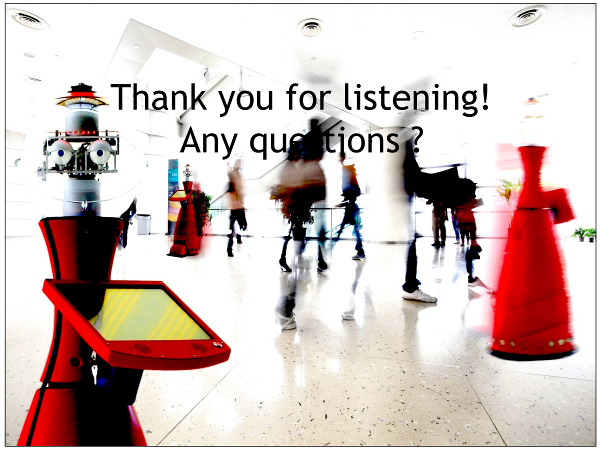
Thank you for listening!
Any questions ?