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Week 5

Human-Robot Interaction

Design for HRI Systems

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Learning Outcomes

- Understand the key stages of an iterative User-Centred Design (UCD) process (also known as Human-Centred Design)
- Understand the importance of following an iterative UCD process
- Review some real-world examples to gain a deeper understanding of the process and issues

What is User/Human-Centred Design?

- It is an approach to interactive System Development that focuses specifically on making systems usable.
- It is characterised by the following:
  - The design is based upon an explicit understanding of users, tasks and environments.
  - Users are involved throughout design and development.
  - The design is driven and refined by user-centred evaluation.
  - **The process is iterative.**
  - The design addresses the whole user experience.
  - The design team includes multidisciplinary skills and perspectives

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Why is a UCD/HCD process important?

- The process ensures user involvement at every stage resulting in:
  - Improved user acceptance
  - Ecologically valid testing for safety and reliability and repeatable performance in different situations of user response and behaviour
  - Better understanding of the user and context of use:
    - user mental models, abilities and limitations
    - their environment that the system will be operating in
    - their existing skills and knowledge
    - expectations and understanding the constraints and limitations of the user in the operational environment
  - Solution/system that is 'fit for purpose' and meets requirements

What are the key stages of UCD?

- Interviews
- Questionnaires
- Focus Groups
- Contextual Inquiry
- Cultural Probes

Requirements Gathering

- Embodiment Workshops
- Scenario-focused Workshops
- Surveys

Conceptual Design

- Co-creation Sessions
- Participatory Design Studio

Prototype Co-Design

- Wizard-of-Oz
- Field trials

Usability and User Experience Evaluation

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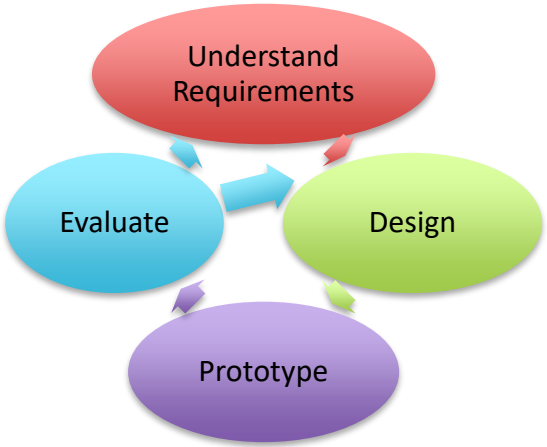
Example UCD Process – Gathering Requirements for a Socially Assistive Robot

An Iterative Design Process



Some things older participants told us

I would like it to play, I don't know, Frank Sinatra while it was doing it.

I'm not interested in what it looks like, all I am interested in is what it costs

I wouldn't mind how it looked but happy perhaps?

What would I do with myself though if all these little beasties are doing everything for me, because it's part of my world to do the gardening and everything. If it's all done for me I might as well climb into a box and …that would be a problem

I'd like it to smell of a human

…that it would run amuck…and that you wouldn't be able to know how to stop it making horrible harsh noises

Caleb-Solly, P., Dogramadzi, S., Ellender, D., Fear, T. and Heuvel, H.V.D., 2014, March. A mixed-method approach to evoke creative and holistic thinking about robots in a home environment. In Proceedings of the 2014 ACM/IEEE international conference on Human-robot interaction (pp. 374-381). ACM.

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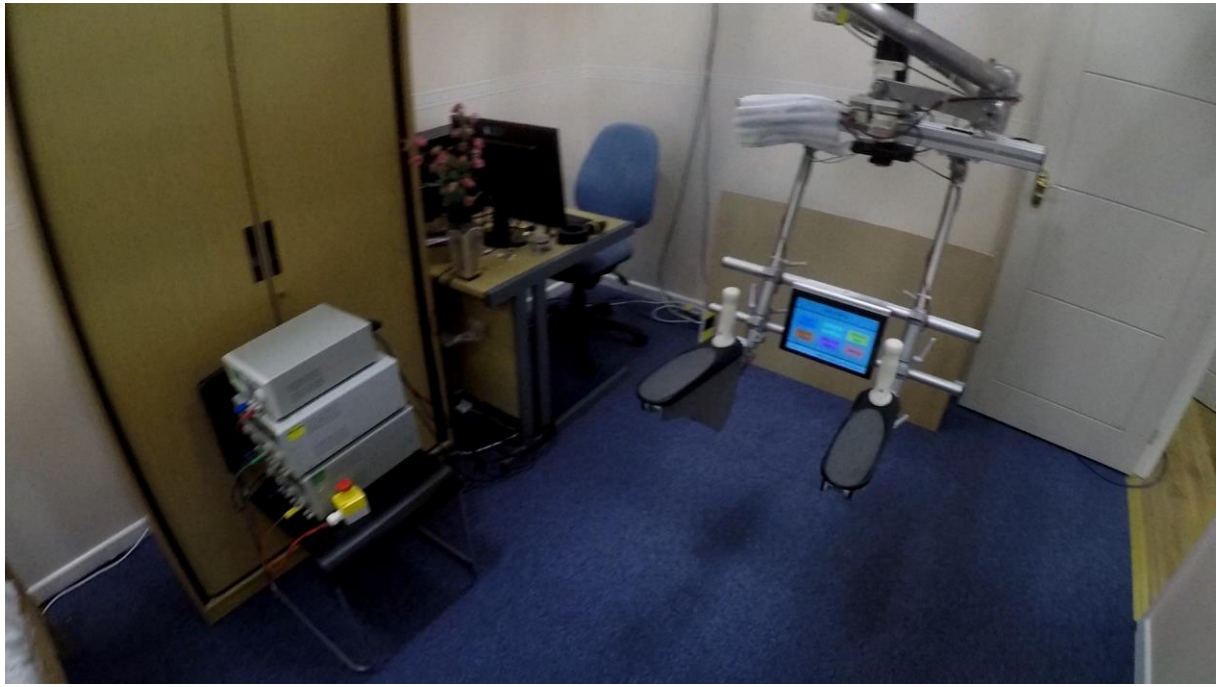
Example UCD Process for CHIRON – How did we get to here? Developing a Physically Assistive Robot



https://chiron.org.uk/

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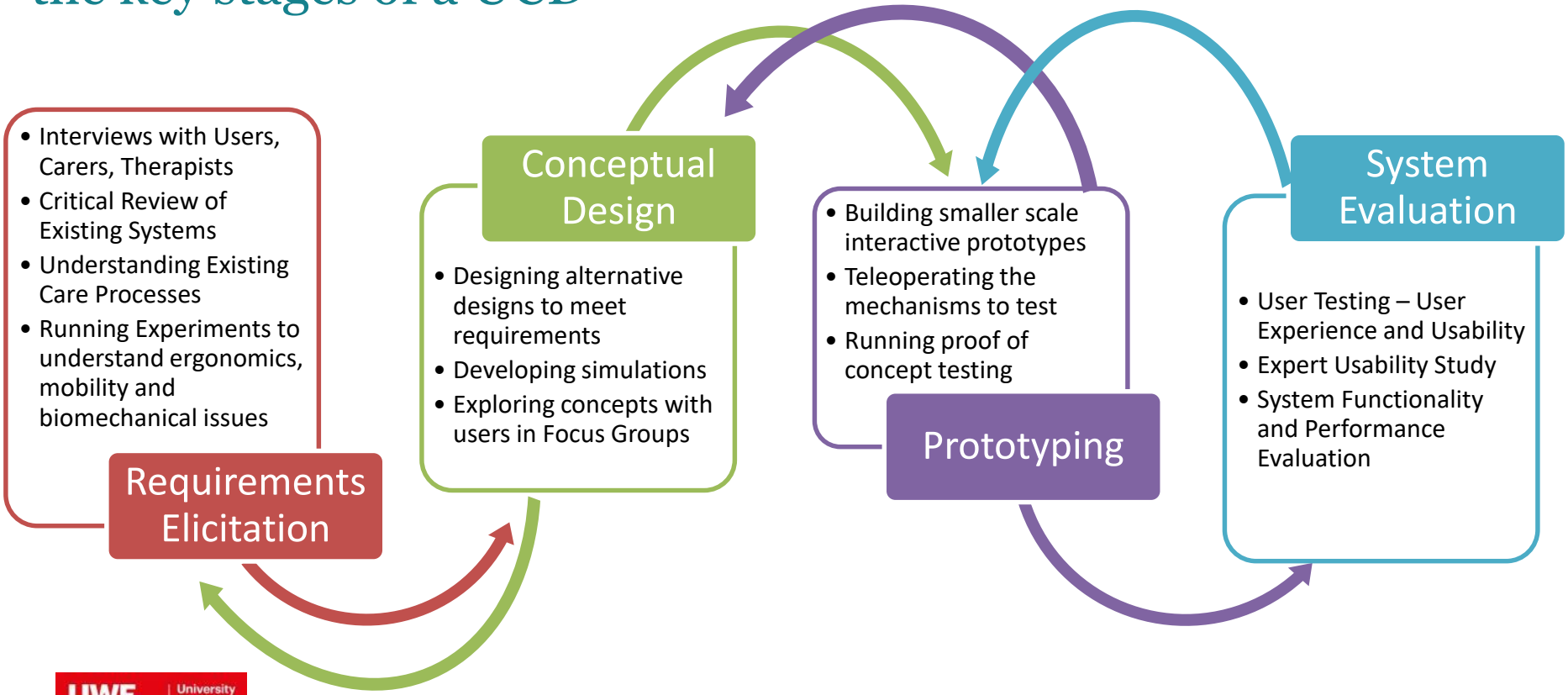
Example UCD Process for CHIRON – the key stages of a UCD



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Example UCD Process for CHIRON – Requirements Elicitation

- Interviews with End Users, Carers, therapists
- Critical Review of Existing Systems
- Understanding Existing Care Processes
- Running Experiments to understand ergonomics, mobility and biomechanical issues

Dobir: "I need help and support with maintaining my personal hygiene, dressing and using the toilet. I would like someone to help me to maintain my dignity....

Persona Use Case	Functional Support
Amy: Use Case 1 - Maintaining Activity Support in the kitchen needed due to a bad back	Light physical support and mobility
	Pick and Place objects
Amy: Use Case 2 – Fall Prevention Problems around the home due to poor eyesight	Searching and locating things
	Timely reminders of hazards
	Social and cognitive assistance
Samuel: Use Case 3 – Self-management Support for management of chronic and long-term conditions	A Medication reminder and support
	Nutrition support
Amy: Use Case 4 – Independent Living Addressing reduced mobility	Help with mobility
	Keeping the house tidy and clean
	Doing the laundry
	Taking the garbage out
	Bathing
Priya: Use Case 5 – Independent Mobility Getting up and about in the morning	Help with getting out of bed and going to the toilet
Manoj: Use Case 6 - Personal Hygiene Dealing independently with incontinence	Help with dealing with toileting in bed
Manoj: Use Case 7 – Carer Support Supporting a single carer for personal care	Additional physical support for a formal or informal carer

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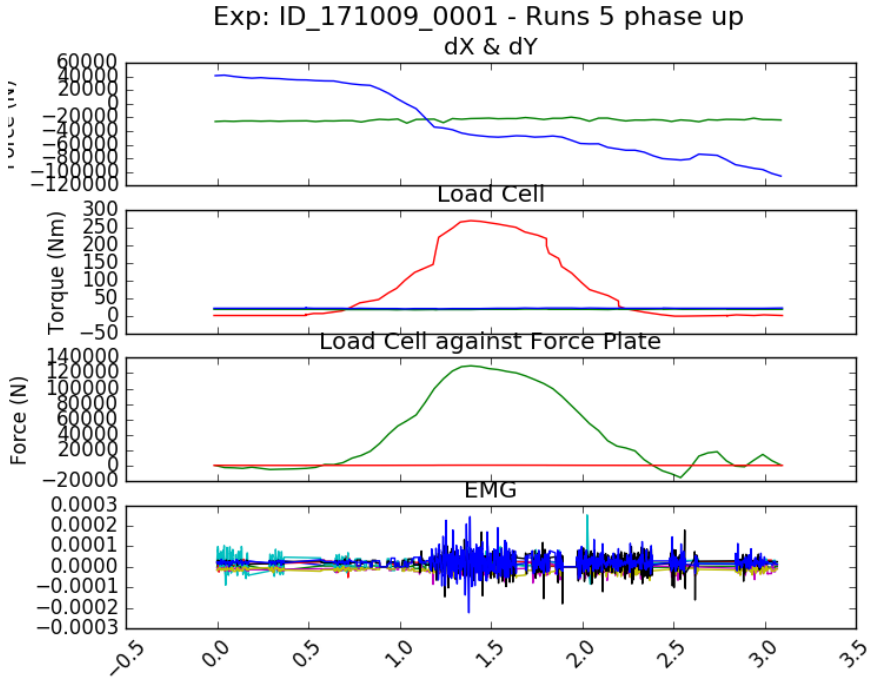
Example UCD Process for CHIRON – Requirements Elicitation

CHIRON Biomechanical Study



Aim: To record the range of dynamic and biomechanical measurements for sit to stand movements.
These will inform operational parameters, as well as the ergonomic design of a future sit to stand assist device.

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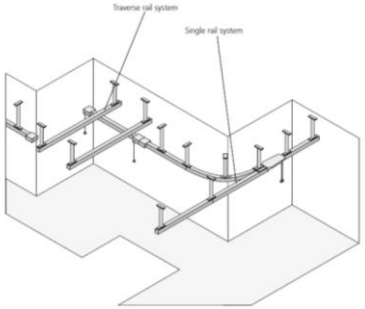
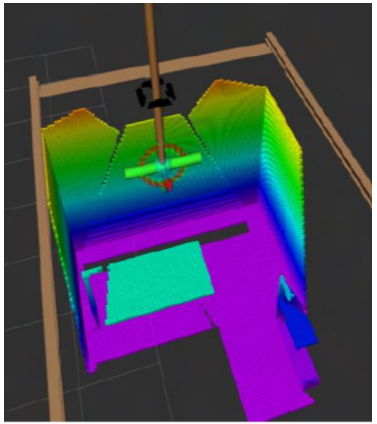
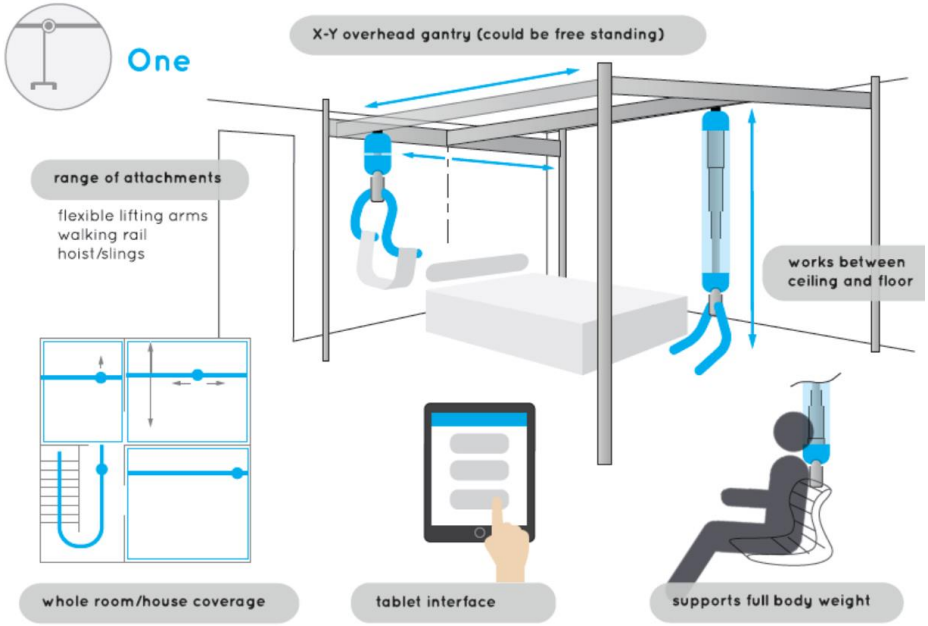
Example UCD Process for the CHIRON – Conceptual Design

- Designing alternative designs to meet requirements
- Developing simulations
- Exploring concepts with users in Focus Groups





Rviz (ROS) Simulation



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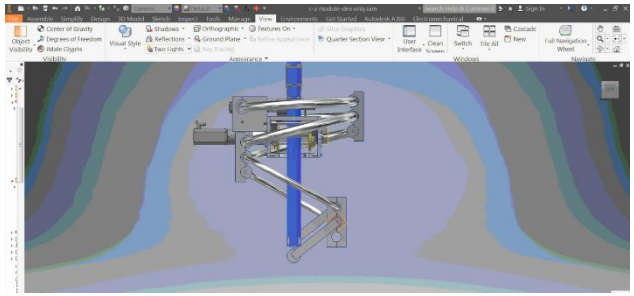
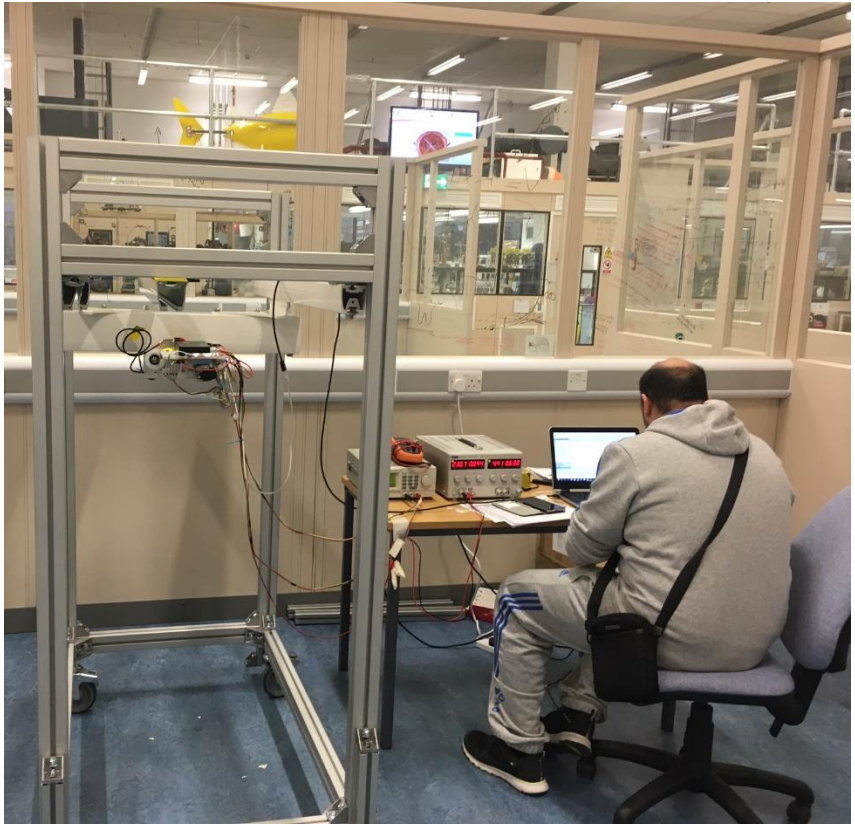
Example UCD Process for the CHIRON – Prototyping

- Building smaller scale interactive prototypes
- Teleoperating the mechanisms to test function
- Running proof of concept testing





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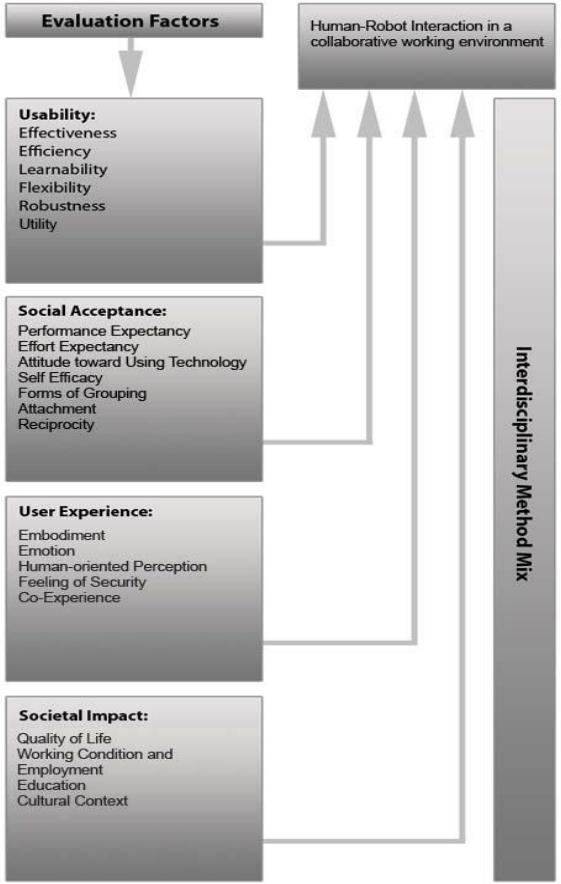
Example UCD Process for the CHIRON – System Evaluation

- User Testing
  - User Experience and Usability
- Expert Usability Study
- System Functionality and Performance Evaluation



Some user feedback on CHIRON

- *"I can foresee situations e.g. in a bathroom or toilet where Pepper might not have easy access"*
- *"Cost saving, functional"*
- *"This is the interface I'm used to"*
- *"Simple, easy"*
- *"Too technical. Inhuman. Lonely"*

Weiss, A., Bernhaupt, R., Lankes, M. and Tscheligi, M., 2009, April. The USUS evaluation framework for human-robot interaction. In *AISB2009: proceedings of the symposium on new frontiers in human-robot interaction* (Vol. 4, pp. 11-26).

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Example UCD: I-DRESS The Concept

The main goal of the I-DRESS project is to develop a system that will provide proactive assistance with dressing to **disabled users** or users such as **high-risk health-care workers**.

The I-DRESS system is being evaluated in two dressing tasks.

Putting on Shoes

Putting on Garments: Gowns & Jackets

Example UCD: I-DRESS Technical objectives (challenges)

Objective 1: User and Garment tracking

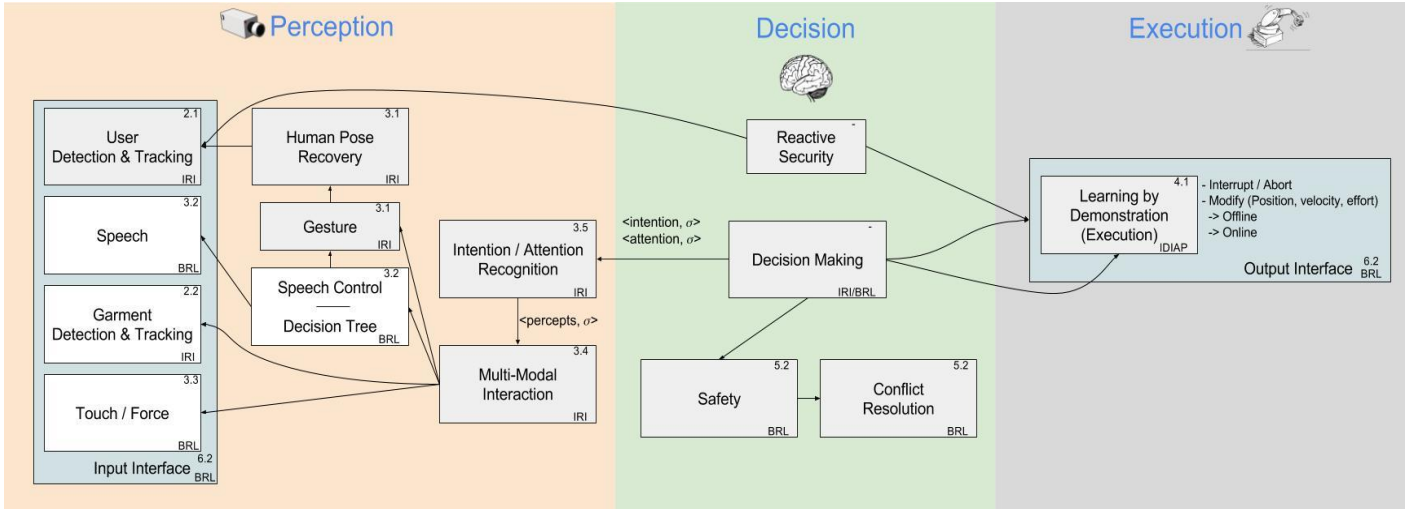
Objective 2: Multimodal Human-Robot Interaction

Objective 3: Robot Learning

Objective 4: Safety through Hazard Analysis

Objective 5: Interface Design and Human Factors

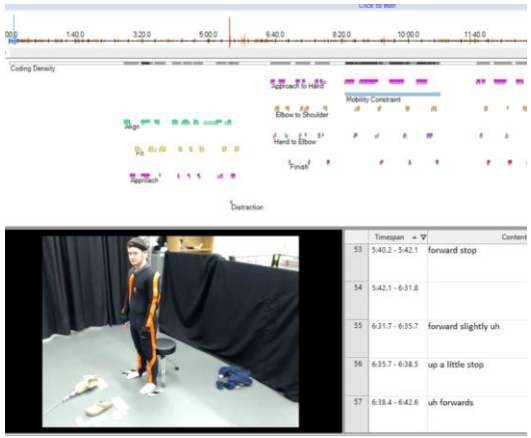
Objective 6: Implementation on a Commercial Robot and User Evaluation



Example UCD: I-DRESS Methodology

- Vocabularies (speech, gestures, etc.)
  - Task segmentation
    - Multimodal interaction framework
      - Hazard analysis
        - Learning from demonstration
          - Interface design

Human-Human Interaction Studies

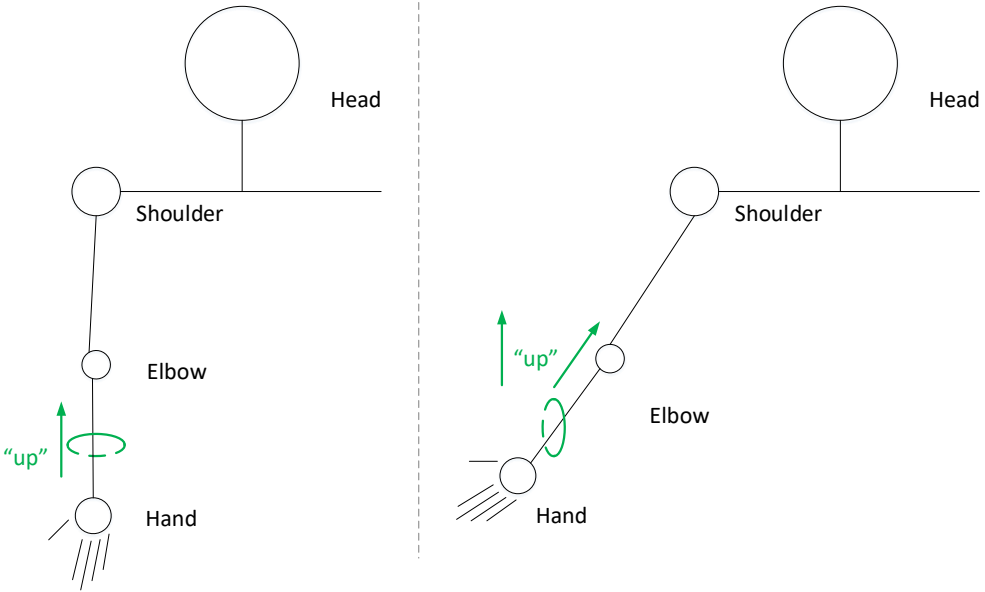


Nvivo coding showing nodes (left pane) video timeline and coding stripes (middle pane) video output, transcription area and vertical coding reference (lower panes)

Example UCD: I-DRESS Exploring the Ambiguity of Language in HRI

Chance, G., Caleb-Solly, P., Jevtić, A. and Dogramadzi, S., 2017, August. What's "up"?—Resolving interaction ambiguity through non-visual cues for a robotic dressing assistant. In *2017 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)* (pp. 284-291). IEEE.

Words spoken during assisted dressing (larger words are spoken more often).



Ambiguity in the command "up" during J2 and J3: when the arm is pointing towards the floor the command "up" is unambiguous (left) whereas if the arm is at an angle to the floor the phrase could take two meanings – up the arm or up orthogonally

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Recommended Reading

- Chance, G., Caleb-Solly, P., Jevtić, A. and Dogramadzi, S., 2017, August. What's "up"?—Resolving interaction ambiguity through non-visual cues for a robotic dressing assistant. In 2017 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN) (pp. 284-291). IEEE.
- Doering, N., Poeschl, S., Gross, H.M., Bley, A., Martin, C. and Boehme, H.J., 2015. User-centered design and evaluation of a mobile shopping robot. International Journal of Social Robotics, 7(2), pp.203-225.
- Lindblom, J. and Andreasson, R., 2016. Current challenges for UX evaluation of human-robot interaction. In Advances in ergonomics of manufacturing: Managing the enterprise of the future (pp. 267-277). Springer, Cham.
- Weiss, A., Bernhaupt, R., Lankes, M. and Tscheligi, M., 2009, April. The USUS evaluation framework for human-robot interaction. In AISB2009: proceedings of the symposium on new frontiers in human-robot interaction (Vol. 4, pp. 11-26).
- Ergonomics of human-system interaction - Part 210: Human-centred design for interactive systems (ISO 9241-210:2010)
- https://www.iso.org/obp/ui/#iso:std:iso:9241:-210:ed-1:v1:en