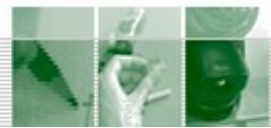


# Oops, Something Is Wrong

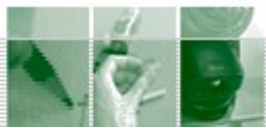
## Error Detection and Recovery for Advanced Human-Robot-Interaction

**Thorsten P. Spexard, Marc Hanheide, Shuyin Li, and Britta Wrede**

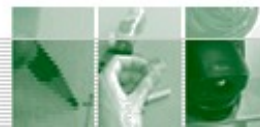
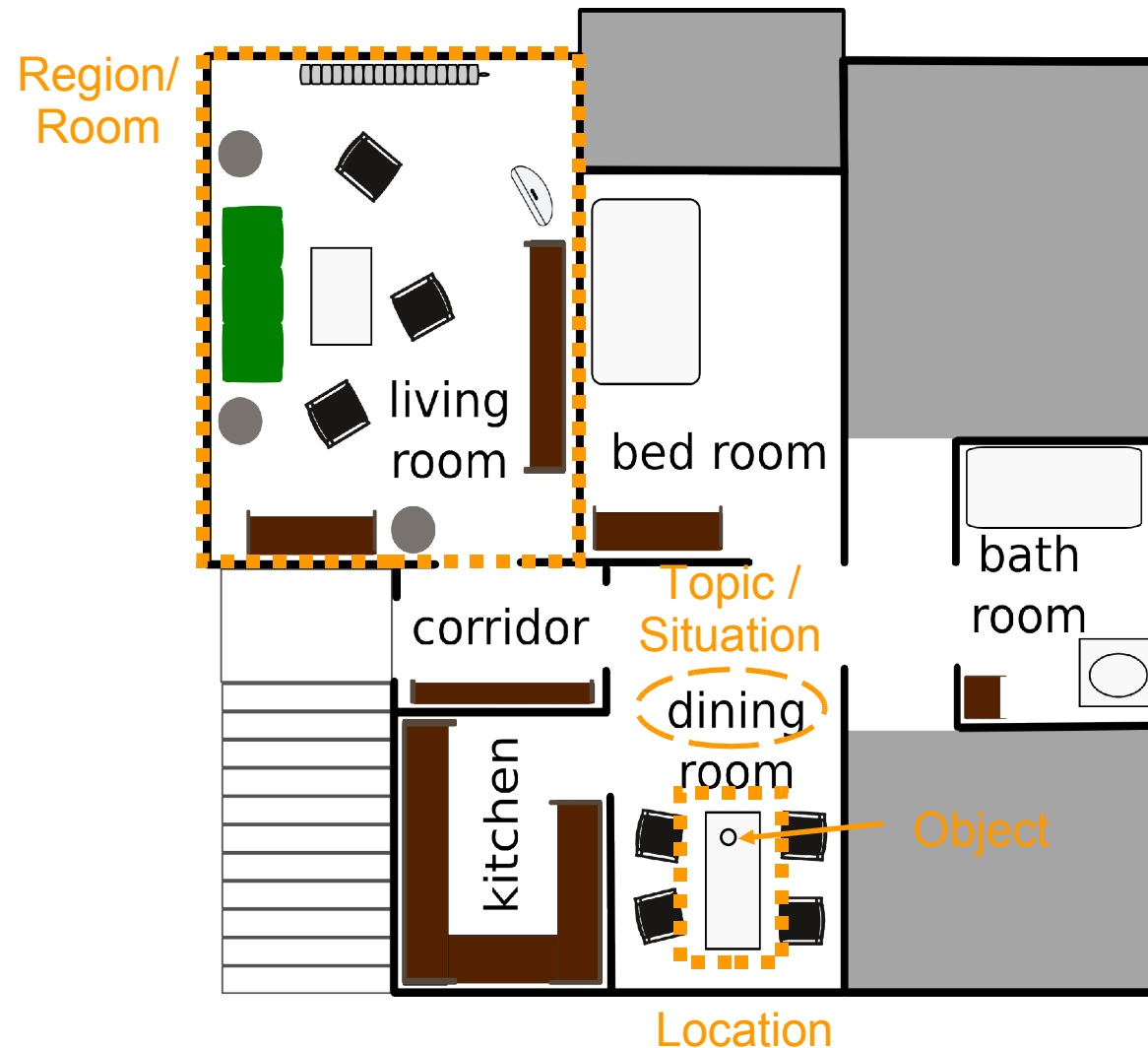
Faculty of Technology - Applied Computer Science - Bielefeld University

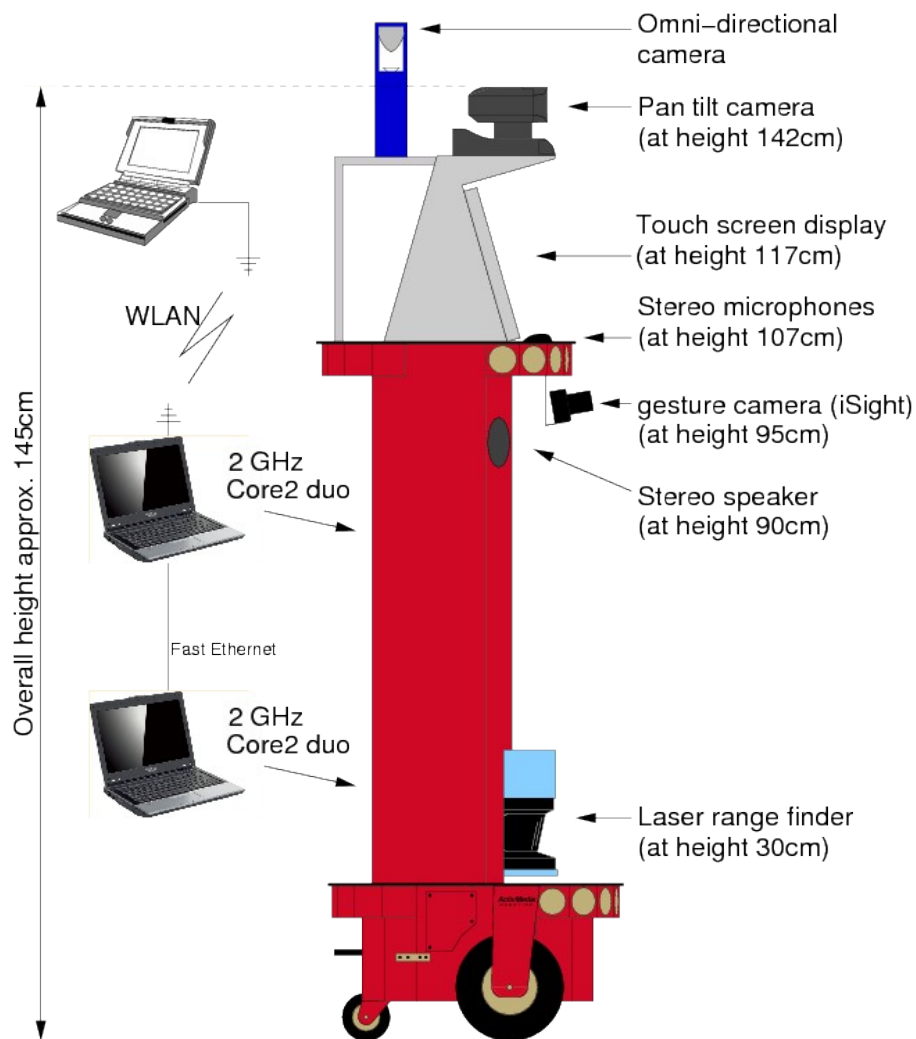


- 1) The Scenario we are interested in: The Home Tour
- 2) Why talking about problems in a workshop talk?
  - Degrade gracefully
- 3) The problem of “mode confusion”
- 4) Error detection and recovery
- 5) Evaluation

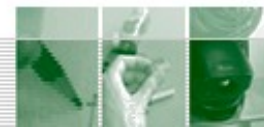


- Learning as a social task
- HomeTour
  - Joint spatial exploration
  - Learning of rooms, locations, objects in real-world environments
  - “fluent” autonomous interaction with a “naïve” human tutor

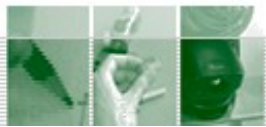




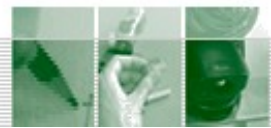
- **Functions of BIRON**
  - Track several interaction partners in parallel
  - Recognize pointing gestures
  - Localize itself and map the environment
  - Recognize conversational topics
  - Focus its attention on interaction partner and spatial positions
  - Follow a person
  - Engage in a multi-modal dialog



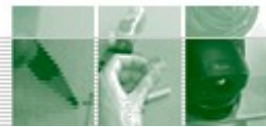
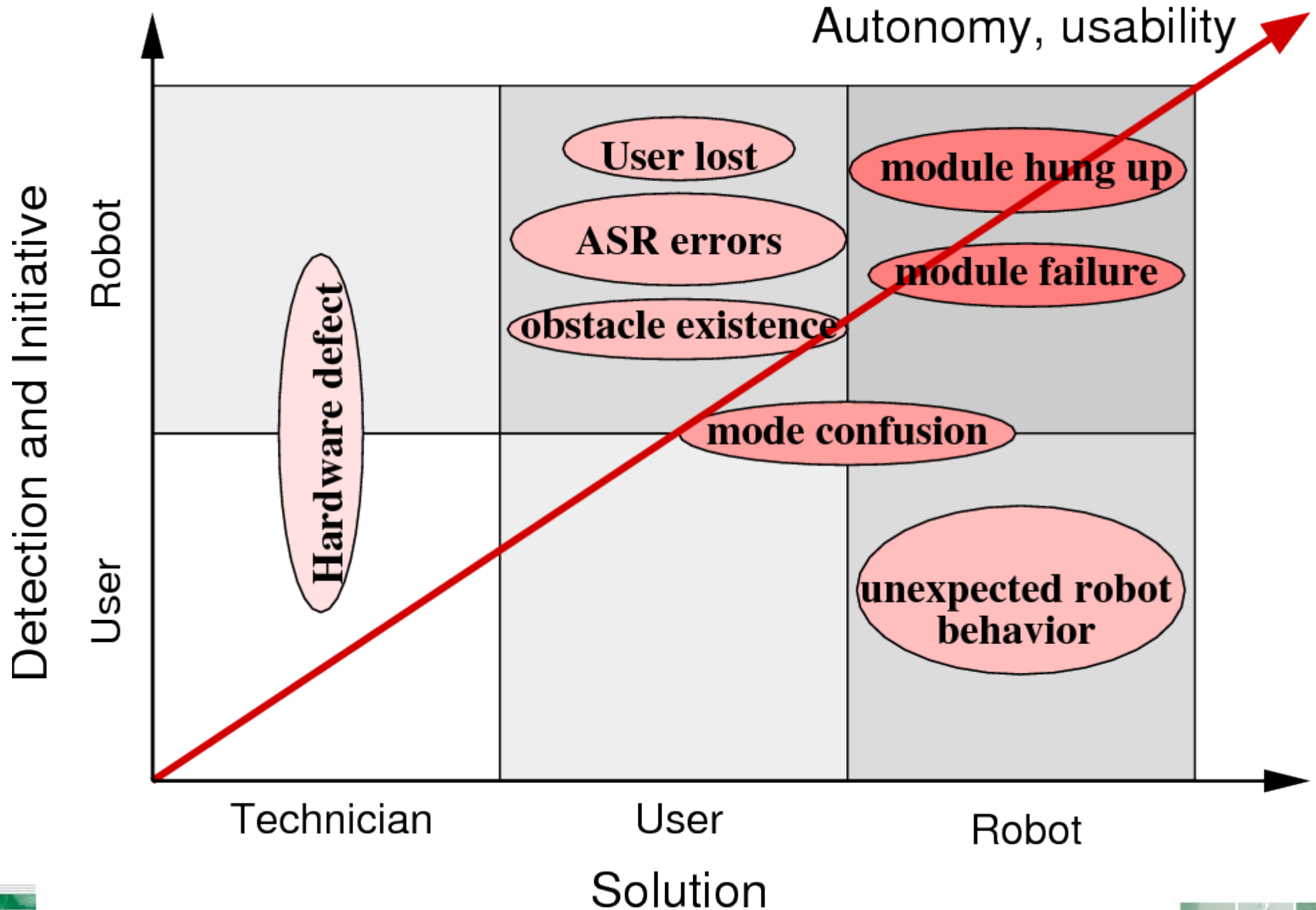
- Subject is an expert (developer)

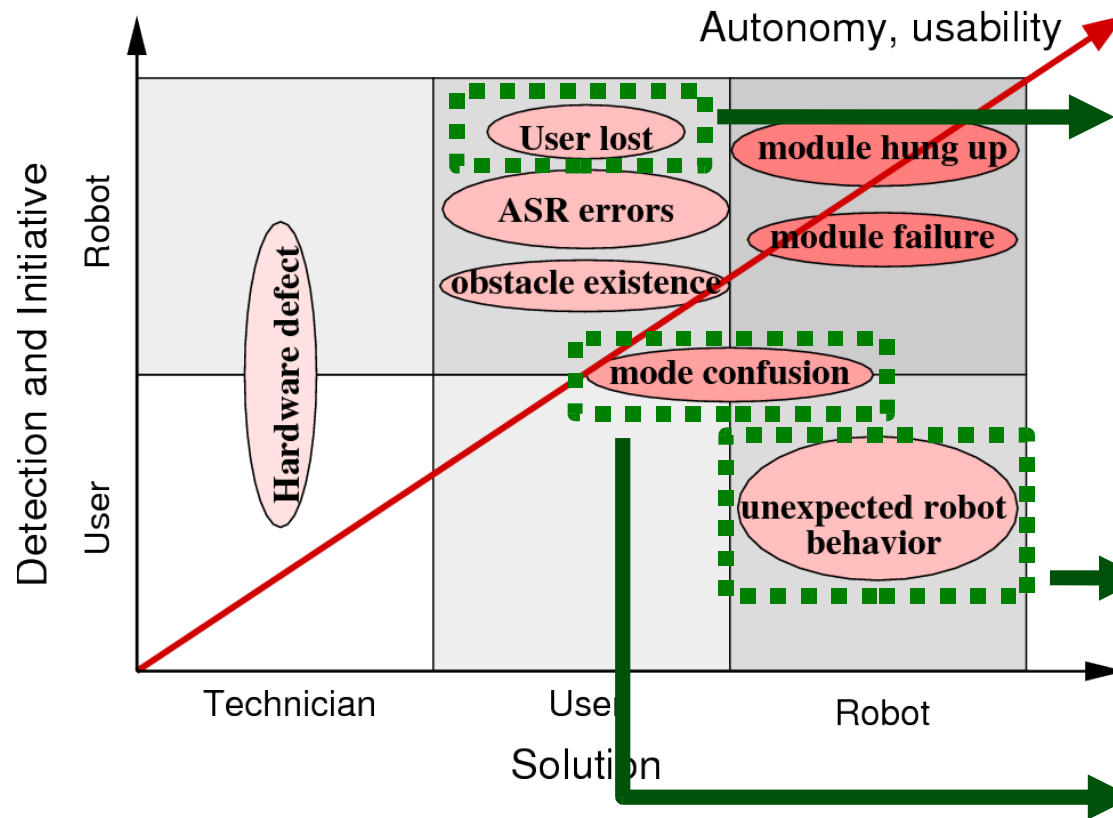


- It worked well in the video, so...
- ... why talking about “problems” and “errors”?
- We want “naïve” (non-expert) people to interact with the robot and that imposes problems/challenges.
  - Mis-understanding
  - Delays
  - Mode confusion / hidden states
  - ...
- Error treatment is critical for “autonomous” human-robot interaction in complex systems
- *Because we are not yet good in engineering social robots?!*
  - Not necessarily, interaction recovery is present in human-human interaction as well



# Who's taking initiative and solution?





## User Lost

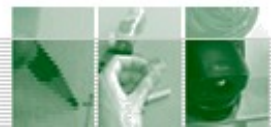
- Robot's initiative, User solution
- Detected by Person Tracking
- Presentation by Dialog

## Unexpected robot behavior

- Explicit correction by user

## Mode Confusion

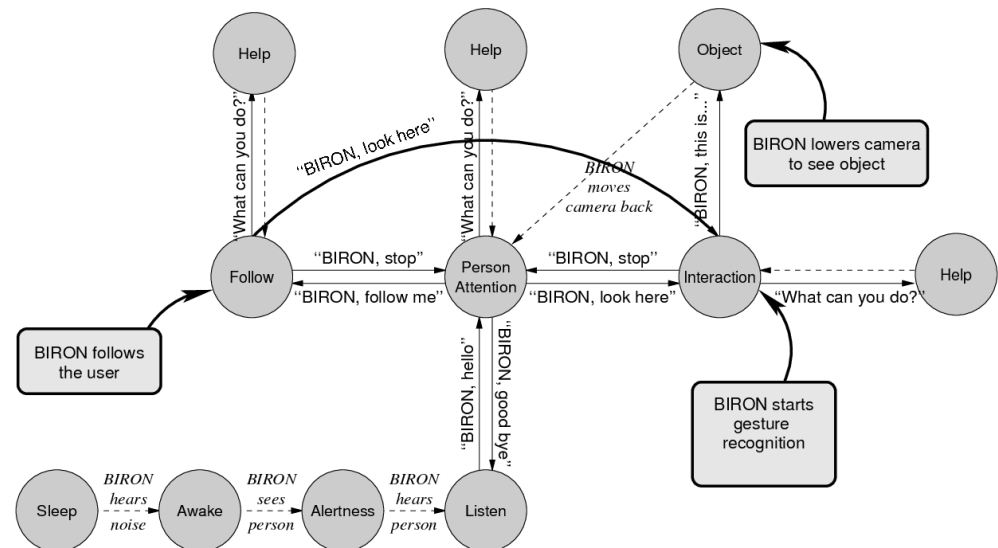
- Complex reasons
- Interlocutors have different assumptions
- A basic common ground needs to be reestablished



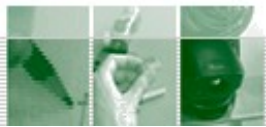
- Successful collaboration/interaction
- establish and maintain a (partial) *common ground*
  - Both interlocutors (robot and human) are mutually aware of their relevant internal states, assumptions, and expectations
  - Appropriate Feedback cues are mandatory to align
  - Grounding as the basis for the underlying dialog model [Li 2007]
- What if the common ground assumption is invalid?
  - Robot can identify “illegal” requests from its assumptions



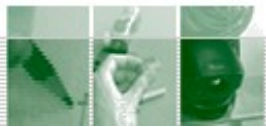
- Robot capabilities are state-dependent
  - Examples of “illegal” requests, due to
    - Hardware arbitration:  
User prompts robot to follow, but robot hardware is busy
    - Open requests:  
Robot asked for name of the room, awaiting an answer
    - Interaction state:  
Robot is not aware of interaction partner
    - Complex internal states



- Too complex interaction design
- Speech understanding errors
- User confusion
- “Wrong” user model
- Broken component (yes indeed, that might happen!)
  - Observation:  
a 98% functional reliability of each independent component leads to less than 54% reliability of the system (it actually not that bad)

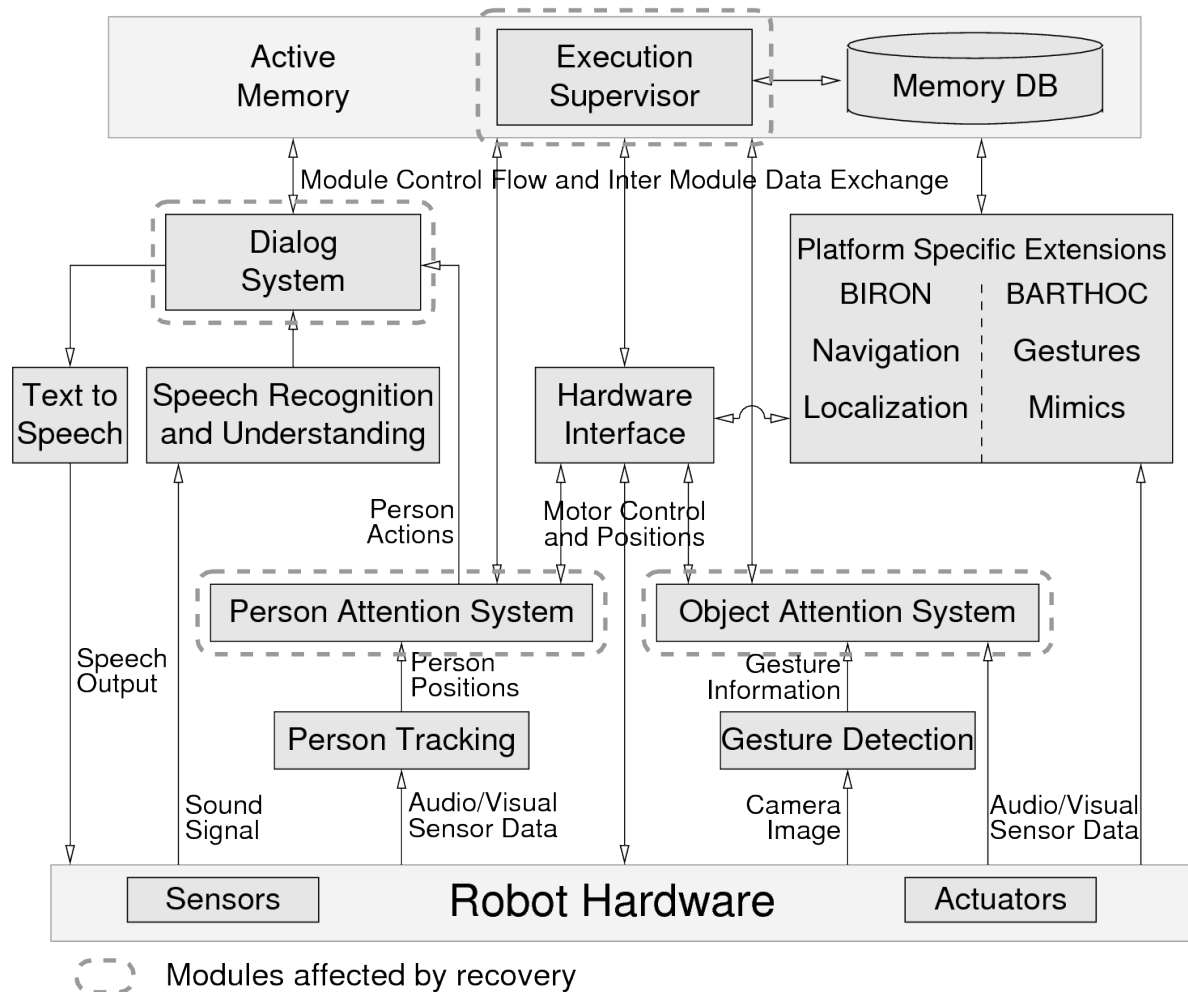


- Detection can be done by both interlocutors: Mixed Initiative
  - Human can ask for restart: “OK BIRON, let's try again”



- Robot can take initiative
- Simple Approach based on Dialog:  
Count “illegal” requests by the user.
  - An illegal task is one that cannot be carried out by the robot
- Two step procedure initiated by the robot:
  1. Robot presents help at every illegal request:
    - Possible actions the robot can carry out currently
    - Express its expectations: “Please tell me yes or no!”
  2. Robot proposes to restart the interaction turn
    - “I think we are getting nowhere, should we start again?”
    - Triggered after the continuous presentation of illegal requests (currently a sequence of 3)





- Different Modules explicitly implement the reset pattern
  - Dialog removes any open grounding relations
  - Arbitration and Execution
  - Person Attention System scanning for interaction partner
  - Memory is partially flashed

Architecture facilitates to connect to the Reset-Event

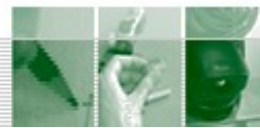


- **Goal:**  
Assess error detection and people's use cases for recovery
- **Task:**
  1. Greeting the robot (“Hello Biron”)
  2. Asking to follow (“Biron, follow me”)
  3. Introducing a room (“This is the living room”)
  4. Taking the robot back (“Follow me”)
  5. Asking about new position (“Where are you”)
- **Subjects we told, that they could “reset” the robot (6 runs)**
- **It has been a pre-study, with a non-optimized system**  
-> several use cases for recovery



Experience ↑	ID	Repeated commands	Error pattern			recovery / reset		situation-related help	Time/run
			does not behave as expected	user lost	understanding errors	robot initiative	user initiative		
	1	5		1	1			00:02:50	
	2	1	1	1	7	1	1	00:03:20	
	3	2	1	2	4	1	1	00:06:30	
	4		1	1	3		2	00:03:00	
	5	2	1	1	10		3	00:06:20	
	6	2		1	3		2	00:03:20	

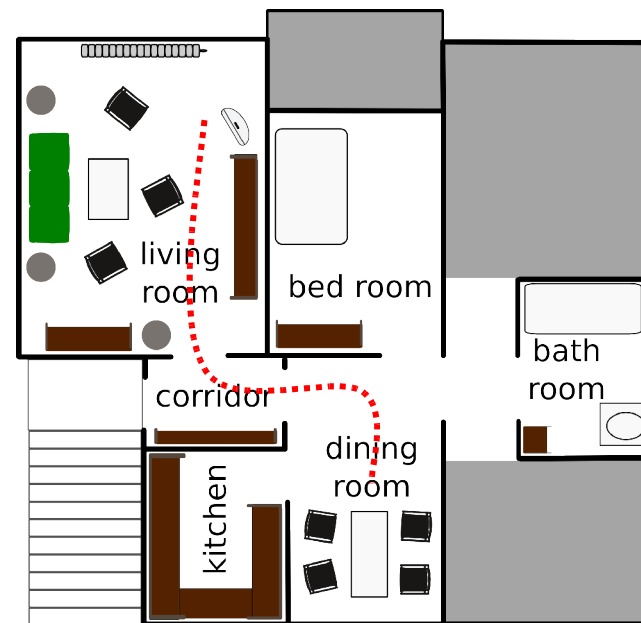
- Three subject with two trials each (1&2, 3&4, 5&6)
  - Developer
  - Seen BIRON before
  - never interacted with a robot
- Especially speech understanding errors let to robot's initiative
- Unexperienced user did one trial without any reset, but benefited from situation-related help

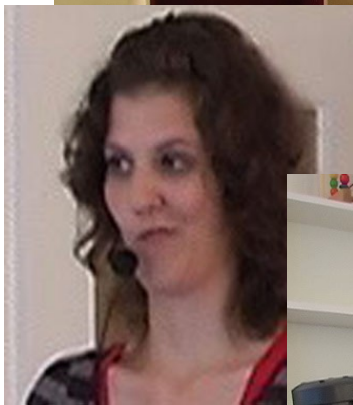
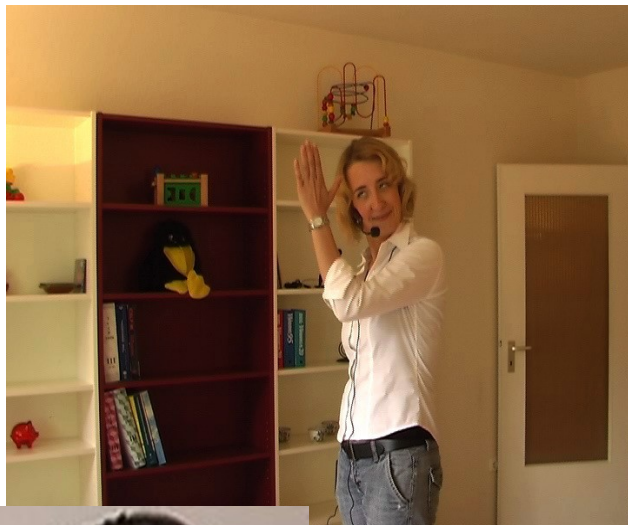


## Tasks:

1. Show the living room to the robot.
2. Show the arm chair to the robot.
3. Proceed with the robot to the dining room.
4. Show the dining room to the robot.
5. Show the table to the robot.

- More complex task (naïve users)
- Subjects were informed about reset possibility
- 10 naïve subjects (out of 24) (no computer scientists)





ID	user reset	repeated commands	unexpected behavior	robot assist.	time / run
1	2	1	1	1	09:03
2	2		2	2	aborted
3	3	1	2	2	10:40
4				2	05:34
5	1		1	2	12:21
6				1	06:47
7	1		1	1	09:16
8	1	1		1	06:54
9	2		2	1	08:33
10				2	7:41
∅	1.2	0.3	0.9	1.5	8:32

- Counting admittedly subjective



- If we cannot well enough engineer social robots we need bootstraps to pull ourselves up by interaction
- Certain errors can be detected...
  - ...by analyzing the dialog history for repetitions and illegal requests
  - ... other on a component level
- A general reset pattern is a concept familiar to subjects...
  - ... and can generally be implemented on an architectural level
- Initiative taken by the robot requires “error-awareness”
- For research system on naïve users interaction, recovery is essential

