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### Industrial HRI Experiments in the SMErobotics project

IROS Workshop: Towards Standardized Experiments in Human-Robot Interactions

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### Overview

- The SMErobotics project
- The need for HRI Experiments
- Discussion points & General thoughts
  - Questionnaires
  - Experiments
  - Results
- Three exemplary experiments in SMErobotics



# **SMErobotics**

### The project in a nutshell

- 25 Research Institutes and Industry Partners from Europe
- Goal: SME-suitable robots
  - Intuitive & efficient programming
  - Symbiotic HRI
  - Semantic Integration
- Demonstrators:
  - Dual Arm Assembly
  - Woodworking
  - Welding
  - Assembly with compliant robot arms
- www.smerobotics.org





# The need for HRI Experiments

### Why and how?

- Evaluate how users interact with the system
- Improve the workflow and efficiency of interaction
- Compare different paradigms
  - Interaction methods
  - Performance
  - Competitors
- Confirm or contradict hypotheses
- Get feedback from domain experts
- Collect data and benchmark algorithms
  - E.g. dataset in service robotics: Cornell CAD-60 & 120 (human activity dataset)



# Questionnaires

Asking for relevant information

- Standardized modular Questionnaires
- Modules for different use cases / domains
- Personal information (e.g. age, gender)
- Expertise in Robotics and Computer Science
- Expectation & Opinion





# Experiments

### How is the experiment done

- Hypothesis statement
- Multimodal experiments
- Direct robot interaction
- Methods
  - Latin Square
  - SUXES
- Wizard-of-Oz vs. Real System
- Open Discussion
- Video recording



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# Image Source: easyasone.wordpress.com

# Results

How to evaluate the data

- Evaluation methods
  - Quantitative
  - Qualitative
- Metrics to compare results
  - p-Value
  - Ranking
  - SUS
- Diagrams to visualize data
- Publish datasets
  - Make results comparable!





# SMErobotics Experiment I

### Modality Preferences in Industrial HRI

- Find preferred input modality for intuitive industrial robot programming
- User Study with 30 participants
- Wizard-of-Oz experiment based on SUXES method
- Modalities: Touch, Gesture, 3D pen input, Speech
- Domains: Pick & Place, Assembly, Welding
- Metrics: p-Value (paired/unpaired t-Test, Kruskal Wallis + Dunn's Test)
- Result:
  - 1. Gesture input (p<0.0001)
  - 2. Touch & 3D Pen input on second place (no significant difference, p=0.64)
  - 3. Speech (p<0.0001)

Stefan Profanter, Alexander Perzylo, Nikhil Somani, Markus Rickert, and Alois Knoll. Analysis and semantic modeling of modality preferences in industrial human-robot interaction. In Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Hamburg, Germany, September 2015.



# SMErobotics Experiment II

Multimodal Activity Recognition in Ind. Manufacturing

- Recognize and classify human activities in industrial scenarios
- Collect data: 98 recordings of 6 different people
- Uses generative classifier and Hierarchical Hidden Markov Model
- Multiple Levels (assemble to basic hand gestures)
- Recognition accuracy: 81% 98%
- → Teaching by Demonstration & Supervision of human worker

Alina Roitberg, Nikhil Somani, Alexander Perzylo, Markus Rickert, and Alois Knoll. Multimodal human activity recognition for industrial manufacturing processes in robotic workcells. In ACM International Conference on Multimodal Interaction (ICMI), Seattle, USA, November 2015.



# See: https://youtu.be/ggb6nUOEcjE

Two fingers: thump down Drawing the trajectory Selecting trajectory for welding Selecting trajectory for welding

Alina Roitberg, Nikhil Somani, Alexander Perzylo, Markus Rickert, and Alois Knoll. Multimodal human activity recognition for industrial manufacturing processes in robotic workcells. In ACM International Conference on Multimodal Interaction (ICMI), Seattle, USA, November 2015.

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# SMErobotics Experiment III

### Different Paradigm for Industrial Robot Programming

- Comparison of traditional Teach-Pad programming with Intuitive User
  Interface
- Preliminary user study with 1 participant
- Gearbox assembly task:
  - Teach-Pad: 48 minutes
  - Intuitive Interface: 8 minutes
- 83% faster

Alexander Perzylo, Nikhil Somani, Stefan Profanter, Markus Rickert, and Alois Knoll. Toward efficient robot teachin and semantic process descriptions for small lot sizes. In Proceedings of Robotics: Science and Systems (RSS), Workshop on Combining AI Reasoning and Cognitive Science with Robotics, Rome, Italy, July 2015.



# See: https://youtu.be/B1Qu8Mt3WtQ



Alexander Perzylo, Nikhil Somani, Stefan Profanter, Markus Rickert, and Alois Knoll. Toward efficient robot teachin and semantic process descriptions for small lot sizes. In Proceedings of Robotics: Science and Systems (RSS), Workshop on Combining Al Reasoning and Cognitive Science with Robotics, Rome, Italy, July 2015.



### Conclusion

- Experiments in different domains have different requirements
- Questionnaires and/or practical experiment
- Need for standardized methods to better compare results
- Results and datasets should be published
- More details on SMErobotics experiment I: Analysis and Semantic Modeling of Modality Preferences in Industrial Human-Robot Interaction Wednesday, 30.09., 08:30-08:45, Saal D



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