Towards shared autonomy for robotic tasks in manufacturing

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Profactor GmbH

- Established in 1995
- Austria's No. 1 in **applied production research**
- 74 employees
- Research for Industry
Contents

Motivation

The XROB System

Human Robot Interaction
  – Cooperation
  – Collaboration

Future Work
Introduction

Aging workforce in Europe
Consequential skill drain

Solution:
Cooperation between Human(s) and Machine(s)

• **Goal:** Increase the effectiveness and efficiency

• **Requirement:** Safe and natural workflow

The Silver Economy

Smart assembly line robots

(Image Sources: Eurostat; Yaskawa Motomon Robotics)
Forms of Human Robot Interaction

Forms of Human Robot Interactions in an Assembly Process

- **Coexistence**
  - Close proximity
  - Human and robots perform individual tasks

- **Assistance**
  - Provide Physical Support
  - Passively guided robot assistance

- **Cooperation**
  - Synchronized action
  - Human and Robot working on the same work piece

- **Collaboration**
  - Coordinated action
  - Human and Robot working on the same task

**Safety Requirements**

Process Speed

Shen Yi, München, 2015
Thiemermann (PhD Thesis), Heimsheim, 2005
Batch Size 1 - Requirements

Paradigm shift from mass production to mass customization
Handle a variety of different tasks, and be able to be reprogrammed fast by non-robot expert
The aim of reducing the amount of programming required by an non-expert using natural modes of communication is still an open topic

M. R. Pedersen et. al, 2016
Skill Based Learning

Skills instantiate action
Form the building blocks of the task
Intuitive object-centered robot abilities, which can easily be parameterized by a non-expert

• Focus on knowledge sharing between robots with similar capabilities
• Action – perception loop
XROB System

Cognitive Reasoning System

Perception System

Planning and Execution System

Application Development

Knowledge Management

Object Recognition

Environment Reconstruction

Object Tracking

Interactive Programming

Simulation

Robot Interfaces

Visualization

ReconstructMe, Profactor GmbH

OMPL 2010

RRT-Connect (ICRA 2000)

ReconstructMe, et al, (ICRA 2017)

ReconstructMe, et al, (CGVIS 2015)

Akkaladevi et. al, (ECAI, 2016)

Akkaladevi et. al, (IHCI 2016)

Akkaladevi et. al, (HRI 2017)
The XROB System - Video
XROB GUI - Video
XROB System – Skill Based Learning

- Set of skills form a **task**
- Tasks combines to form a **recipe** (for the process)
- In built services for sensor and actuators
- Parametrization online
  - Position
  - Scan
  - Reference
  - Evaluation
Applications

- Human Robot Cooperation
  - Hand-guided
  - Tangible Interfaces
- Human Robot Collaboration
  - Interactive learning
Human Robot Cooperation
Human Robot Cooperation

Human robot cooperation – where both agents simultaneously work on the same work piece

The AssistMe Project

https://www.profactor.at/.../projects/assistme/
Human Robot Cooperation – Video (1)
Human Robot Cooperation – Video (2)
Comparison of two robotic systems

<table>
<thead>
<tr>
<th>&quot;Title: Screwing&quot;</th>
<th>Robot A</th>
<th>Robot B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Evaluation Nb.1</td>
<td>Evaluation Nb.2</td>
</tr>
<tr>
<td></td>
<td>Basic System</td>
<td>Improved System</td>
</tr>
<tr>
<td></td>
<td>01/2016</td>
<td>10/2016</td>
</tr>
<tr>
<td>Robot Interaction (HRI)</td>
<td>Wired Teach Pendant(UR10)</td>
<td>Wireless Tablet</td>
</tr>
<tr>
<td></td>
<td>Direct-manual physical guidance (UR10)</td>
<td>Improved physical guidance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>via external FT-Sensor (Space Navigator)</td>
</tr>
<tr>
<td>Computer Vision</td>
<td>Not available (blind)</td>
<td>3D-sensor (Asus Xtion, RGBD)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2D-sensor (Allied Vision)</td>
</tr>
<tr>
<td>Graphical-UI</td>
<td>UR PolyScope</td>
<td>XRob-GUI (robot motion, sensor data, sw-templates)</td>
</tr>
</tbody>
</table>

Duration (in minutes) of parametrization for different robotic systems

![Bar chart comparison between Robot A and Robot B](chart.png)
Tangible Interfaces - Video
Human Robot Collaboration

Human Robot Collaboration is where both agents perform coordinated actions on the same task

Project KoMoProd
- Creating a “common understanding” of the task
- Generation of recipes online

[Diagram of XRob}

https://www.profactor.at/.../projects/komoprod/
Human Robot Collaboration - Video

Welcome to the KoMoProd Demonstrator
Interactive Learning
Contributions

Easy intuitive programming for non-experts
Programming by demonstration features with help of GUI
• Tangible interfaces
• Interactive learning
Applicability to Human robot interactive assembly tasks with varying complexity
Future work

MMAassist II - Assistive Systems for production in Human machine cooperation context (FFG, 858623), started on 01.05.2017 (3 Year Project) with 25 partners (10 Scientific partners, 15 Industrial partners)

Homepage: www.mmassist.at
Thank you

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This work is funded by the projects KoMoProd (Austrian Ministry for Transport, Innovation and Technology), AssistMe (FFG, 848653), CompleteMe (FFG, 849441) and MMAssistII (FFG, 858623)
Appendix
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**Process Speed**

**Safety Requirements**

Shen, Yi: System für die Mensch-Roboter-Koexistenz in der Fließmontage (Forschungsberichte / IWB 305), München, 2015.
XROB System Contd...

Easy-to-use features that significantly speed up commissioning and make the operation more cost-efficient and flexible than common programming methods.

The special software architecture allows easy and intuitive creation of processes and configuration of the components of a robot system via a single user interface.
XROB

XROB platform for building human robot interactions in an intuitive way

Enables applications requiring customized patterns of human robot interactions

A flexible quality inspection system with intuitive configuration capabilities