Shared Autonomy to Enable Seamless Integration of Human Robot Workplaces

Supported by:

Interreg
Danube Transnational Programme
Smart Factory Hub

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Topics to be addressed

- From EU funded research to Industrial Application
- Robotic Co-worker Technologies development for industrial applications
- Workflow-based robot process design and execution
- Onboard process planning and configuration tools
- **Symbiotic** human-robot collaboration for multimodal Human Robot Interaction
- SmartFactory HUB – an Interreg project related to I4.0
PROFACTOR Profil

- Austria’s no. 1 in **applied production research**
- Multidisciplinary team with **74 employees**
- Business locations in **Steyr** and **Vienna**
- **6 Mio. EUR turn-over** (2015)
- Since 1995 **over 1,700 (inter-)national projects in industry (1,360) und research (350)**
Increasing the competitiveness!

Aim: to support human beings in a volatile, richly varied and highly flexible production

- Decision-making competence, knowledge and experience of workers
- Precision, endurance, speed or the power of the machine

Intelligent Automatization for Mass Customization.
Ergonomic Collaboration Human & Machine (LOCOBOT)

- **Initial situation**
  - Reduction of “red” work places

- **Research approach**
  - Solutions for practical division of work between human and machine, which is realizable with adequate use of resources

- **Results**
  - Improvement of ergonomics through development of assistant systems
  - Modular design of *intelligent hard- and software components* (e.g. compliant robot arm)
  - Software environment for *user-friendly development of solutions and coordination of component interaction*
Locobot’s application development

Modeling application logic
• user-friendly workflow modeling environment (WME)

Supervisory control is generated
• ‘workflow execution control‘ (WEC)

= using skills like puzzle pieces for the application logic
Results – EuroNews Report
Robot Assistance - Idea

„A robot for every work shop“

Fast Setup

Versatile

Easy to use

Small lotsizes

Ad-hoc usage

Fast programming
Challenges for flexible robotic systems

- Reduction of Invest
- Cover a wide area of use
- Shortest ramp up periods for on-demand applications
- Lower training, operating- and maintenance costs
A robot for each working place (each garage) - features

- Movable, modulare Systems
- Short Ramp up (few hours)
- Modification in a few minutes
- Process execution also by Non Experts using only one Interface (HMI)
- Communication / Data Input using an intuitive HMI System with automatic functions
- Adaptive process execution
Solution – Software/Hardware construction kit

- Sensors & Tools
- Robots (UR, KUKA, nn)
- Control system (IPC, PC) + Software
XRob – Features

- Workflow – based, intuitive und integrated **process mapping** and execution in **only one user Interface**

- **Consolidation of existing Input tools of the sub components** (Robot, Vision, Tool, usw…)

- **Intelligent, semi automatic tools** for process planning

- **Use of standardized IT Interfaces** (TCP/IP, DIO, ProfiNet,…) – fast integration to the Environment
XRob – Software Tool Kit

Workflow Manager

Robot Control

Tooling Control

Safety Control

Interfaces

2D/3D-position detection

Process Simulation

Automatic path planning

3D-Workspace scanning

HMI-System

Cognitive Funktion

Online - Tacking

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XRob – Technologies

Tool kit for quick setup and safe operation

- 3D scanning of the workspace
- Semi automatic creating of a collision model
- Inline - 2D/3D position detection
- Collision avoidance through automatic path planning
XRob – Technologies

Tool kit for quick setup and safe operation

- Configuration all involved components via a user interface
- Workflow-based process
- Process status and progress mapping
The Software system X Rob allows the creation of complex robot application within a few minutes
Screwing Assistant

▲ Screwing of covers and mouting parts on mobile workpiece holder in the assembly line

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R&D Project AssitMe  BMW Steyr  2015

© Profactor GmbH

Pilotsytem  Flexible Screwing Station  BRP  Rotax 2016
Screwing Assistant

Screwing of accessories / Covers
XRob – Application

Inspection Assistant – Flexible Quality Gate

- 3D-Inspection of the locking conditions of plugs and oil cover plates (since autumn 2013)
XRob – Applications

Inspection Assistant

- 3D Inspection of Plugs and Oil cap on the engine
- Acustic Testing System for vehicel body parts

© Profactor GmbH

Pilotproject Flexible Quality Gate BMW Steyr 2013

Flexible Acoustic Inspection Systems 2015

© Profactor GmbH
Assembly Assistent

3rd Hand Support
Handling Assistant

➔ Pin Picking (since 2009)

New: Selective Handling (AR-based)
XRob – Application

Paint Assistant

➔ Painting of 3D-Objects

A result from the Austrian Lighthous project addmanu
www.addmanu.at

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Printing on 3D Surfaces
Research projects

áz Cognitive interaction - robot knows user requirements

Welcome to the KoMoProd Demonstrator
Symbiotic human-robot collaboration for safe and dynamic multimodal manufacturing systems (SYMBIOTIC)

Early results and outlook for human robot symbiosis
The project’s final goal is to test and quantify the aforementioned four objectives in terms of:

- Safety
- Feasibility
- Intuitiveness
- Adaptability
- Scalability

Three demonstrators:
- Food-processing (Robomotion)
- Aeronautics (Aciturri)
- Automotive (Volvo Cars)
Project Objectives

Active collision avoidance for safe human robot collaboration in real time.

Adaptive task plan generation for robots and human workers allowing collaboration.

Dynamic adaptation to changes in the shop-floor environment with zero programming for the robot users.

Instructions generation for supporting human workers on what and how to do.
Smart Factory Hub overview
Presented by:
Christian Wögerer, Profactor

Project: Improving RD and business policy conditions for transnational cooperation in the manufacturing industry

Acronym: SMART FACTORY HUB

Budapest, 20.09.2017
Topics addressed

1. Why factories? Why manufacturing sector?
2. Global trends
3. What is Smart Factory?
4. Identified challenges
5. About Smart Factory Hub project


www.interreg-danube.eu/Smart-Factory-Hub
① Why factories?  
Why manufacturing sector?

MANUFACTURING INDUSTRY

- main generator of RD, innovation, growth and employment;
- in all regions contributes the highest share to the total regional value added;
- in average more than a 25% of service activities are directly linked to the industry,
- every 100 busiest jobs created in the industry create 60 to 200 new jobs in other industries.
- 80% of all private R&D investments is accounted for by industry.

INCREASING PRESSURE ON MANUFACTURERS to be more efficient and innovative in their processes.

The cause of this pressure:
1) increased production capacity in low-cost economies and
2) increased innovation and level of sophistication of supply chains in high-cost economies.

- Micro and small companies are facing problems with QUALITY STANDARDS (ISO 9001, TS, etc)
- LOW PRODUCTION EFFICIENCY (production failures, etc)
- Ineffective production process,
- Problems with HUMAN RESOURCE management
② **Global trends**

In 3 years, the capacity and data transfer speed will be doubled.
In Germany, Industry 4.0 will generate significant productivity gains.
Global trends

In Germany, Industry 4.0 will lead to increased manufacturing employment.

Return of production capacities back to Germany

A significant shift in the skill profile is required to enable growth.

Sources: Federal Statistical Office of Germany; BCG analysis.
Our focus is oriented into SMEs!!!

1) **NOVEL TECHNOLOGIES** (improving efficiency, effectiveness, quality, flexibility, etc)

2) **EFFECTIVE PRODUCTION PROCESS** (applying industry standards, Lean manufacturing academy, etc)

3) **EFFECTIVE HUMAN RESOURCE MANAGEMENT** (effective system to motivate employees, monitoring employee performance, etc)
What is Smart Factory / Smart manufacturing?

Smart Manufacturing describes the vision of what industrial production will look like in the years to come. It is a strategy which promotes digitalization and computerization of production with the strong customization of products under the conditions of highly flexible (mass-) production.

It’s about connecting data, machines, people and processes!
What is Smart Factory / Smart manufacturing?

Smart Manufacturing objectives (% of manufacturers), EU Analysis

<table>
<thead>
<tr>
<th>Objective</th>
<th>% of Manufacturers</th>
</tr>
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<tbody>
<tr>
<td>Improve product quality</td>
<td>57.9%</td>
</tr>
<tr>
<td>Increase speed of operations</td>
<td>57.3%</td>
</tr>
<tr>
<td>Decrease manufacturing costs</td>
<td>57.9%</td>
</tr>
<tr>
<td>Improve maintenance/uptime</td>
<td>46.3%</td>
</tr>
<tr>
<td>Improve information for business analytics</td>
<td>41.6%</td>
</tr>
<tr>
<td>Improve agility and responsiveness</td>
<td>41.9%</td>
</tr>
<tr>
<td>Improve Information for production decisions</td>
<td>40.7%</td>
</tr>
<tr>
<td>Improve coordination with customers</td>
<td>39.5%</td>
</tr>
<tr>
<td>Improve coordination with suppliers</td>
<td>34.9%</td>
</tr>
<tr>
<td>Develop remote monitoring capabilities</td>
<td>33.7%</td>
</tr>
<tr>
<td>Lower energy costs</td>
<td>29.1%</td>
</tr>
<tr>
<td>Improve safety</td>
<td>27.9%</td>
</tr>
<tr>
<td>Improve compliance (customer specifications or regulatory)</td>
<td>24.7%</td>
</tr>
<tr>
<td>Develop visualization capabilities</td>
<td>18.9%</td>
</tr>
<tr>
<td>Other</td>
<td>1.2%</td>
</tr>
<tr>
<td>None of the above</td>
<td>5.5%</td>
</tr>
</tbody>
</table>

Source: https://www.linkedin.com/pulse/industry-40-4th-planetary-industrial-revolution-fernando


Smart Factory

Internet of data
Smart Buildings
Smart Grid
Internet of things
Smart Mobility
Smart Homes
Internet of services
Smart Logistics
Business Web
Social Web

Value drivers
- Service/after sales
- Resource/process
- Asset utilization
- Quality
- Inventories
- Labor
- Human-robot collaboration
- Remote monitoring and control
- Predictive maintenance
- Augmented reality for MRO
- Machine flexibility
- Routing flexibility
- Real-time yield optimization
- Intelligent lots
- Smart energy consumption
- Virtual/self-service
- Predictive maintenance
- Rapid experimentation and simulation
- Concurrent engineering
- Customer cocreation/open innovation
- Data-driven design to value
- Data-driven demand prediction
- Digital quality management
- Advanced process control
- Statistical process control
- Real-time supply-chain optimization
- In-situ 3D printing
- Automation of knowledge work
- Digital performance management
- Remote collaboration
- Batch size
- Supply/demand match
- Time to market
- Asset utilization
- Quality
- Inventories
- Labor
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Project co-funded by European Union funds (ERDF, IPA)
What is Smart Factory / Smart manufacturing?

15 areas of relevance

1. Smart Supply network
   Transparency over supplier inventories and vehicle logistics allows for automatic and optimized supply decisions

2. Next-gen manufacturing systems
   Manufacturing systems make automated and smart decisions (e.g., production scheduling), offer intelligent machine applications, seamless engineering integration and allow for remote visualization, monitoring, control, and alerts

3. Cloud storage / processing
   Data storage and application processing on secure cloud servers

4. Data analytics
   Advanced decision algorithms & real-time analytics

5. Cybersecurity
   Encrypted data and protection mechanisms against cyber threats

6. Intellig. sensors/actors
   Sensors deeply integrated in machines wirelessly stream data and have an own analytics engine (edge analytics)

7. Cyber physical systems
   Interconnected systems and social machines control physical entities

8. Smart maintenance
   Machine maintenance becomes integrated autonomous, aided by predictive algorithms and remote assistance systems

9. Mobile workforce
   Workers are equipped with mobile devices and augmented reality devices to process real-time information

10. Self-driving vehicles
    Material is handled via autonomous vehicles and intelligent transportation units

11. Intelligent products
    Products carry relevant information for machines to make decisions

12. Additive manufacturing
    3D printing allows for rapid prototyping and rapid spare part printing

13. Robotics
    Use of flexible robots augments intelligence, automates certain processes and creates new forms of worker-robot interaction

14. Advanced materials
    New materials such as nanomaterials as well as integrated computational materials engineering (ICME)

15. Responsive manufacturing
    Individual manufacturing steps are designed for customer interaction so that products can be tailor-made for customers

Source: https://iot-analytics.com/industrial-internet-disrupt-smart-factory/
Identified challenges

- Policy makers translating strategies into concrete measures
- Smart Manufacturing is complex (vertical – horizontal)
- Production SMEs have concrete problems:
  - Need to develop due to competition
  - Faced with micro problems in their existing productions
  - Lack of knowledge and resources to move forward
About Smart Factory Hub project (Transfer Lab)
About Smart Factory Hub project (Policy Lab)

SMART FACTORY PROJECT TOPICS:
1. NOVEL TECHNOLOGIES
2. EFFECTIVE PRODUCTION PROCESS
3. EFFECTIVE HUMAN RESOURCES

POLITICAL COMMITMENT 
OPEN GOVERNMENT 
ARTICULATION OF 
TECHNOLOGICAL 
CAPITAL 
DEVETELPMENT OF 
INNOVATION MODELS

REGIONAL SCHEMES (GRANTS)
- CLUSTERS
- R&D DEPARTMENTS
- INNOVATION CENTERS

Policy measures
Policy makers

SMART FACTORY HUB

Policy measures
Policy makers

MAPPING TOOL

Transnational mobility actions

www.interreg-danube.eu/Smart-Factory-Hub

Project co-funded by European Union funds (ERDF, IPA)
About Smart Factory Hub project (Methodology)
Partners and geographical area
Thank You!

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