Flexible manipulation using dual arm robots

THOMAS EU Project

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Motivation

- Currently there are about 2.3 million industrial manufacturing SMEs in the EU (99% of all companies)
- Small scale production exhibits “one of a kind” product variability requiring production structure & process / equipment flexibility
- Strategies for reducing cell’s maintenance and auxiliary systems cost & effort required will promote production automation
- Complex manual tasks cannot be fully automated with a good ration of cost vs robustness
- At least 85% of the production tasks in major industries are automatable through robotic applications

The vision is:

“to create a dynamically reconfigurable shopfloor with mobile dual arm robots, able to perceive their environment and cooperate with other robots and humans”
Objectives

- **O1. Enabling mobility on products and resources** by means of mobile resources able to navigate in the shop floor while utilizing dexterous tooling.

- **O2. Enabling perception of the task and the environment** using a) the individual resource’s sensors and b) collaborative perception by combining sensors of multiple resources and shop floor sensors.

- **O3. Dynamic balancing of workload and redirecting to stations** allowing the resources to communicate automatically adjust their behaviour.

- **O4. Fast programming and automatic execution of multiple tasks.** By applying skills over the perceived environment and by automatically generating the robot program.

- **O5. Safe collaboration between humans and robots** eliminating physical barriers (fences, etc.) by introducing cognitive capabilities allowing the robots to detect the human and its intentions.
Concept

"Enabling mobility on products and resources"

Human-Robot and Robot-Robot collaboration in a safe way"

Perception & skills to automatically program and execute multiple tasks"

"Dynamic balancing and redirecting to stations"
Environment & Process Perception

✓ 3D vision enabled process perception for manipulation

✓ Process context awareness perception

✓ In cell & Cell to Cell navigation

✓ Multi sensors based enhance safe navigation
Environment & Process Perception

✓ **3D vision** enabled **process perception for manipulation**

✓ Process **context awareness** perception

✓ In cell & Cell to Cell navigation

✓ Multi sensors based **enhance safe navigation**

**Autonomous Object detection & Motion generation**
Automated programming & execution

✓ CAD based **autonomous program generation**

✓ Collision free **grasp, path & motion planning**

✓ Offline **robot skills composition**

✓ Online **skills refinement** based on sensor input
H-R and R-R Collaboration & Safety

✓ **Hybrid Safety**: fusing 2D – 3D sensor data

✓ **Direct H-R interaction**: (voice, gestures, wearables)

✓ **In – direct H-R interaction**: (human intention detection)

✓ Manipulator **End of Arm Safety**

✓ Human – Robot **workspace supervision**
H-R and R-R Collaboration & Safety

✓ **Hybrid Safety**: fusing 2D – 3D sensor data

✓ **Direct H-R interaction**: (voice, gestures, wearables)

✓ **In – direct H-R interaction**: (human intention detection)

✓ **Manipulator End of Arm Safety**

✓ **Human – Robot workspace supervision**
Dynamic work re-organization architecture

✓ Shopfloor **Digital World Model**

✓ **Real Time update** of the World based on sensors & data processing modules

✓ AI based **HR Task Planning**

✓ Service based integration & data flow

✓ **Station Controller** for execution coordination & monitoring
### Front Axle Assembly Line – Current State

<table>
<thead>
<tr>
<th>Station</th>
<th>Task</th>
<th>Resource</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Pre-assembly of right damper</td>
<td>Human</td>
<td>12 secs</td>
</tr>
<tr>
<td>S1</td>
<td>Load pre-assembled damper on the compression machine, compression of right damper and load compressed damper on the AGV</td>
<td>Human – Compression mach.</td>
<td>30 secs</td>
</tr>
<tr>
<td>S2</td>
<td>Pre-assembly of left damper</td>
<td>Human</td>
<td>12 secs</td>
</tr>
<tr>
<td>S2</td>
<td>Load pre-assembled damper on the compression machine, compression of left damper and load compressed damper on the AGV</td>
<td>Human – Compression mach.</td>
<td>30 secs</td>
</tr>
<tr>
<td>S3</td>
<td>Screwing machine connect each damper with one disk</td>
<td>Screwing machine</td>
<td>57 secs</td>
</tr>
<tr>
<td>S4</td>
<td>Cables / Screws Insertion</td>
<td>Human</td>
<td>50 secs</td>
</tr>
</tbody>
</table>

![Diagram of the assembly line](image)
Automotive Case Study

Front Axle Assembly Line – Vision (1/2)

Station 1 - RDS
- Load pre-assembly in compression
- Align pre-assembly in compression
- Compression / Drilling
- Unload alignment rod / Insert nut
- Load compressed damper on MPP
- Cables / Screws Insertion
- Right Damper pre-assembly

Station 2 - LDS
- Left Damper pre-assembly
- Load pre-assembly in compression
- Align pre-assembly in compression
- Unload alignment rod / Insert nut
- Compression / Drilling
- Load compressed damper on MPP
- Cables / Screws Insertion
- Tighten cables on the disks
- Assemble dampers on the disks

Includes Move from S1 to S2
Includes Move A) from S2 to S1 B) from S1 to S2
Includes Move from S1 to S2
Includes Pick up Screwdrivers

Legend:
- HUMAN
- MRP 1
- STATION OVERALL TIME
- MRP 2
- COMPRESSOR MACHINE
Automotive Case Study

Front Axle Assembly Line – Vision (2/2)

<table>
<thead>
<tr>
<th>KPI</th>
<th>Current State</th>
<th>Hybrid Paradigm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight Handled by Operators (Kg)</td>
<td>6</td>
<td>0.5</td>
</tr>
<tr>
<td>No. of models</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Operator Activity (%)</td>
<td>71.5</td>
<td>100</td>
</tr>
<tr>
<td>No. of Operators</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>
Thank you for your Attention!

Questions?

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For more information visit us at www.thomas-project.eu