Collaborative Robot Technology and Applications

Esben Østergaard
Universal Robots
About Me

Ph.D. in Robotics

Assistant Professor Maersk Mc-Kinney Moller Institute, University of Southern Denmark

Computer Science Major, Aarhus University

Ph.D. studies – AI ST – Tsukuba – Tokyo

“Research Scientist” – USC Robotics – Los Angeles

Founder and CTO of Universal Robots A/S
Automation for everybody

Universal Robots makes robot technology available to EVERYONE
The Universal Robot

Our robots are made into a tool that can be used by the production staff to help them do their work better.
Company Overview

From Idea to Global Game Changer

- 2004: The idea
- 2005: Company founded
- 2006: Work
- 2007: First prototype – UR5
- 2008: First sales, ran out of money

- 2009: Sales in Denmark
- 2010: European distribution
- 2011: Distribution UR5 in Asia. Development of UR10
- 2012: Europe, Asia and the US. Launch of UR10
- 2013: Subsidiaries in New York and Shanghai
- 2014: Establishment of offices in Spain, Singapore & India
Global Distribution
Universal Robots - Expansion

Universal Robots – Odense Denmark
New World Headquarters
Universal Robots Growth

Today: 2014

- 127 Employees
- 297 Distributors
- Shipping 140 Robots/month
- By 2017 shipping 600 Robots/month
Conventional Robots

Contrast

Difference between Conventional and Collaborative Robots
What Made Conventional Robotics Successful?

- **Budget**
- **Mass production/Repeatability**
- **Software**
- **Safety**
Budget: What Makes Up Budget?

Total Budget = $250K-$500K

- Hardware
- Installation
- Software

Guarding
Mass Production/Repeatability

- Makes a lot of one product
  - No changeovers
  - Multishift operation

- Repeatable motions
  - Robot is used for one task
  - Programmed (1) time

- ROI
  - Mass production = Reasonable ROI
  - Repeatable Motion = Reasonable ROI
Software

Who is going to develop the program?

- Initial Program
- Modification
- New Programs
- Deployment

System Integrator
Safety

• Can the application tolerate cages?
• Does upstream and downstream processes need to change?
Model for Success: Conventional Robots

- One location
- Doing One task
- Guarded
- For a long period of time

Budget – Mass Production/Repeatability – Software - Safety
Return on Investment

- Key Denominator in the ROI Equation is work
- Mass Production
- Repeatability
- Fixed/Guarded Location

ROI: Bottom line in order to justify the investment for conventional robot. A robot in one location, doing one task, for a long period of time is necessary to have a reasonable ROI.
Conventional Robotics – Who Is Buying Them?
Large Global Companies

= Large Global Enterprise
SME (Small – Medium Enterprise)

Why hasn’t SME’s been able to successfully implement conventional robotics?

- **Budget** – Most SME has smaller limited budget making the ROI much more critical component of implementation
- **Mass Production/repeatability** – Most SME do not have the “Mass Production” capacity
- **Software** – One of the more difficult pieces of criteria to overcome. SME need to be able to interact with the software frequently
- **Safety** – Guarded robots in fixed locations is difficult. Limited space. Changing production lines adds cost and complexity
Collaborative Robots

Human – Robots Collaboration

✓ Attractively priced
✓ Easy programming
✓ Safe
Flexibility

Flexible

Automation for everybody

- Robots can be programmed onsite by employees
- Robots can be quickly re-tasked to do multiple jobs quickly
- Robots are lightweight and can be moved around easily in the production facility

Component of Flexibility
Market – The Industry, Before

Manual Work:
- High wages
- Variable quality
- Problems with the Labour Inspectorate

1st Gen. Industrial Robots:
- Big investment
- Long start-up period
- Limited flexibility

Outsourcing:
- Product knowledge disappears
- Copying of product

Special Machinery:
- No flexibility
- Must be special designed
Collaborative Robots – Future of Robotics

Industrial Robotics - Growth Perspectives

- Robotics for Automotive Industry
- Food
- Medical
- Entertainment
- Logistics

Today

Future

Robots as multipurpose tools for manufacturing SMEs
Robots for domestic services

Insourcing: Increase Quality & Flexibility
Robot Safety (now)

Locomotive Act (Red Flag Act)
England, 1861
Robot Safety (Standards and Guidelines)

Machinery Directive
- Must make a risk assessment

We have now ISO 10218-1
- Written for large "cast iron" robots
- Can be used for collaborative robots, but in many cases seems like overkill
Robot Safety (Standards and Guidelines)

New standardization work:
- International effort:
  - TC 184, SC2, WG3

Working on TS 15066 ->
ISO 10218-3: Collaborative Robots

But >when< and >what<
- Pain vs. Injury
- Wordings and markings
- Safety functions
- When does the standard apply
Market – Unique Potential

- There was a large untapped market for easy-to-use robots
- In Denmark, in Europa, and Globally
- Demand for automation is increasing

97%

Of all companies globally are SMV’s
Case Story: RSS Manufacturing & Phylrich
Collaborative Robots are allowing end user to take complete ownership of the robot.

Collaborative Robots are creating their own marketplace. We are not looking to replace conventional robots.

By adding flexibility the ROI is able to manageable for both SME’s and Large global corporations.
Return on Investment

• Conventional Robots = Work
  - Fix position enables work for conventional robots

• Collaborative Robots = Work
  - Flexibility creates work for collaborative robots
  - Flexibility creates a tool to redeploy
Our Robots Are Being Used By Small, Medium, And Large Companies

References in every market

Our industrial robots are used by small, medium and large companies

[Logos of various companies]
# UR5 & UR10

## Technical Specifications

<table>
<thead>
<tr>
<th></th>
<th>UR5</th>
<th>UR10, preliminary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>16 kg</td>
<td>28 kg</td>
</tr>
<tr>
<td>Payload</td>
<td>5 kg</td>
<td>10 kg</td>
</tr>
<tr>
<td>Reach</td>
<td>850 mm</td>
<td>1300 mm</td>
</tr>
<tr>
<td>Joint ranges</td>
<td>+/- 360° on all joints</td>
<td>+/- 360° on all joints</td>
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<tr>
<td>Speed</td>
<td>Joint: Max 100°/sec, Tool: Approx. 1 m/sec.</td>
<td>Joint: Max 120°/sec, Tool: Approx. 1 m/sec.</td>
</tr>
<tr>
<td>Repeatability</td>
<td>+/- 0.1 mm</td>
<td></td>
</tr>
<tr>
<td>Footprint</td>
<td>05149 mm</td>
<td>08190 mm</td>
</tr>
<tr>
<td>Degrees of freedom</td>
<td>6 rotating joints</td>
<td>6 rotating joints</td>
</tr>
<tr>
<td>Control box size (WxHxD)</td>
<td>462 mm x 423 mm x 268 mm</td>
<td>462 mm x 423 mm x 268 mm</td>
</tr>
<tr>
<td>I/O ports</td>
<td>10 digital in, 10 digital out, 4 analogue in, 2 analogue out</td>
<td>10 digital in, 10 digital out, 4 analogue in, 2 analogue out</td>
</tr>
<tr>
<td>I/O power supply</td>
<td>24 V 1200 mA in control box and 12 V/24 V 600 mA in tool</td>
<td>24 V 1200 mA in control box and 12 V/24 V 600 mA in tool</td>
</tr>
<tr>
<td>Communications</td>
<td>TCP/IP, Ethernet sockets</td>
<td>TCP/IP, Ethernet sockets</td>
</tr>
<tr>
<td>Programming</td>
<td>Polyscope graphical user interface on 12 inch touchscreen with mounting</td>
<td>Polyscope graphical user interface on 12 inch touchscreen with mounting</td>
</tr>
<tr>
<td>Noise</td>
<td>Comparatively noiseless</td>
<td>Comparatively noiseless</td>
</tr>
<tr>
<td>3D classification</td>
<td>3P64</td>
<td>3P64</td>
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<tr>
<td>Power consumption</td>
<td>Approx. 200 watts using a typical program</td>
<td>Approx. 350 watts using a typical program</td>
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<tr>
<td>Collaboration operations</td>
<td>Tested in accordance with sections 5.10.1 and 5.10.5 of EN ISO 10218-1:2006</td>
<td>Tested in accordance with sections 5.10.1 and 5.10.5 of EN ISO 10218-1:2006</td>
</tr>
<tr>
<td>Materials</td>
<td>Aluminium, ABS plastic</td>
<td>Aluminium, ABS plastic</td>
</tr>
<tr>
<td>Temperature</td>
<td>The robot can work in a temperature range of 0-50°C</td>
<td>The robot can work in a temperature range of 0-50°C</td>
</tr>
<tr>
<td>Power supply</td>
<td>200-240 VAC, 50-60 Hz</td>
<td>200-240 VAC, 50-60 Hz</td>
</tr>
</tbody>
</table>

5.4 metre cable between robot and control box
4.5 metre cable between touchscreen and control box
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