Dr. Till Reuter
CEO KUKA AG

Capital Market Day AUTOMATICA
June 03, 2014
Development of KUKA Group

Growth through change

Today

- Industrial robotics and low payloads
- Focus on General Industry

Future

- Sensitive and sensor-based robotics
- Automation solutions

Product

Region/market

Structure

- Expansion in China
- Expansion in General Industry

- Focus on General Industry
- Strengthening of Sales

- Asia region
- Service robotics

- Focus on customer clusters
- Focus on region
Development of robots

New technologies are opening up new markets

1st Robotic Revolution
Industrial automation

2nd Robotic Revolution
Sensitive, safe robot-based automation (LBR iiwa¹)

3rd Robotic Revolution
Mobility

4th Robotic Revolution
Intelligent and perceptive robot systems

Industry 4.0

¹ LBR iiwa – Leichtbauroboter intelligent industrial work assistant
Service robotics with LBR iiwa

Revolution in production
### Service robotics with LBR iiwa

#### High potential in the automotive sector

<table>
<thead>
<tr>
<th>Power train</th>
<th>Press shop</th>
<th>Body Shop</th>
<th>Paint shop</th>
<th>Final assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Power train" /></td>
<td><img src="image" alt="Press shop" /></td>
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<td><img src="image" alt="Paint shop" /></td>
<td><img src="image" alt="Final assembly" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of robots per segment</th>
<th>40-100</th>
<th>7-15</th>
<th>400-600</th>
<th>40-50</th>
<th>10-20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robot applications</td>
<td>Handling, Assembly, Welding, Machining</td>
<td>Handling, Press linking</td>
<td>Spot welding, Laser welding, Gluing, Riveting, Handling, Body transfer, .....</td>
<td>Painting, Sealing</td>
<td>Assembly, Handling</td>
</tr>
<tr>
<td>Degree of automation</td>
<td>Medium to high</td>
<td>High</td>
<td>Very high</td>
<td>High</td>
<td>Very low</td>
</tr>
</tbody>
</table>

Based on production of 200,000 cars per year

1) LBR iiwa – Leichtbauroboter intelligent industrial work assistant
KUKA software

Sunrise opens up new markets for KUKA

KUKA customers

KUKA Cloud Services

Software

KUKA Sunrise

KUKA robots
KUKA development

Hardware – Software – Solution – Processes

- Sunrise
- KR C4
- KR C2
- Weight classes
- Vision
- Haptics
- Sensors

- General Industry (e.g. aerospace, laser, gluing...)
- Emerging markets
- Service Robotics

Solutions from KUKA

Alema
Human-robot cooperation
Disclaimer

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Manfred Gundel
CEO of KUKA Roboter GmbH

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June 03, 2014
Evolutionary stages of automation
Collaboration boosts flexibility and productivity

- High flexibility at limited productivity
- High productivity at limited flexibility
- High flexibility and high productivity by Human-Robot-Collaboration

Quelle: Daimler
Collaboration

Do we need protection principles for HRC$^1$?

MOVIE
Collaboration

What protection principles do exist for HRC\(^1\)?

1. The robot always keeps its distance from humans

2. The robot can come into safe contact with humans

The KUKA LBR iiwa\(^2\) was specially designed to come into safe contact with humans
## Functions of the LBR iiwa

<table>
<thead>
<tr>
<th><strong>Position controller</strong></th>
<th><img src="image1.png" alt="Image" /></th>
</tr>
</thead>
<tbody>
<tr>
<td>The LBR iiwa moves to the programmed position “stubbornly” with high accuracy</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Stiffness controller</strong></th>
<th><img src="image2.png" alt="Image" /></th>
</tr>
</thead>
<tbody>
<tr>
<td>The LBR iiwa behaves like a spring with stiffness and damping parameters in cartesian or axis-specific mode</td>
<td></td>
</tr>
<tr>
<td>Activation of a defined force</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Gravity compensation</strong></th>
<th><img src="image3.png" alt="Image" /></th>
</tr>
</thead>
<tbody>
<tr>
<td>The LBR iiwa behaves as if weightless; movement results from application of the slightest external force</td>
<td></td>
</tr>
<tr>
<td>Manual guidance and teaching by demonstration</td>
<td></td>
</tr>
</tbody>
</table>

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1) LBR iiwa – Leichtbauroboter intelligent industrial work assistant
KUKA Aktiengesellschaft
Automation

KUKA masters all scenarios of HRC

<table>
<thead>
<tr>
<th>Full automation</th>
<th>Limitation of Access</th>
<th>Presence detection</th>
<th>Intervention zone</th>
<th>Assistance</th>
<th>Collabo-ration</th>
<th>Collaboration &amp; mobile Robotics</th>
</tr>
</thead>
</table>

Industrial robots

Lightweight robot: LBR iiwa

1) Human robot collaboration
2) LBR iiwa – Leichtbauroboter intelligent industrial work assistant
Scenarios of HRC

Full automation (state of technology)

1) Human robot collaboration

KUKA Aktiengesellschaft
Scenarios of HRC

Limitation of Access

No persons in the workspace
No contact

1) Human robot collaboration
KUKA Aktiengesellschaft
Scenarios of HRC

Presence detection

1) Human robot collaboration

Humans in workspace for a short period

Only when robot is at standstill
Scenarios of HRC

Intervention zones

1) Human robot collaboration
Scenarios of HRC\(^1\)

Assistance

1) Human robot collaboration

Continuous interaction

Contact is possible
Scenarios of HRC

1. Collaboration

- Continuous interaction
- Unlimited contact
- Collaboration
Scenarios of HRC¹

Collaboration & mobile Robotics

1) Human robot collaboration

KUKA Aktiengesellschaft
Vision: Arena 2036

New production concepts

MOVIE
Frank Klingemann
CEO of KUKA Systems GmbH

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June 03, 2014
Factory of the future
Innovations at KUKA

Human-robot collaboration

Efficient use of energy and resources
- Guidelines for rating energy efficiency
- Energy simulation tool

New system concepts
- „Pulse“
- Matrix body shop
- New standards
Factory of the future

Innovation focus at KUKA Systems

Human-robot collaboration

MOVIE
Factory of the future

Production today

Manual manufacturing

Full automation

Level of automation
Factory of the future

Production tomorrow

Manual manufacturing  HRC\(^1\)  Full automation

Level of automation

---

1) Human robot collaboration

KUKA Aktiengesellschaft
Factory of the future
Design principles

Factory:
Versatile, highly flexible and energy-efficient factory

Basis for Industry 4.0

Line:
Welding and assembly line

Shop:
Press shop, body shop, assembly

Cell/station:
Welding cell, inspection and testing cell, KUKA flexFELLOW, KUKA flexTOWER

Process:
Joining, handling, assembling, screw fastening, inserting plugs...
Applications with the LBR iiwa

The road to HRC\(^1\) solutions

- Invitation to tender
- Quotation
- Order
- Detailed planning
- Installation

Simulation tool (vmrk\(^2\))

HRC\(^1\) production concept

- Factory concept
- Process analysis
- HRC\(^1\) expertise and tools
- HRC\(^1\) catalog

- Cost-effectiveness
- LBR iiwa HRC\(^1\) technology

- Commissioning
- Programming
- Optimization
- Acceptance
- Work safety approval

---

1) Human robot collaboration
2) vmrk-Komponenten: v – Geschwindigkeit (velocity), m – Masse (quantum), r – Radius (radius), k – Körperzone (human body part)
Applications with the LBR iiwa¹

Solutions in the field of service robotics

Cost-effectiveness calculation based on KUKA flexFELLOW

¹) LBR iiwa – Leichtbauroboter intelligent industrial work assistant
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Applications with the LBR iiwa

Operation as KUKA flexFELLOW

Operation with human workers
Secondary tasks result in interruptions of production
- Spot checks of geometric quality (3 parts measured per 50 parts)
- Personal allowance
- Intermittent logistical interruptions

<table>
<thead>
<tr>
<th></th>
<th>Manual</th>
<th>KUKA flexFELLOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross cycle time</td>
<td>82 s</td>
<td>63 s</td>
</tr>
<tr>
<td>Parts per hour</td>
<td>44</td>
<td>57</td>
</tr>
<tr>
<td>Parts per shift (7.5 h)</td>
<td>330</td>
<td>430</td>
</tr>
</tbody>
</table>

1) LBR iiwa – Leichtbauroboter intelligent industrial work assistant
KUKA Aktiengesellschaft
Applications with the LBR iiwa

Advantages of KUKA flexFELLOW

Operation of KUKA flexFELLOW with LBR iiwa
Secondary tasks do not result in interruptions to production
- Released machine capacity
- Released worker capacity

Customer’s production increased by approx. 30%
Return of investment < 2 years

1) LBR iiwa – Leichtbauroboter intelligent industrial work assistant
KUKA Aktiengesellschaft
Competitive advantage for Systems

Goal: Spontaneous and scalable automation

Station no.

1 2 3 4 5 6 7 8

Expansion stage

1

Expansion stage

2

Expansion stage

3

Expansion stage

4

Capacity limit

Product A

Product B

Quantity

Time

Qualitative representation
KUKA flexFELLOW operation I

Example: KTPO¹

Customer advantages

- Avoidance of non-ergonomic work
- Fast material provision
- Permanent setpoint/actual value comparison for process optimization and quality assurance

¹ KTPO: KUKA Toledo Production Operations
KUKA flexFELLOW operation II

Example: Contract manufacturing

Customer advantages

- Firmly calculable output
- Reduction in secondary tasks/breaks
- Released worker capacity
- Elimination of waiting times
KUKA flexFELLOW operation III

Example: Inserting plugs

Customer advantages

- Avoidance of non-ergonomic work
- Fast material provision
- Reliable insertion of plugs in every position
- Permanent setpoint/actual value comparison for process optimization and quality assurance
Christian Tarragona  
Head of Software of KUKA Laboratories GmbH  
Capital Market Day AUTOMATICA 
June 03, 2014
Growth through technology

LBR iiwa¹ – creating a new robotic world

[+] COWORKER

[+] ASSISTANT

[+] COMPANION

Enabled by

¹ LBR iiwa – Leichtbauroboter intelligent industrial work assistant

KUKA Aktiengesellschaft
Growth through technology

Software – driver of innovation

“software defines the product”
Sunrise control systems

Enables safe and sensor-based multi-kinematics

- modular & open interfaces
- sensors
- multi-kinematics
- safety
- object based motion
- programming & operation

- 1ms cycle and switching
- Fast triggers on signals and events
- Parallel real-time processes
- Hybrid control
- Coordinate system transformation services
Future development

Sunrise develops new markets for KUKA
Growth through technology
Sunrise – using mainstream technology

[+] Operating

[+] Programming

[+] Hardware
Growth through technology

Sunrise – towards to the 4th Robotic Revolution

KUKA Cloud Robotics

Industry 4.0

KUKA Aktiengesellschaft

sensor-based, multi-kinematics, mobile, human robot collaboration

innovations, costs, services

Enhance
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