From Research to Products: The Development of the KUKA Light-Weight Robot

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Overview

Introduction
- KUKA Roboter GmbH
- innovation = from research to products
- robot assistants

Light-weight robot product genesis
- research
- technology transfer
- product development

Light-weight robot key characteristics

Application examples and visions

Summary and outlook
Introduction – KUKA Robot Group
Introduction – Why do companies buy robots today?

- increase productivity and reduce manual labour costs
- increase flexibility / variants and volume
- improve Life Cycle Cost
- improve quality
- reduce environmental impact
- improve work environment

⇒ manifest as customer requirements
Introduction – Drivers for Innovation

Customer Requirements → Innovation ← New Technologies

(market pull) (technology push)

„If I had asked my customers what they wanted, they would have said a faster horse.“

Henry Ford
Introduction – KUKA Group – Technology Leadership

Innovation at the heart of KUKA’s business strategy!

- "Famulus" – **first** electromagnetic Robot with six axes
- **First** single-arm Robot without parallelogram
- **First** Long-Range Robot
- **First** Heavy payload Robot
- **First** Robot remote diagnosis via Internet
- Integration of Soft-PLC
- **First** Entertainment Robot
- Cooperative Robots
- **First** Safe Robot
- **First** Light Weight Robot
- **First** Robot with a total of 1,000 kilos

## Introduction – Comparing classical industrial robots with future production assistants

<table>
<thead>
<tr>
<th>Classical industrial robot</th>
<th>Future production assistant</th>
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<tbody>
<tr>
<td>fixed installation</td>
<td>flexibly relocatable (manual or on mobile robots)</td>
</tr>
<tr>
<td>periodic, repeatable tasks; seldom changes</td>
<td>frequent task changes; tasks seldomly repeated</td>
</tr>
<tr>
<td>online / offline programmed by a robot specialist</td>
<td>online instructed by a process expert supported by offline methods</td>
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<tr>
<td>seldom interaction with the worker, only if being programmed</td>
<td>frequent interaction with the worker, even force / precision assistance</td>
</tr>
<tr>
<td>worker and robot separated through fences</td>
<td>work space sharing with the worker</td>
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<tr>
<td>profitable only with medium to large lot sizes</td>
<td>profitable even at small lot sizes</td>
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Product Genesis – Research Stage

DLR, Institute of Robotics and Mechatronics

LBR I (1991)
LBR II (1998)
LBR III (2003)
Product Genesis – Technology Transfer Stage

- Collaborative research project sponsored by the German Ministry Education and Research (BMBF): PAPAS
- Goals of the technology transfer:
  - merging best of both DLR and KUKA worlds to obtain a DLR light-weight robot with the look&feel of an industrial robot control
  - KUKA: sequence control, robot programming language, operator interface
  - DLR: compliant control, torque measurement in joints; ("plug-and-play" fast tool changer)
Product Genesis – Technology Transfer Stage

- Collaborative research project sponsored by the German Ministry Education and Research (BMBF): DESIRE
  www.service-robotik-initiative.de
- Goals for KUKA and DLR:
  - improving the integration of KUKA and DLR controllers
  - single PC controller, improved operator interface, prototypical
Product Genesis – Product Development Stage

LWR 3

- 18 prototype robots built
- improved integration of LWR control within KUKA Roboter controller
- software development with advanced features
- first application experiments within the framework of collaborative research projects and bilateral projects with key customers

LWR 4

- 60 zero series robots
- sale to universities, research institutions and companies for research and pre-series application development
- sale only in Europe
- collect experiences about operational availability

Dec. 2008

Quotations for LWR: HelmutFiege@kuka-roboter.de
KUKA Light-Weight Robot – Basic Data

- **Payload:** 7 kg (14 kg w. limit.)
- **Weight:** 14 kg
- **Number of axes:** 7 (R–P–R–P–R–P–R)
- **Supply:**
  - 48 V DC internal,
  - 220 V AC external
- **Controller:** KRC 2 Ir (19” cabinet)
- **Energy supply:** internal energy supply
Key characteristics – Sensor-based control

Conventional

- Position control
  - Position sensor on motor side
  - Motor current measurement
- Stiff design of the mechanical structure as basis for high control quality

Sensor-based

- Compliance control
  - Position sensor on motor and output side
  - Torque sensor on output side
- High stiffness through active vibration damping
Application examples – Automatica 2006

Climbing robot supporting its own weight

Robot in hard contact and with closed kinematic chain
Application vision – Programming by Demonstration
Application vision – “Plug-and-Produce”

Working from cart

Relocate to work place

**Characteristics:** („Plug-and-Play“ adapter/communication for robot foot/hand/tools, calibration/registration, programme generation, …)
Application vision – Prototypical flexible machine tool automation

- Light-weight robot, controller and parts rack are integrated in a trolley to be transported easily from one place to another.
- Programming by demonstration is easy, intuitive and fast, only little knowledge is required.
- The compliance behaviour of the LWR enables complex movements with kinematic constraints (e.g., door opening by a circular movement)
- Demo installation by DMG Automation GmbH and KUKA Roboter GmbH, exhibit at EMO 2007 at the booth of DMG.
Application example – KUKA Educational Framework

Service-based simulation framework based on MSRS with several training tutorials for supporting robotics education

Free Download:
www.kuka.com/en/education
The Future – Ongoing R&D projects

The SME worker’s third hand  
Safe human-robot collaboration  
Mobile dual arm/hand manipulation
Summary and Conclusions

KUKA Robot Group

- technology leader
- innovation = from research to products

Successful example: KUKA light weight robot

- technology transfer through collaborative research projects, cooperation with core partners (here: DLR) and employment of key people
- key characteristics: light-weight, sensor-based control

Application examples and visions:

- robot assistant, worker’s third hand, flexible machine tool automation
- programming by demonstration

Future

- robots suitable for SME manufacturing, service robotics
- unlimited possibilities!
Thank you for your attention!

Questions?

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