Smart Factory 자동화를 위한 KUKA 로봇의 유럽 내 실제 적용 사례 소개

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KUKA AG - Strategy

Integrated software solutions and modular product platform

Robotics expertise

Application and industry expertise

Systems and process expertise

Global market access

KUKA KOREA
Robots for payloads from 3 to 1.300 kg

Light Weight Robot (LWR) „IIWA“
for Human Robot Collaboration (HRC)

Small robots „Agilus“
Low payload

Middle payload

High payload

Highest payload „Titan“

Special mechanics
What is Industry 4.0?

Cyber Physical Systems

Mechatronic

Mass Production

Steam Power

1. Industrial revolution follows introduction of water- and steam-powered mechanical manufacturing facilities. End of 18th century.

2. Industrial revolution follows introduction of electrically-powered mass production based on the division of labour. Start of 20th century.

3. Industrial revolution uses electronics and IT to achieve further automation of manufacturing. Start of 1970s.


Source: DFKI 2011
What are Cyber Physical Systems?

- ...measure the physical and chemical environment with sensors ("Actual Value")
- ...calculate a digital representation of the physical/chemical reality
  - "Virtualization" of the reality ("Virtual Reality")
  - "Digital Twin", "Digital Mirror", "Digital Shadow", etc.
- ...continuously compare this situation with "Set Values"
- ...compute new "Control values" and give them out to actuators
- ➔ closed loop controls
- ...can be distributed (holon)
- ...and hierarchical (holarchic)
- ...and self-similar like fractals
  - "Fractal Automation" © by KUKA since 1999

Source: http://wikipedia.org/wiki/Fractal

http://www.trademarks411.com/marks/75866864-fractal-automation
IoT is all about Control and Optimize w or w/o Humans in the closed loops
The whole Mess of today

- Machine or Cell HMI
- Programmed
- Machine or Cell Controller
- Machine Application in Machine Language
- Handshake via I/O-Bits
- Communication

- Robot Controller
- Robot Application in Robot Language
- Handshake via I/O-Bits
- Communication

- Process Controller
- Process Controller Firmware
- Handshake via I/O-Bits
- Communication

- Cells, Machines, Robots, Processes
- Configured

Legend:
White = done by the system integrator
Colour = done by device manufacturers
What would “programming robots” mean being “translated” to the office world?

The printer must be programmed before it can print???

Crazy, isn’t it?
The KUKA mxAutomation Solution today (a 1st Step)

Machine and KUKA Robot HMI

Programmed

Machine Controller

- Machine and KUKA Robot
- Application in Machine Language

mxAutomation Library

(Client) Driver

Communication, i.e. EtherCAT

KUKA Robot Controller KR C4

- mxAutomation “Interpreter” (Server)
- Driver
- Communication

KUKA Robot

Robot Controller
The Edge Control Solution (Option 1)

Communication: OPC UA, TSN, Ethernet

Robot Controller
SOA Server offering “Welding” Services
Semantic Self Desc.
Communication

Process Controller
SOA Server Offering “Welding” Services
Semantic Self Desc.
Communication

Machine Controller
SOA Server Offering “Machine Services”
Semantic Self Desc.
Communication

Robot Controller
SOA Server offering “Movement” Services
Semantic Self Desc.
Communication

Edge Cloud Controller
Cloud

On Premise

HMIs in Smart Devices “anywhere”

Programmed
1. Real-time PLC
2. Real-time Safe PLC
3. Cloud Connection

Communication: OPC-UA, TSN, Ethernet

White = done by the system integrator
Colour = done by device manufacturers
The Edge Control Solution (Option 2)

- Communication: OPC UA, TSN, Ethernet

- Robot Controller
  - SOA Server offering "Movement" Services
  - Semantic Self Desc.
  - Communication

- Machine Controller
  - SOA Server offering "Machine Services"
  - Semantic Self Desc.
  - Communication

- Process Controller
  - SOA Server offering "Welding" Services
  - Semantic Self Desc.
  - Communication

1. Real-time PLC
2. Real-time Safe PLC
3. Cloud Connection

- Cloud
- On Premise
- Edge Cloud Controller
- HMIs in Smart Devices “anywhere”

- White = done by the system integrator
- Colour = done by device manufacturers
International Standards are key to Industry 4.0
How KUKA is responding

- Sensitive and Safe Robots for Human Robot Cooperation (HRC)
  - No more fences, TÜV approved
  - Smart, SIL2 safe Sensors within the robots
  - Assistant systems for humans
  - Not to replace workers but to assist them!
  - New safe human approach recognition technologies for bigger industrial robots
    - If a human approaches, the robot will slow down
    - If a human is too close, the robot stops

- Programming KUKA Robots
  1. The iiwa can be programmed in Java
  2. …or not programmed at all but teaching by doing
  3. All KUKA robots also can be controlled completely from remote controllers (i.e. from Edge Cloud Controllers) via network communication
  4. Output from simulation systems can be used to program KUKA robots
How KUKA is responding

- Mobile products, machines and tools are a very important part of Industry 4.0
Utilizing Communication and Computing Power

- Moore’s law (computer capabilities doubling every 18 months)
- Nielsen’s Law (Internet Bandwidth doubling every 24 months)
- Time Sensitive Networks (IEEE 802.1 TSN) provides
  - deterministic hard real-time and
  - Distributed clocks with nanoseconds accuracy
- Small, distributed, networked devices ➔ Holon Systems

Cascaded Cloud Computing…

- „Public Cloud“ or just „Cloud“ ➔ Computers (Servers) somewhere in the Internet
- „Private Cloud“ ➔ Computers on premise (keep your data in-house)
- „Hybrid Cloud“ ➔ Combination of both
- “Edge Cloud“ ➔ Computers on the edge of the network just beside the devices

Big Data Computing

- Data collection, Data stream analytics, Machine learning
- Predictive maintenance, etc.

How KUKA is responding
How KUKA is responding

- Engineering along the value chains (horizontally integration)
  - From the product idea to the recycling
- Simulation in the Cloud
- Programming with IT-Languages
  - No more proprietary special languages (robots, PLCs, technology controllers, etc.)
  - No more proprietary and incompatible field busses
  - Edge Cloud servers instead of PLCs
- Machine to Business communication to private und public Clouds
  - OPC UA Cloud connection
- Machine to Machine Communication (peer to peer) in deterministic real-time
  - Self configuration, ad hoc entering/leaving the network
  - OPC UA Publisher/Subscriber on Time Sensitive Networks
How KUKA is responding

- Utilization of Smart Devices (Phones and Tablets)
  - „Bring your own Device“ (BYOD) or „Corporate Owned, Personally Enabled“ (COPE)
  - Helps people making faster and better decisions
  - Not only screen and touch
    - Accelerometers and gyroscopes, Audio Input (microphone), Output (speaker)
    - Global positioning, Internet Gateway
    - Sending Emails, SMS, Receiving Push messages, and many more…

- Virtualization
  - Operating Systems
  - Networks (VLANs, Software Defined Networks)
  - Smart Products, Machines, Tools (“Digital Twins”)
KUKA Connect in conjunction with another Cloud

Any Cloud

KUKA Connect

KUKA RT-Edge

Digital Twins

OpS UA on TSN

KUKA Devices

Community Partner Devices

Open API

OPC UA on TSN

KUKA Devices

Open API

HMIs & Apps

App Store

Public Cloud

Private Cloud

Firewall

Things
Example feasibility studies & production videos

Collaborate Assembly

KMRiiwa part handling

KUKA Connect

Random place Screwing

Random place handling

Robot part assembly
## Product overview – LBR iiwa, 7 kg and 14 kg

- Lightweight construction using aluminum design
- Torque sensors in fail safe technology
- Automated mastering

<table>
<thead>
<tr>
<th></th>
<th>LBR iiwa 7 R800</th>
<th>LBR iiwa 14 R820</th>
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<tbody>
<tr>
<td>Rated payload</td>
<td>7 kg</td>
<td>14 kg</td>
</tr>
<tr>
<td>Number of axes</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Mounting flange A7</td>
<td>DIN ISO 9409-1-A50</td>
<td>DIN ISO 9409-1-A50</td>
</tr>
<tr>
<td>Mounting position</td>
<td>User-defined</td>
<td>User-defined</td>
</tr>
<tr>
<td>Protection level</td>
<td>IP 54</td>
<td>IP 54</td>
</tr>
<tr>
<td>Pose repeatability</td>
<td>±0,1 mm</td>
<td>±0,1 mm</td>
</tr>
<tr>
<td>Torque accuracy</td>
<td>±2 %</td>
<td>±2 %</td>
</tr>
<tr>
<td>Weight</td>
<td>23,9 kg</td>
<td>29,9 kg</td>
</tr>
</tbody>
</table>
## KMRiiwa

### Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Dimension</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height of the vehicle</td>
<td>700</td>
<td>mm</td>
</tr>
<tr>
<td>Length with scanners</td>
<td>1190</td>
<td>mm</td>
</tr>
<tr>
<td>Width with scanners</td>
<td>720</td>
<td>mm</td>
</tr>
<tr>
<td>Weight approx.</td>
<td>400</td>
<td>kg</td>
</tr>
<tr>
<td>Additional payload</td>
<td>Max. 400</td>
<td>kg</td>
</tr>
<tr>
<td>Maximum velocity straight direction</td>
<td>4</td>
<td>km/h</td>
</tr>
<tr>
<td>Maximum velocity crosswise direction</td>
<td>2</td>
<td>km/h</td>
</tr>
<tr>
<td>Wheel diameter</td>
<td>250</td>
<td>mm</td>
</tr>
<tr>
<td>Surrounding temperature</td>
<td>+5°C...+35°C</td>
<td></td>
</tr>
<tr>
<td>Humidity</td>
<td>max. 80%</td>
<td></td>
</tr>
</tbody>
</table>
Thank you for your attention.