POLITECNICO DI MILANO

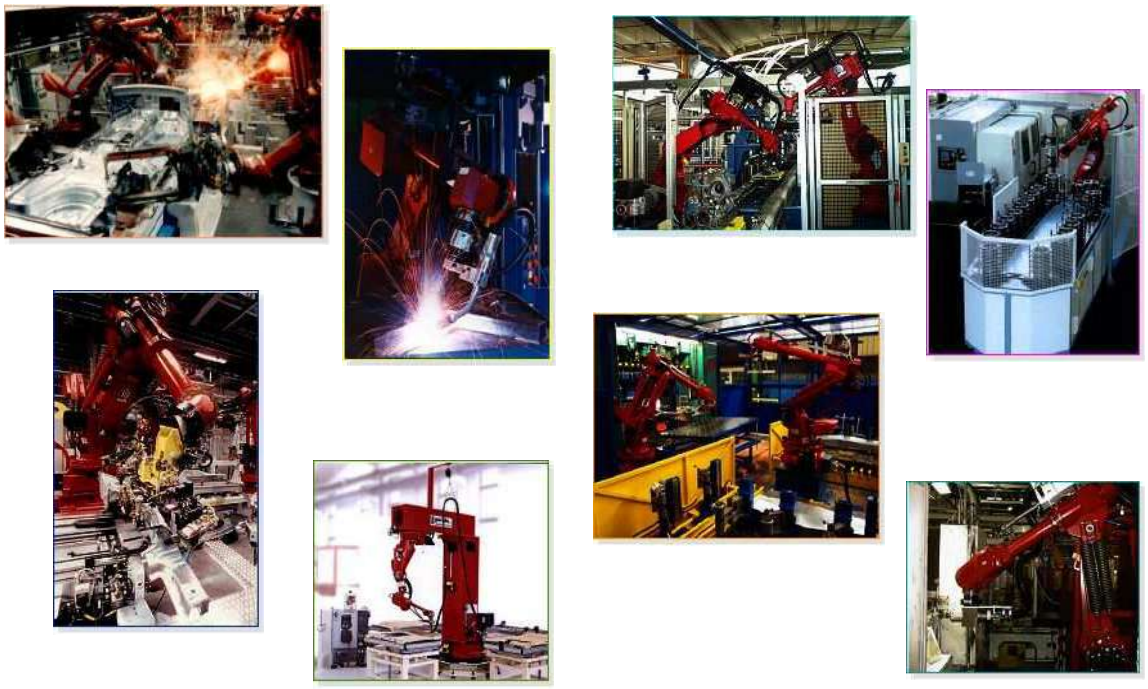
# Industrial and service robotics: state of the art and trends


## Paolo Rocco

Politecnico di Milano - Dipartimento di Elettronica, Informazione e Bioingegneria


Workshop – Future trends in machine tools and manufacturing – EMO Milano 2015
October 8th, 2015

# Industrial robotics and…



Source: Comau Robotics

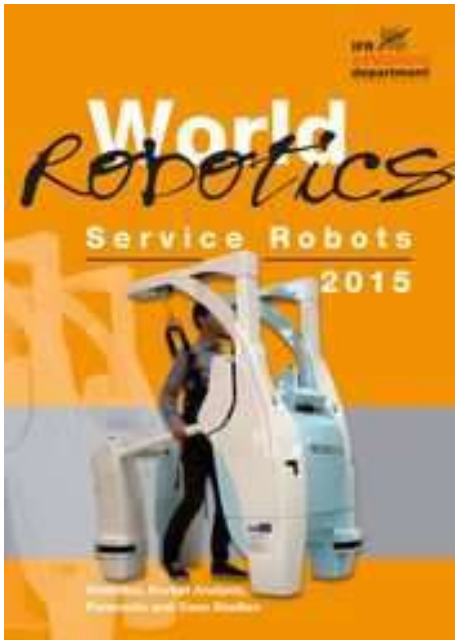
# Outline

- Industrial robotics: some statistics
- Current trends in industrial robotics
  - Industry 4.0
  - Collaborative robotics
  - Easy-to-use robots
  - New applications
- Service robotics
- Research

# How is industrial robotic doing?

Source: OECD

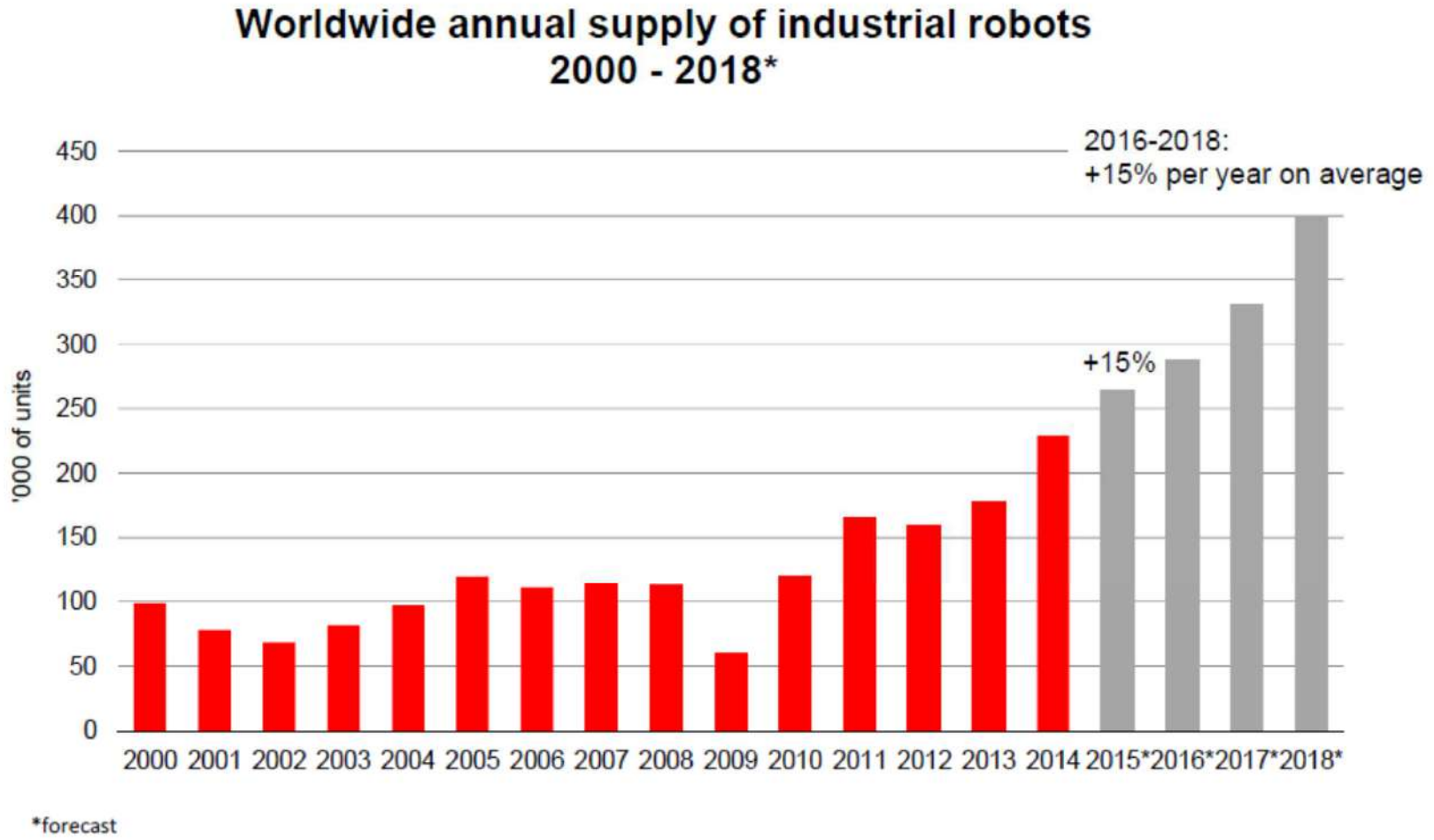
# An excellent source of information…




Just released!

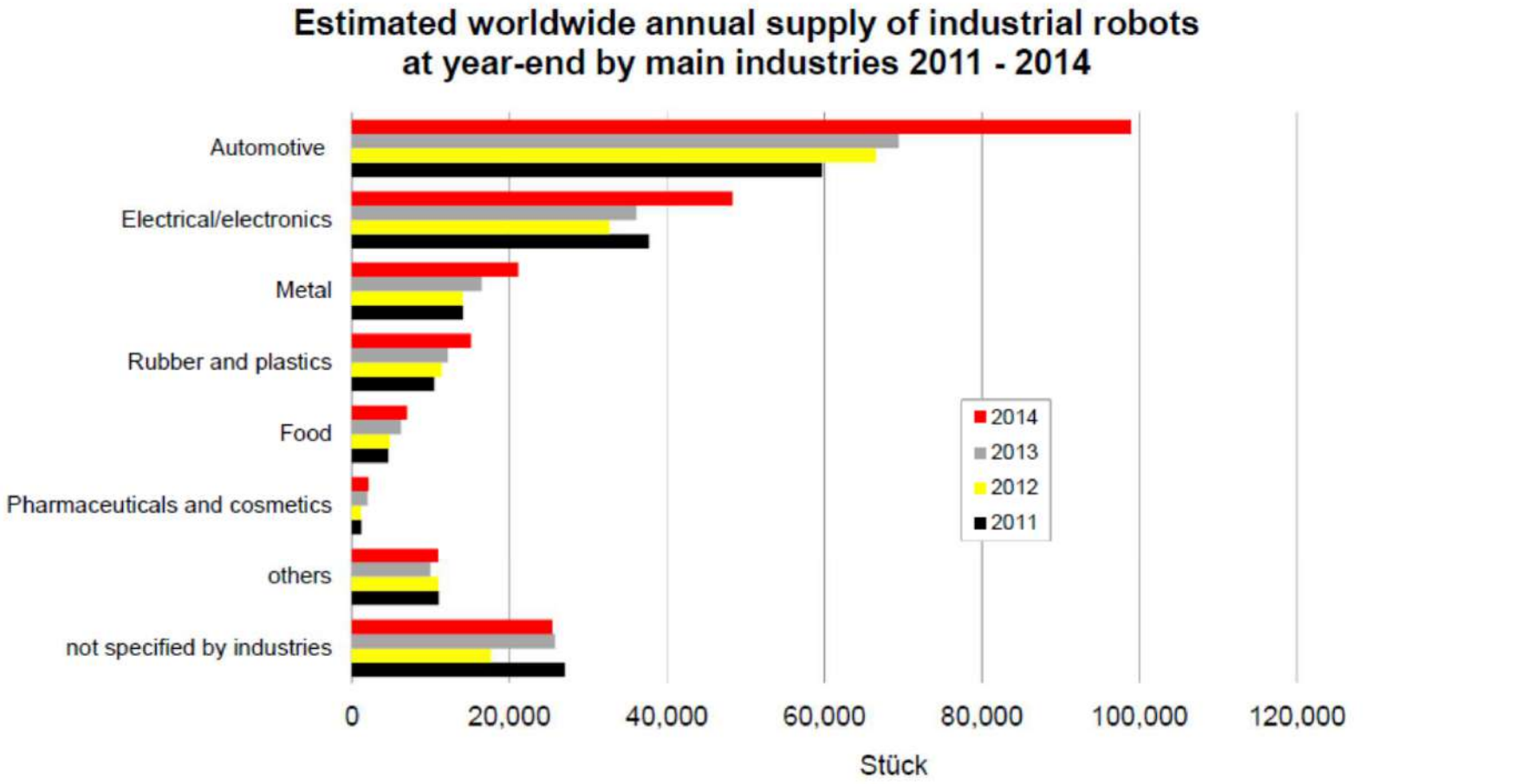
IFR statistical department

# Industrial robotics: some statistics




Source: IFR World Robotics 2015

# Industrial robotics: some statistics

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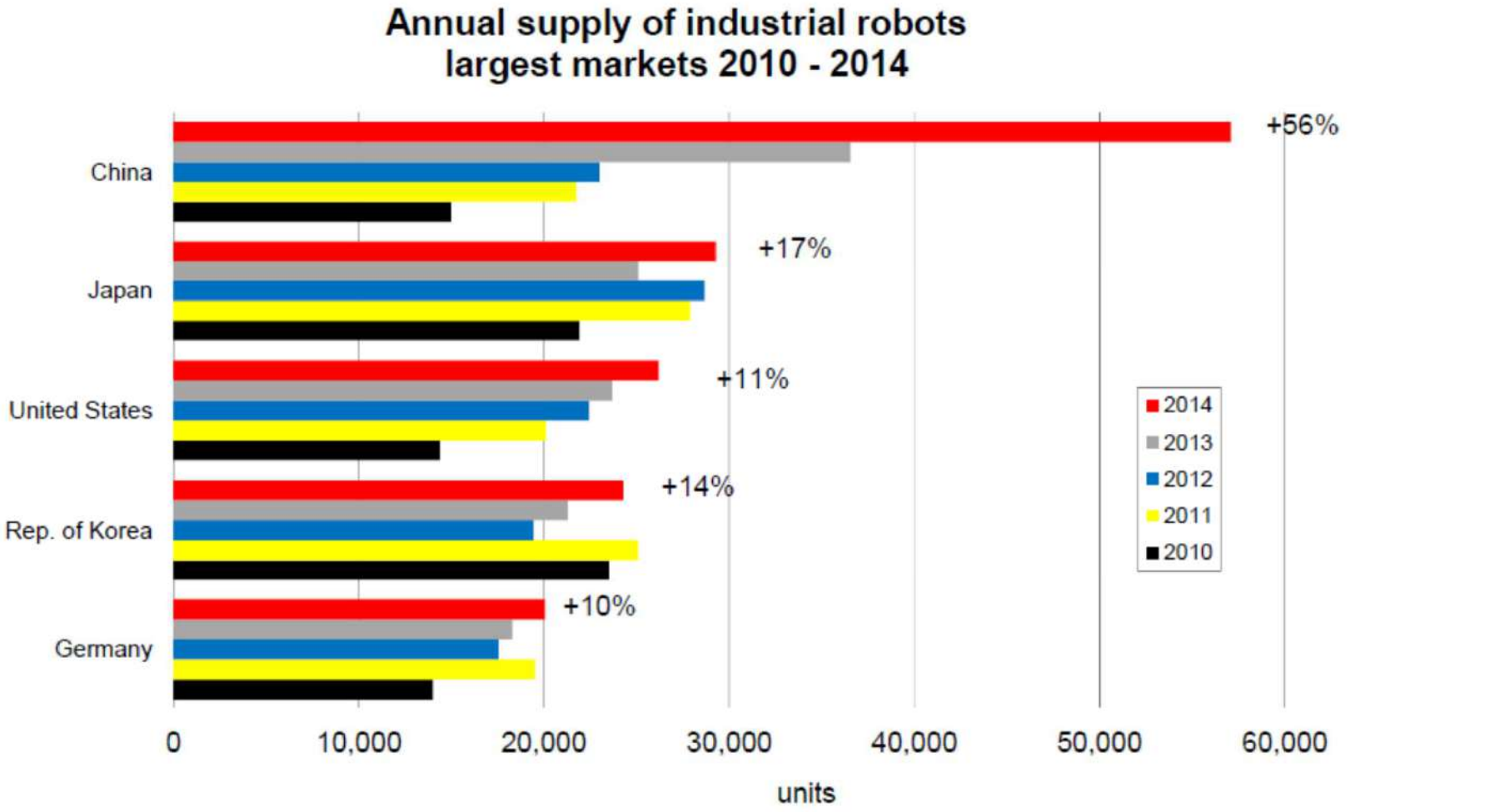


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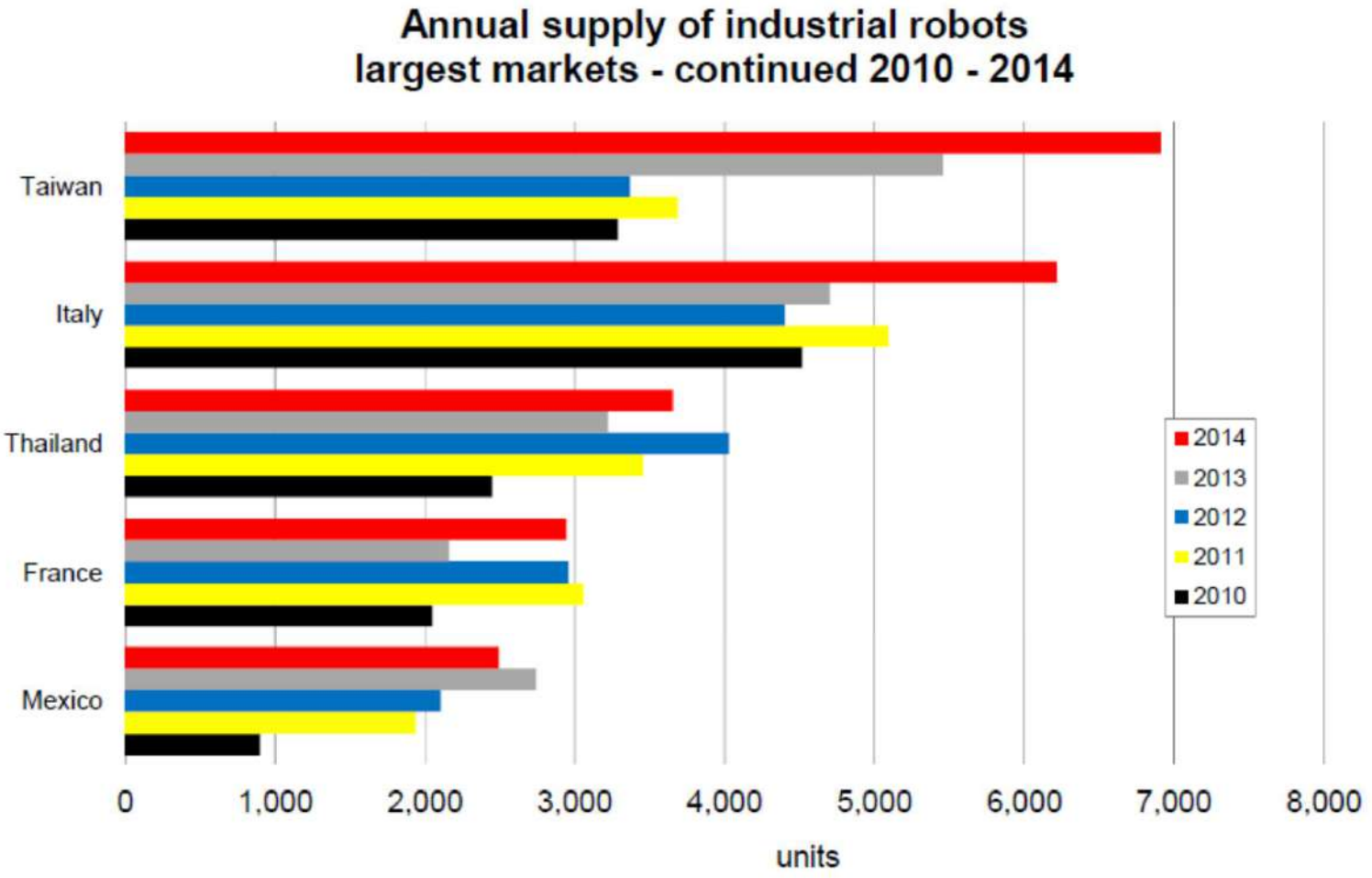
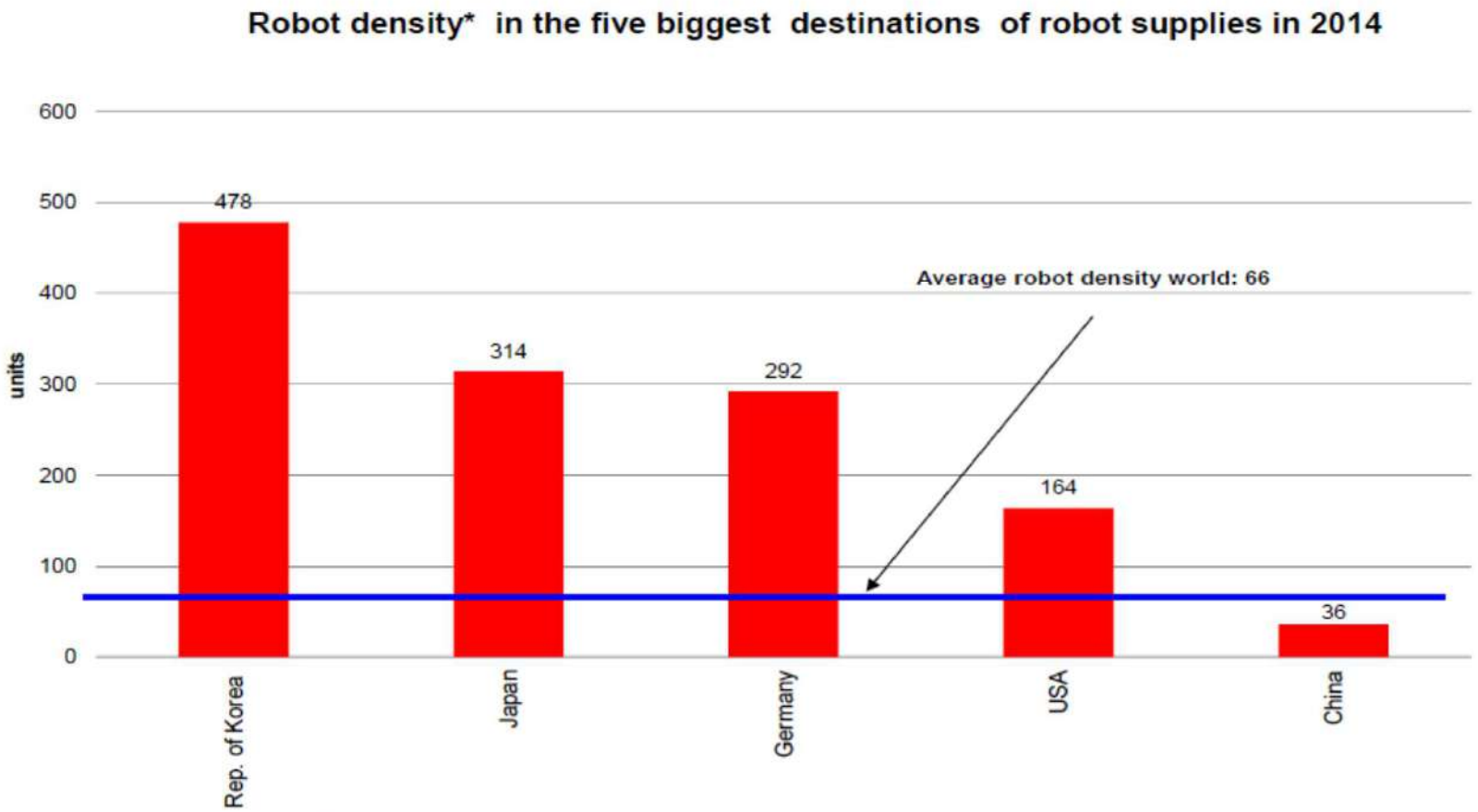



Source: IFR World Robotics 2015

# Industrial robotics: some statistics




Source: IFR World Robotics 2015

# Industrial robotics: some statistics

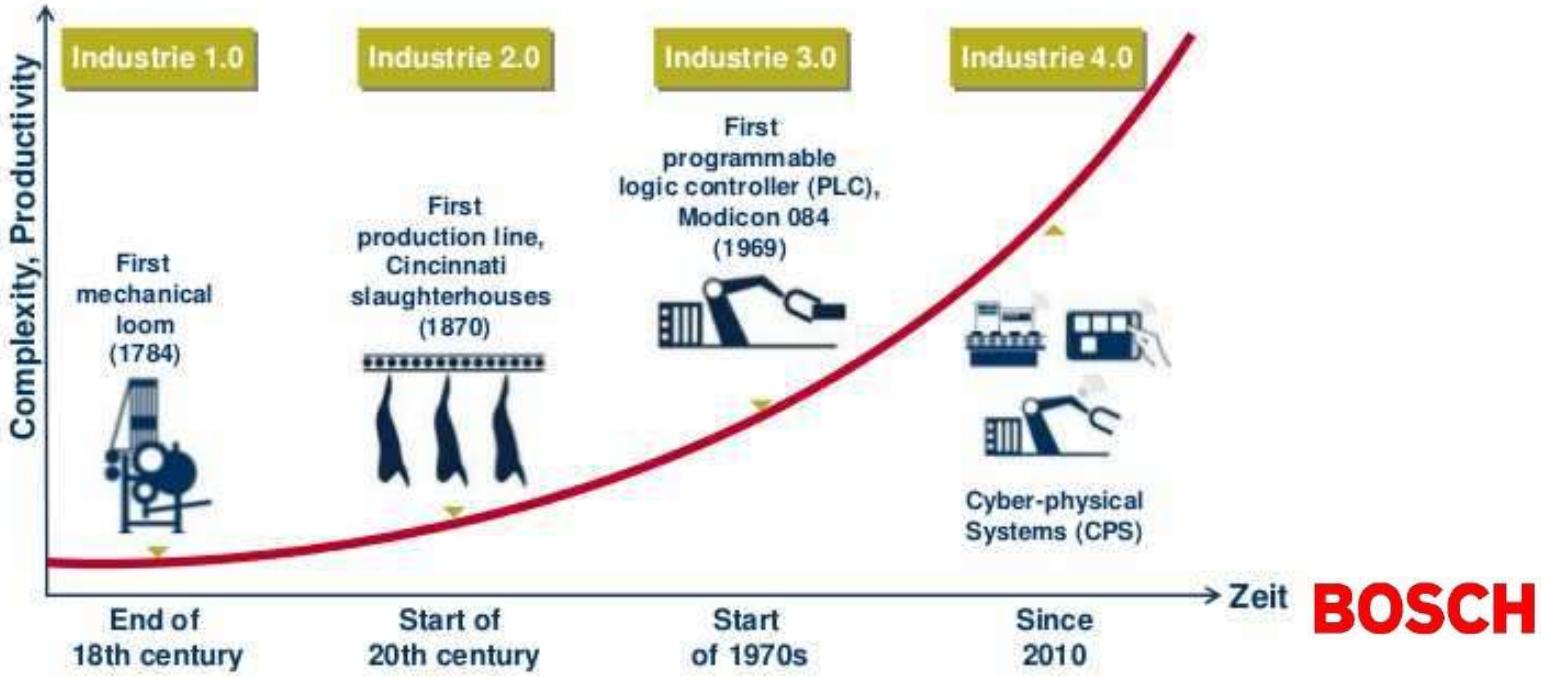
- Worldwide operational stock of industrial robots: **1.5 million of units**
- Value of the global market of industrial robots: **US$ 10.7 billion**
- Value of the global market of robotic systems: **US$ 32 billion**

# Industrial robotics: some trends

Source: Trendonline

# Industry 4.0

- Robots as key components in the manufacturing of Industry 4.0
- Integration of machinery, warehousing systems and production facilities as Cyber-Physical systems
- Flexibility, cost effectiveness and productivity in smart factories



# Collaborative robotics

- Humans and robots collaborating at the same task
- Increase productivity
- Particularly interesting for SMEs
- Assist the aging workforce

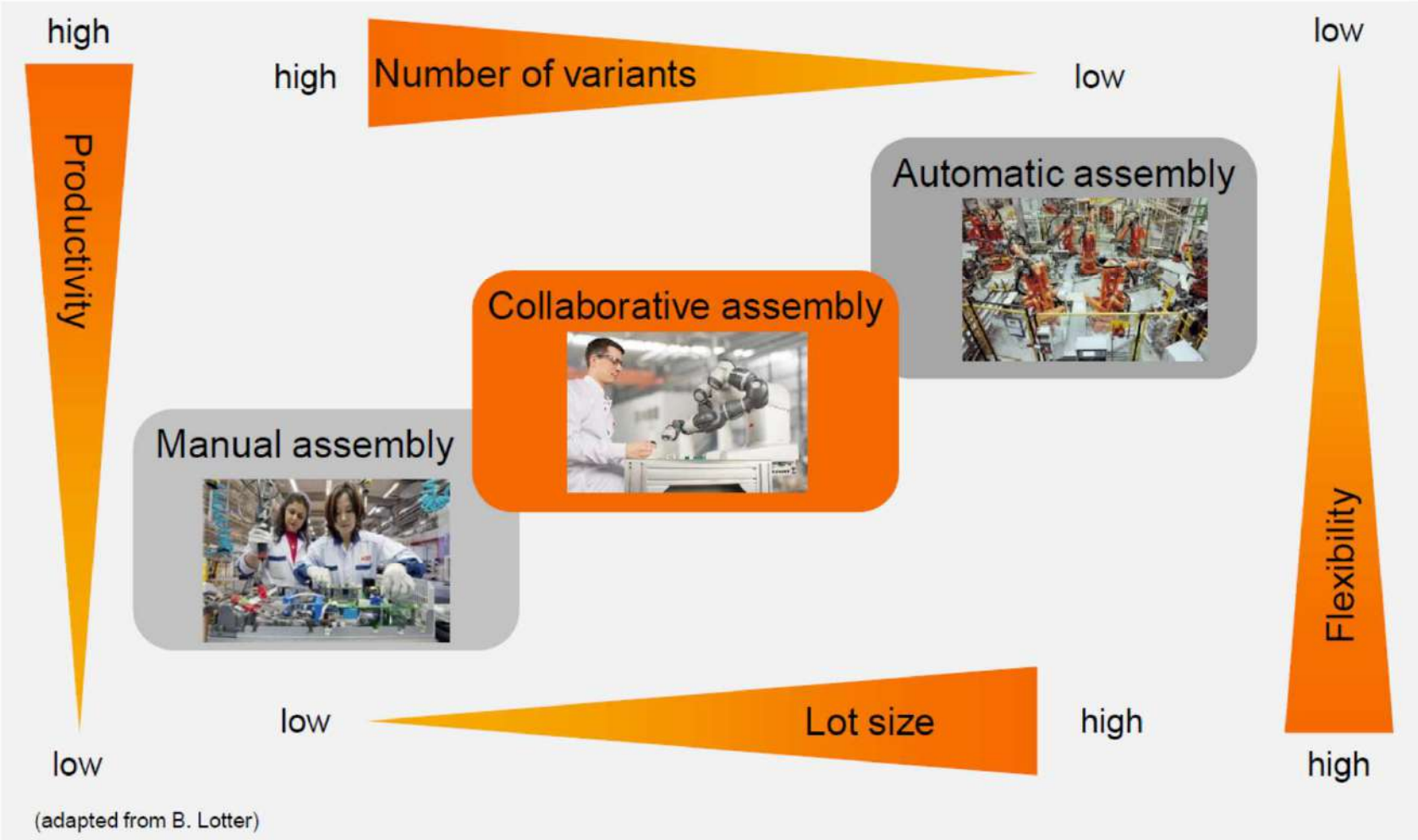
Source: KUKA

# Collaborative robotics

- Dual arm manipulators
- Low inertia, low payload, still good precision
- Good potential for assembly of electronic parts

Source: ABB

# Collaborative robotics



# Collaborative operations

- Safety-rated monitored stop

Source: ABB

- Hand-guiding

Source: ABB

Source: ABB

Source: KUKA

- Speed and separation monitoring

Source: ABB

- Power and force limiting by inherent design or control

Source: ABB

Source: KUKA

Source: Universal Robot

# Easy-to-use robots

- New programming interfaces
- Decrease of the deployment time
- High potential for SMEs

Source: Universal Robots

# Mobile robot manipulators

- Unlimited workspace
- Support human-robot interaction
- Support flexible manufacturing

Source: KUKA

# New application fields

## Pharmaceutical industry

- Robots for clean room are required
- High potential for automation

Source: Kawasaki

## Construction industry

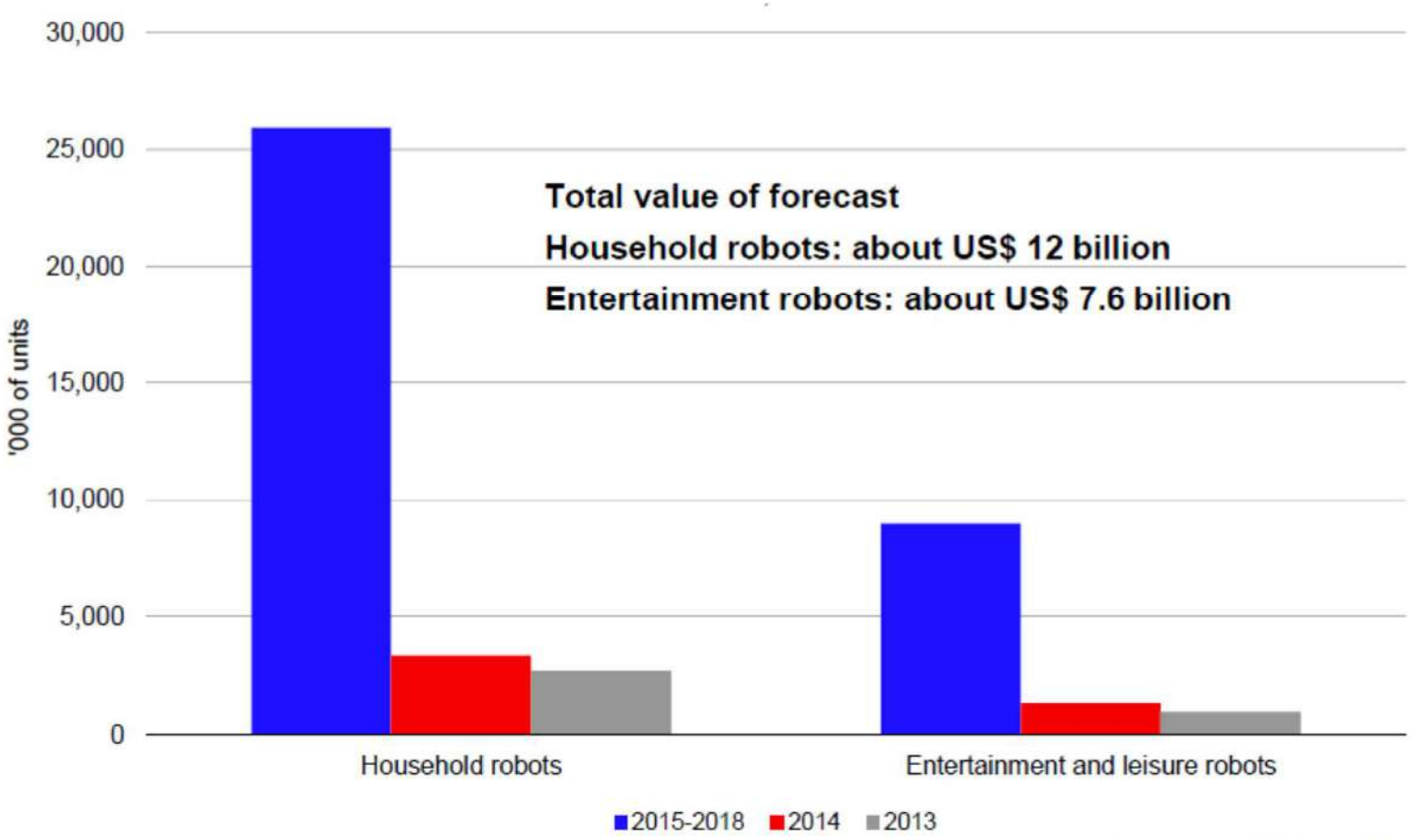
- Heavy load robots
- Can be used for monotonous tasks (handling of bricks and heavy blocks)

Source: RobotWorx

# Service robotics

Source: Aldebaran

# Service robots for personal/domestic use




Source: IFR World Robotics 2015

# Service robots for personal/domestic use

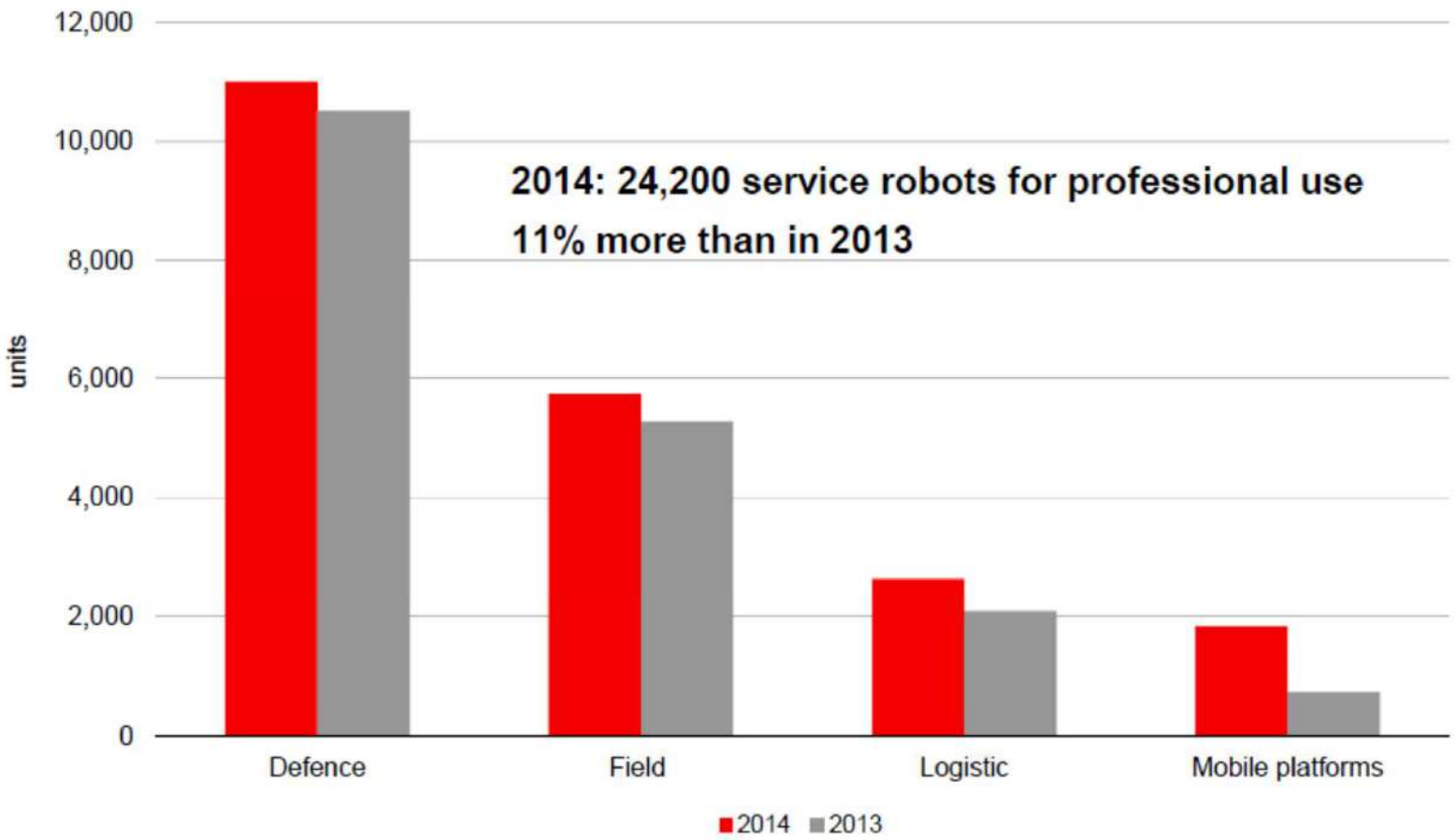
## Main categories

- Vacuum and floor cleaning
- Lawn-mowing robots
- Entertainment and leisure robots

Source: Vorwerk

Source: Thymio

# Service robots for professional use




Source: IFR World Robotics 2015

# Service robots for professional use

## Medical systems

- Diagnostic systems
- Robot assisted surgery or therapy
- Rehabilitation systems

Source: Cyberdyne

Source: AlterG

## Field robots

- Milking robots
- Farming and livestock breeding systems

Source: Lely

## Logistic systems

- AGVs
- Both for industrial and non-industrial sectors

Source: Blubotics

# What is research doing?

Source: Ufficio marchi e brevetti

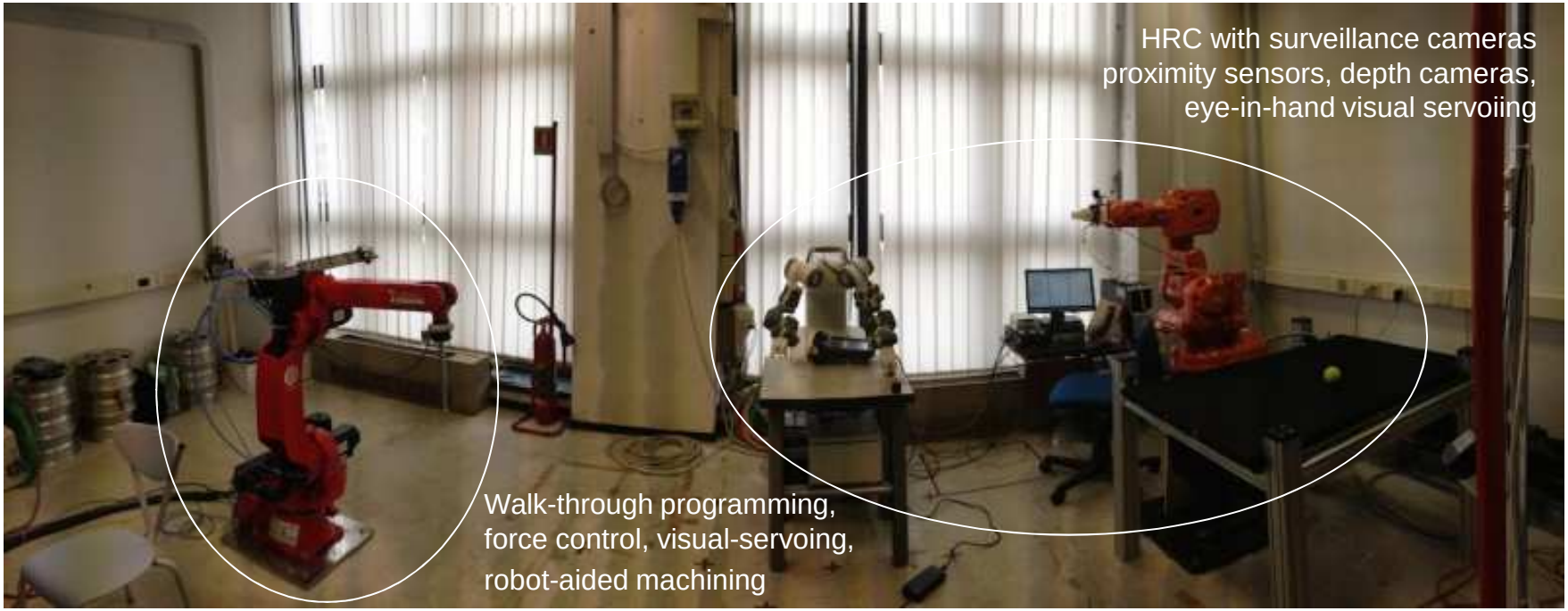
# Hot topics

IROS Hamburg 2015

## Top ten keywords of the presented papers

| |
|---|
| Human-Robot Interaction |
| Unmanned Aerial Systems |
| Motion and Path Planning |
| Computer Vision |
| SLAM |
| Surgical Robotics |
| Biologically-Inspired Robots |
| Force and Tactile Sensing |
| Mapping |
| Localization |

# MERLIN Lab

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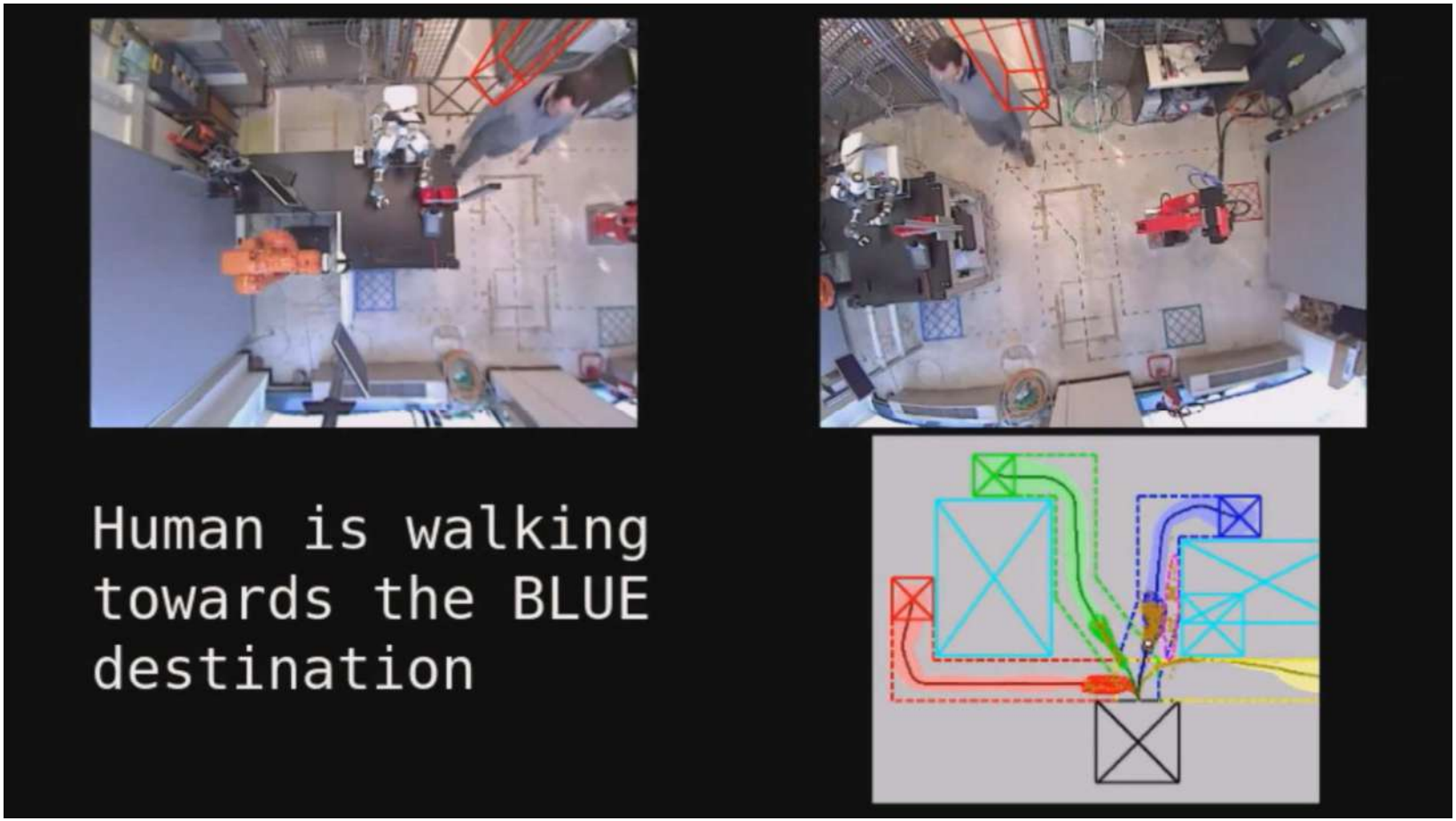
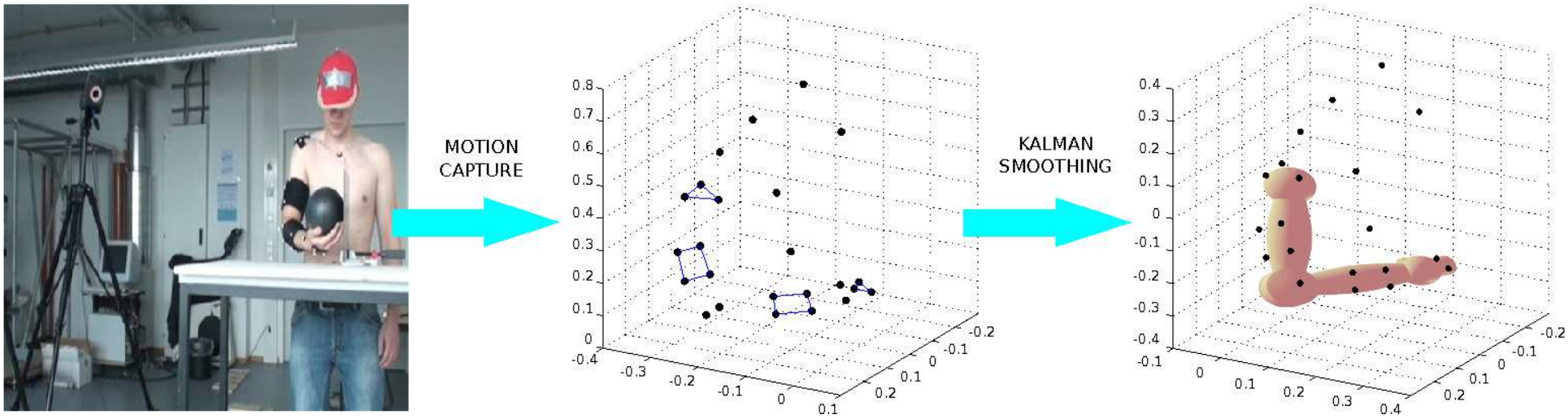
# Human detection and intention estimation



# Human-like trajectories

From marker to motion of an equivalent 7 dof arm:

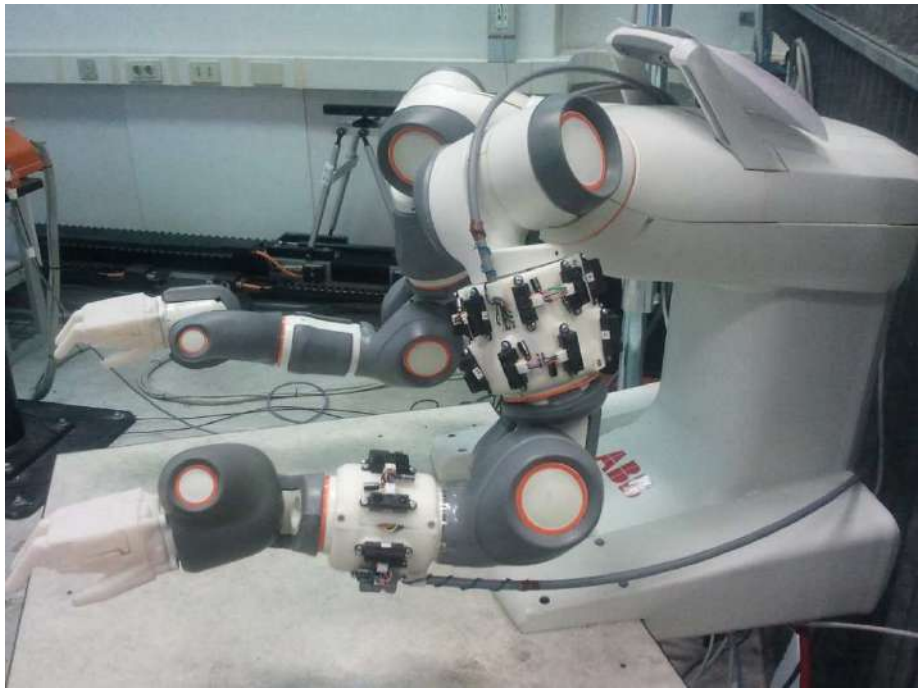


# Human-like trajectories

# Sensor based reactive control

Multi-spot LED based sensory system on FRIDA

- shells made with 3D printer
- 16 LED sensors on the arm shell
- 8 LED sensors on the forearm shell

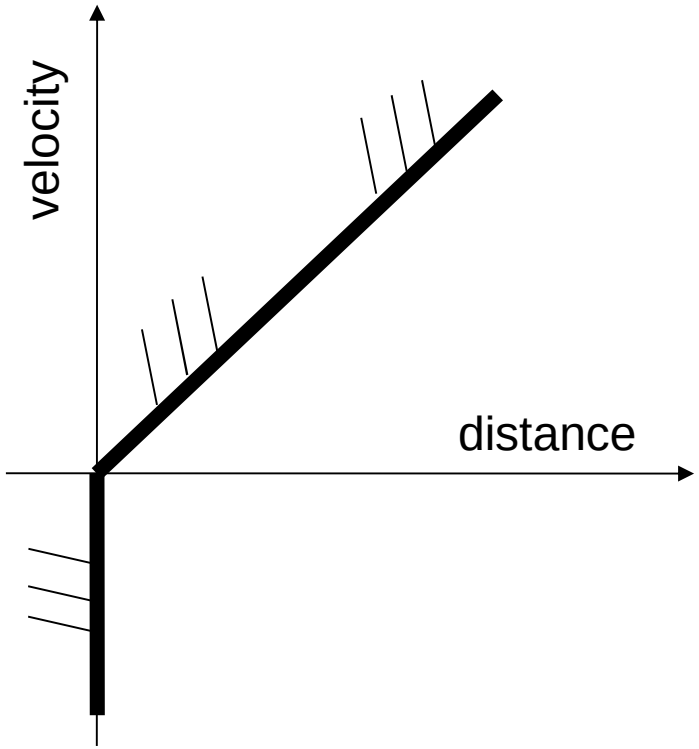


# Sensor based reactive control

# Safety as a motion constraint

Accounting for **safety as a constraint** like in standards.

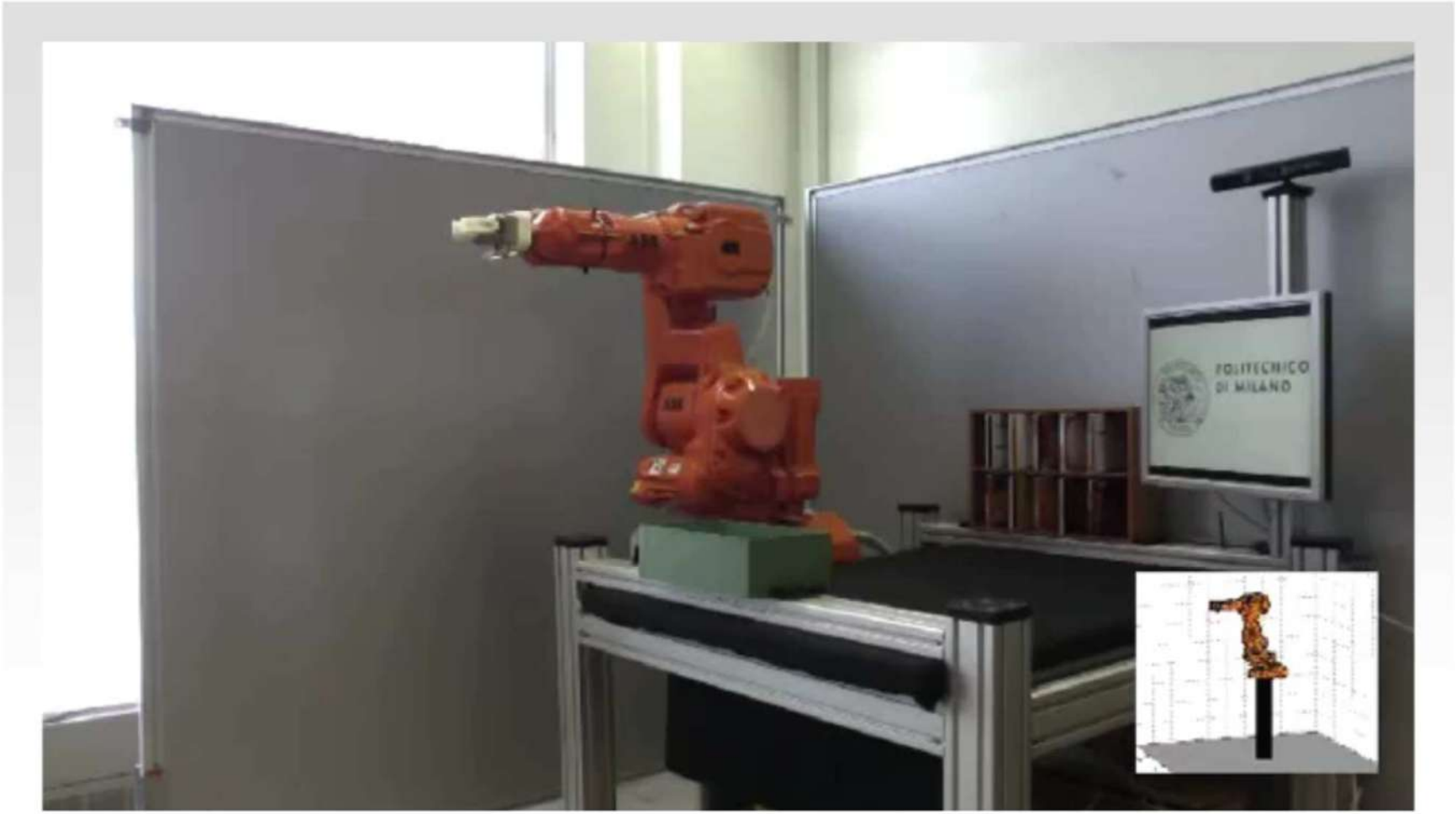
Distance ≥ Velocity * StoppingTime



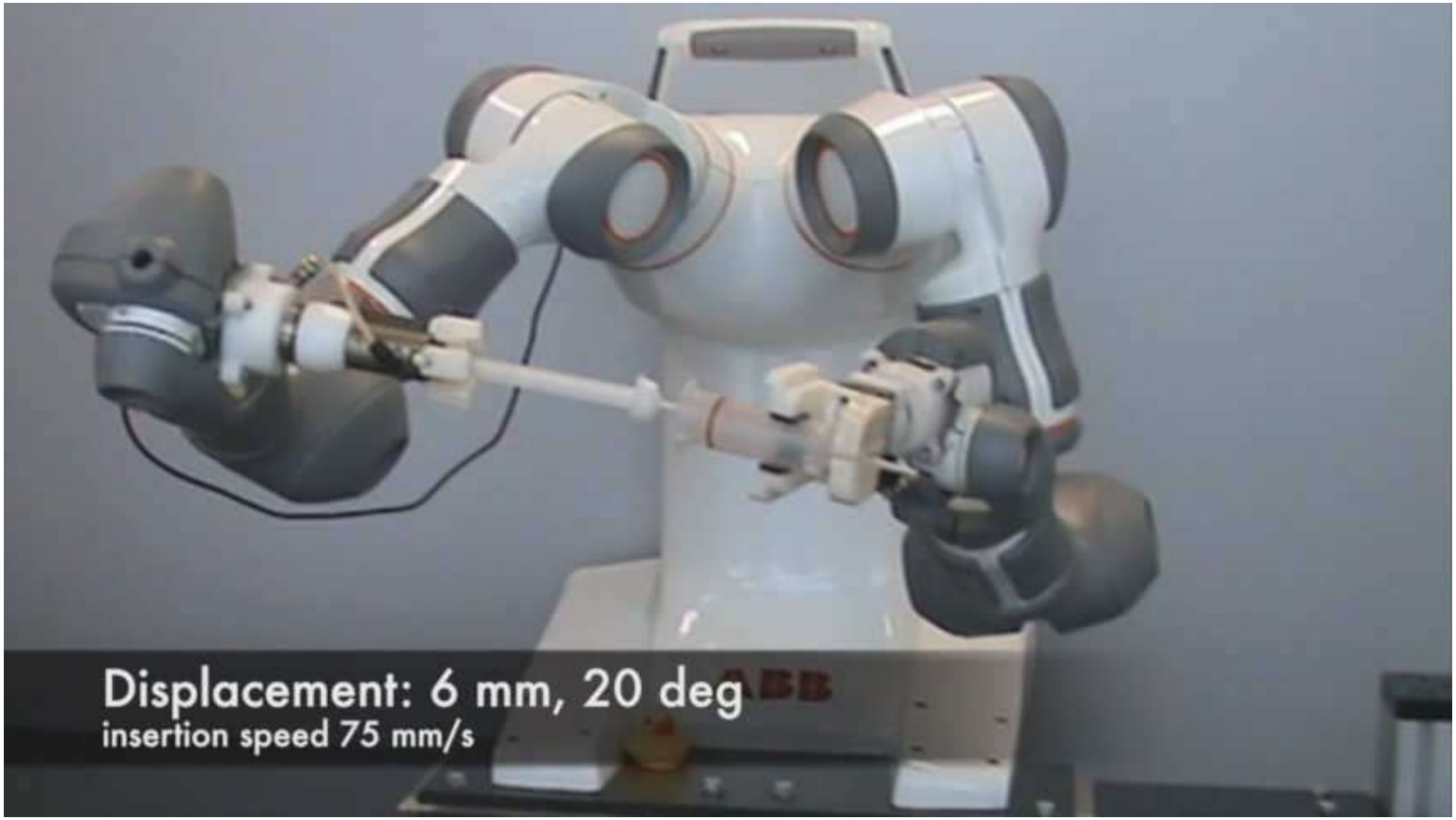

Productivity aims at maximizing the robot speed along the path

Safety constraints might require the robot to slow down on path

# Safety as a motion constraint



# New dual-arm applications



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