



 POLITECNICO DI MILANO



Industrial and service robotics: state of the art and trends

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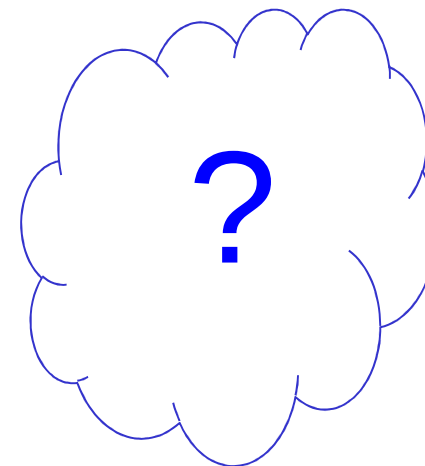
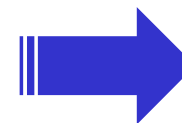
Workshop – Future trends in machine tools and manufacturing – EMO Milano 2015
October 8th, 2015





Industrial robotics and...

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Source: Comau Robotics



- 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?

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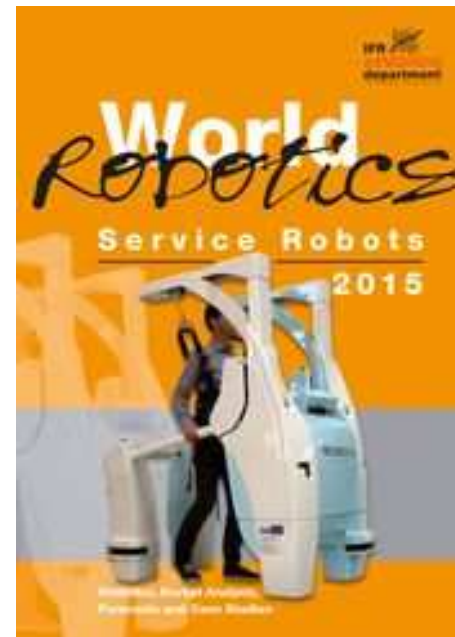


Source: OECD



An excellent source of information...

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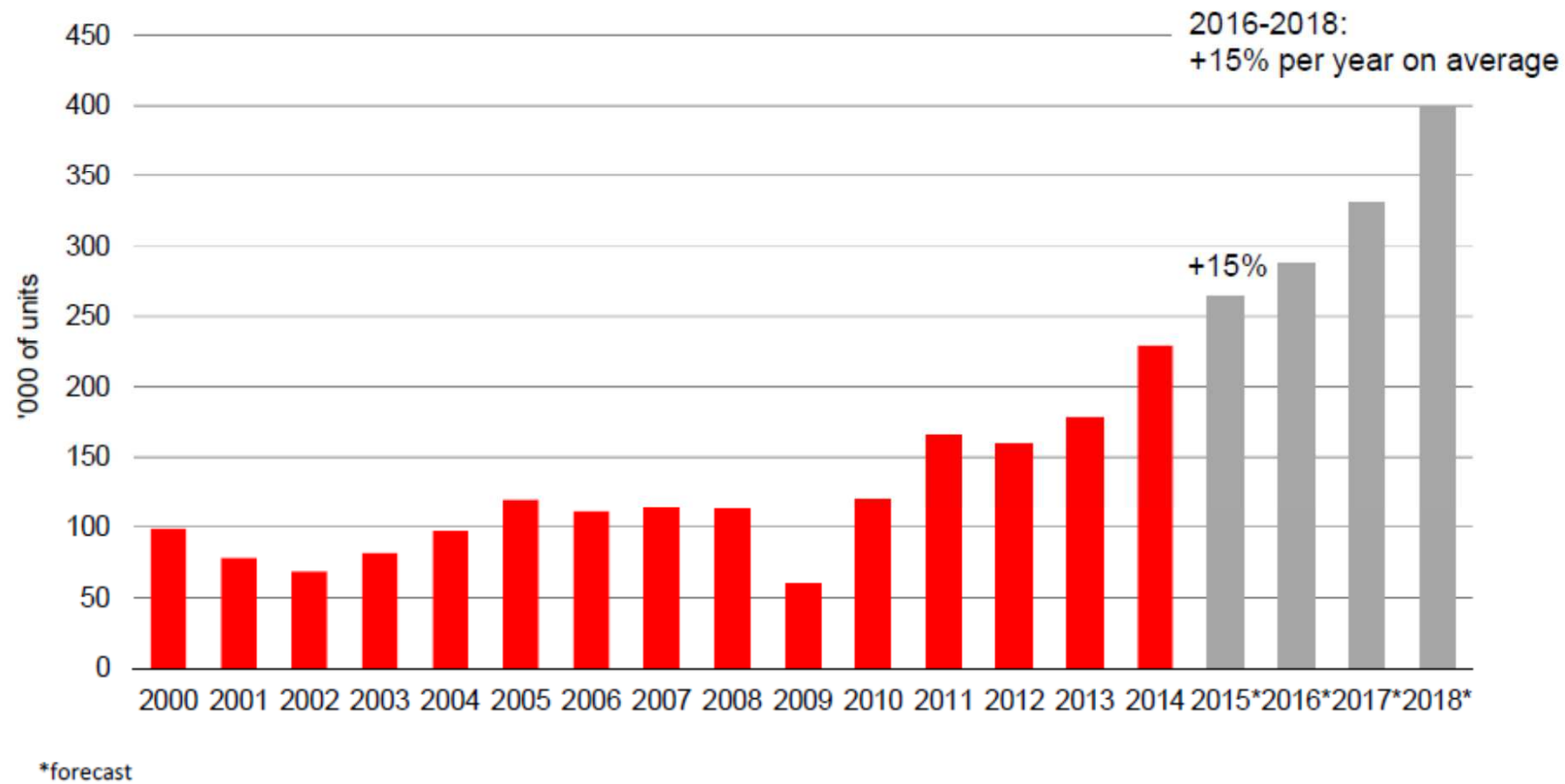
Just released!





Industrial robotics: some statistics

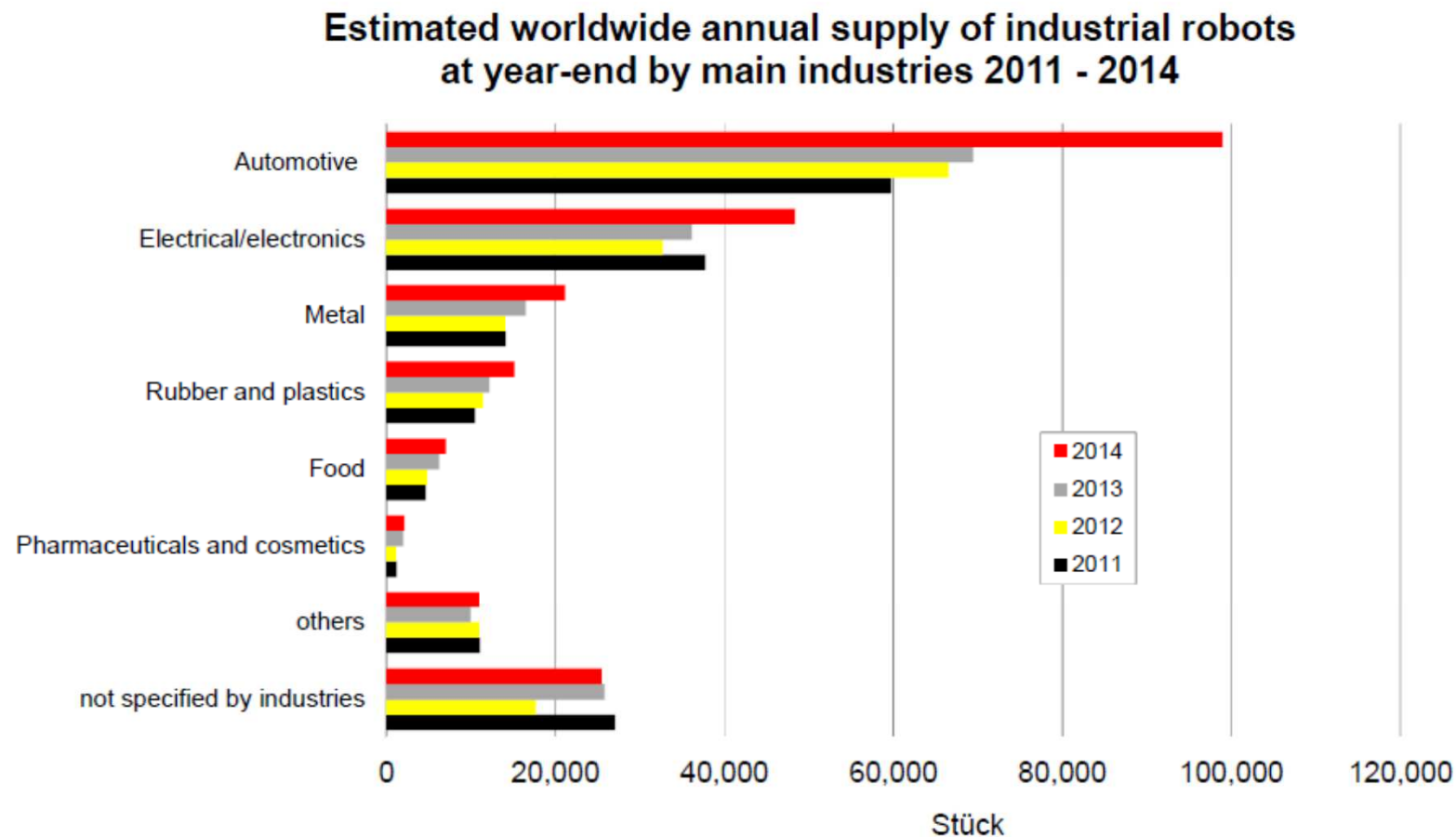
Worldwide annual supply of industrial robots
2000 - 2018*



Source: IFR World Robotics 2015



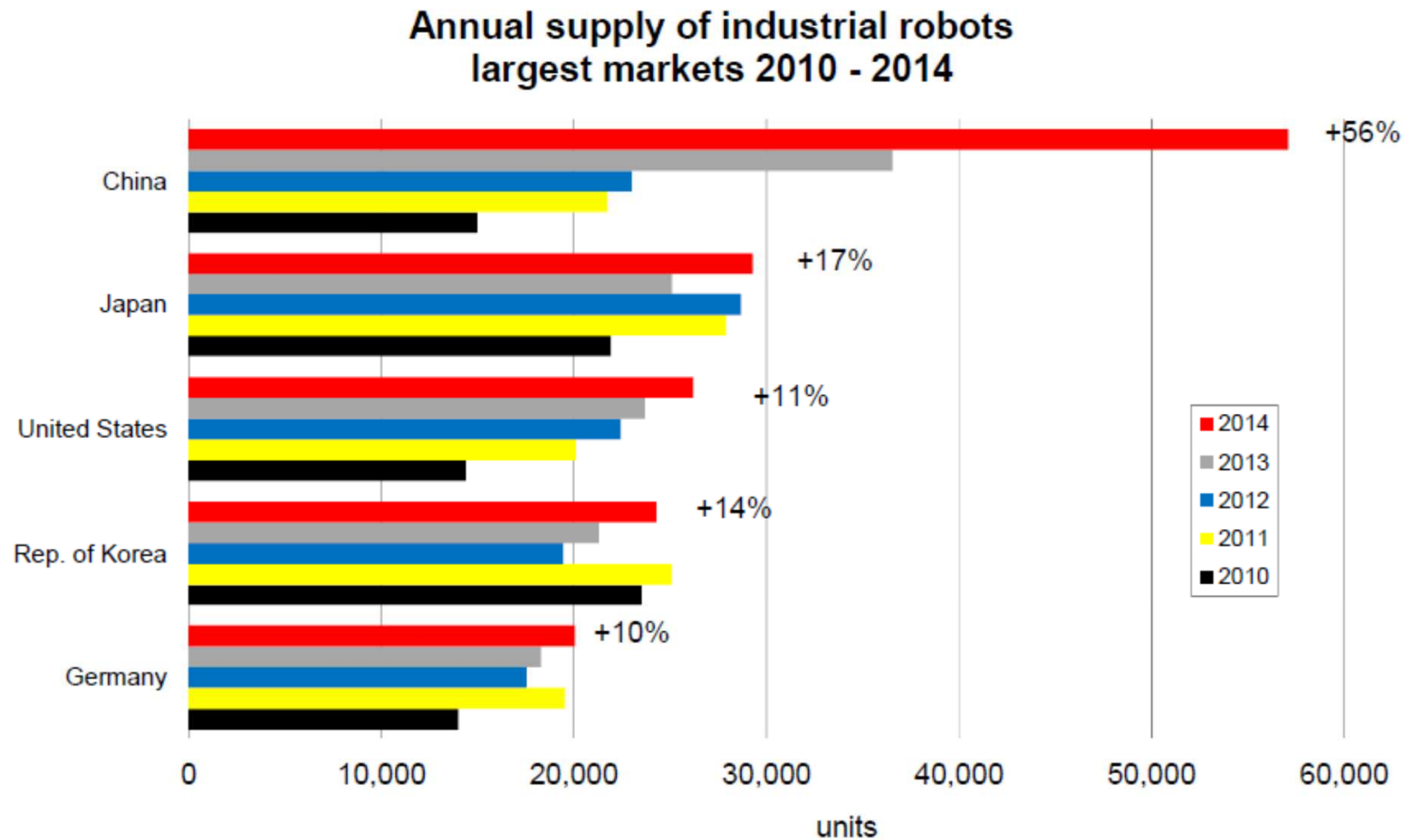
Industrial robotics: some statistics



Source: IFR World Robotics 2015



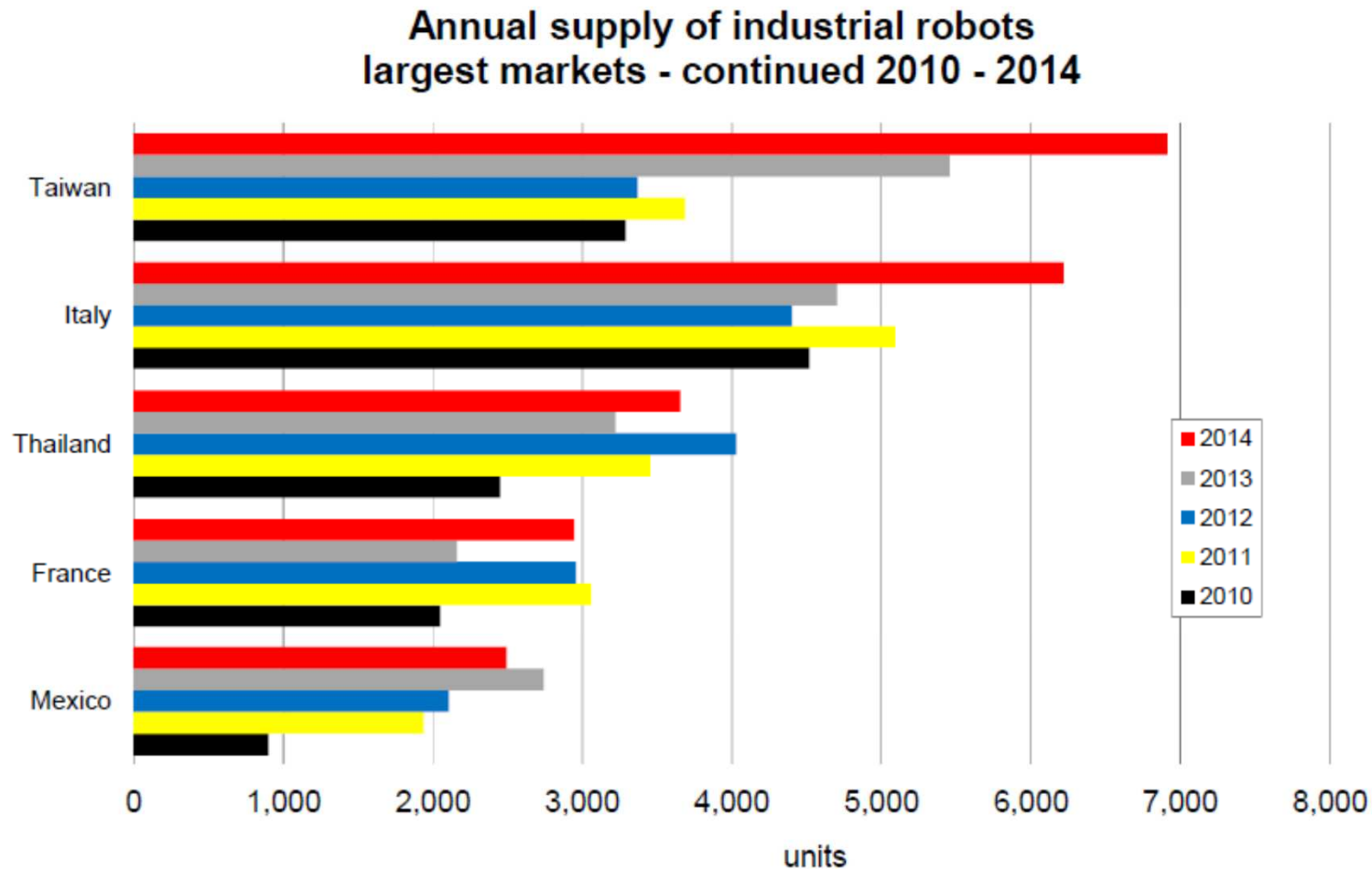
Industrial robotics: some statistics



Source: IFR World Robotics 2015



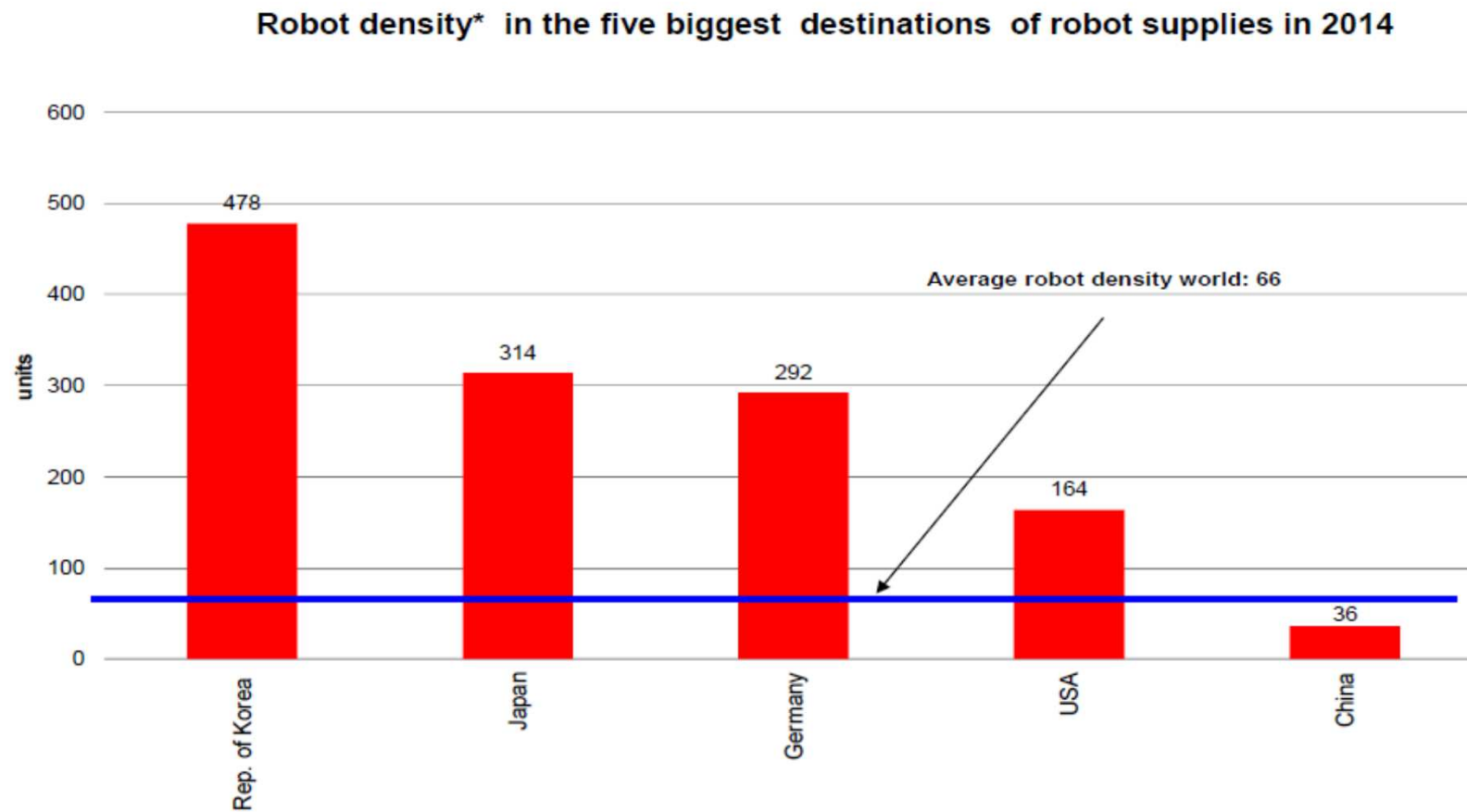
Industrial robotics: some statistics



Source: IFR World Robotics 2015



Industrial robotics: some statistics



*Number of multipurpose industrial robots (all types)
per 10,000 employees in the manufacturing industry (ISIC rev.4: C) 2014

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

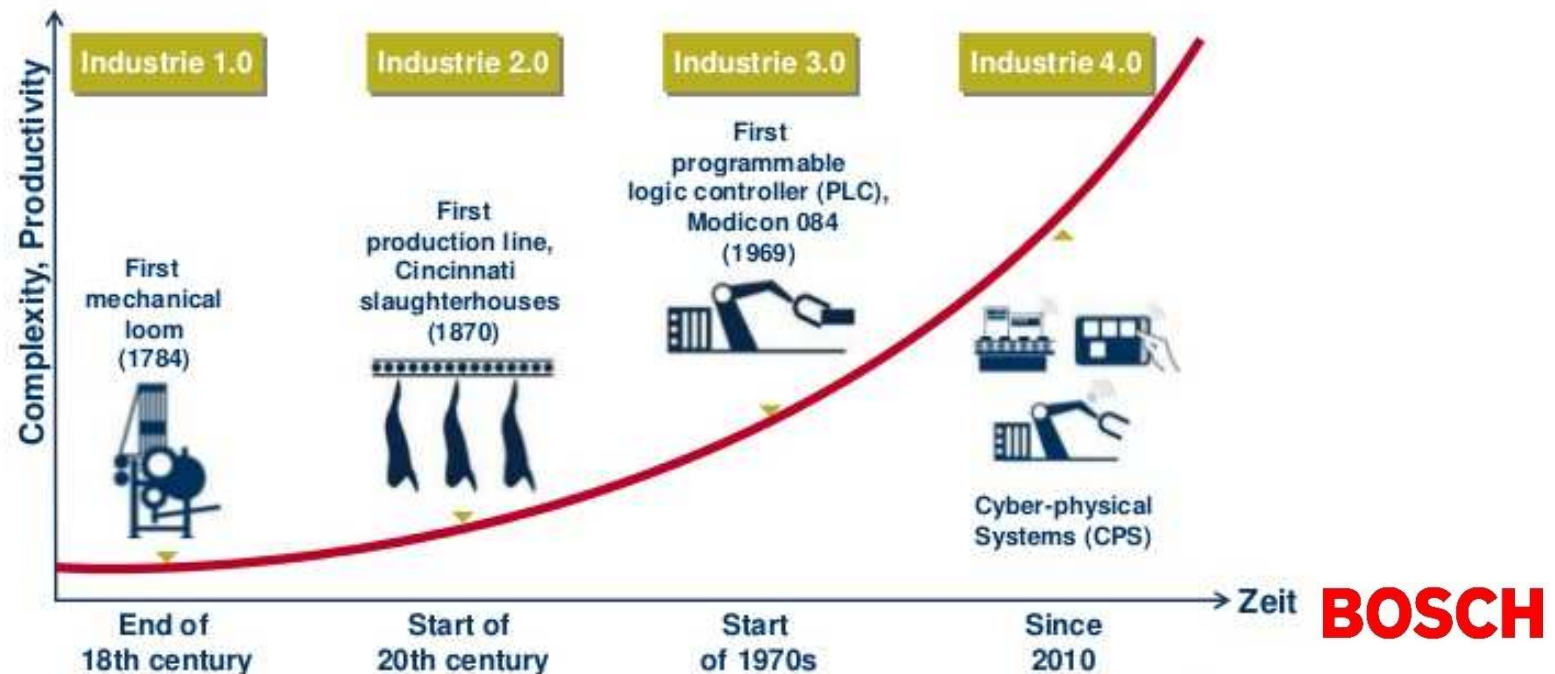
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Source: Trendonline

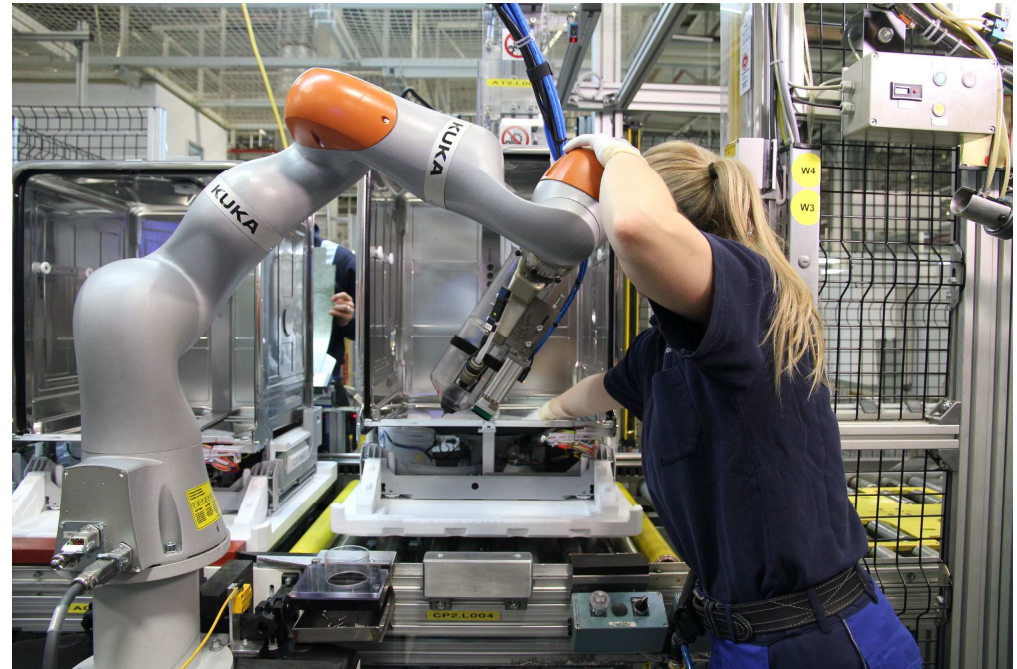


- Robots as key components in the manufacturing of Industry 4.0
- Integration of machinery, warehousing systems and production facilities as Cyber-Physical systems
- Flexibility, cost effectiveness and productivity in smart factories





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



Source: KUKA



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

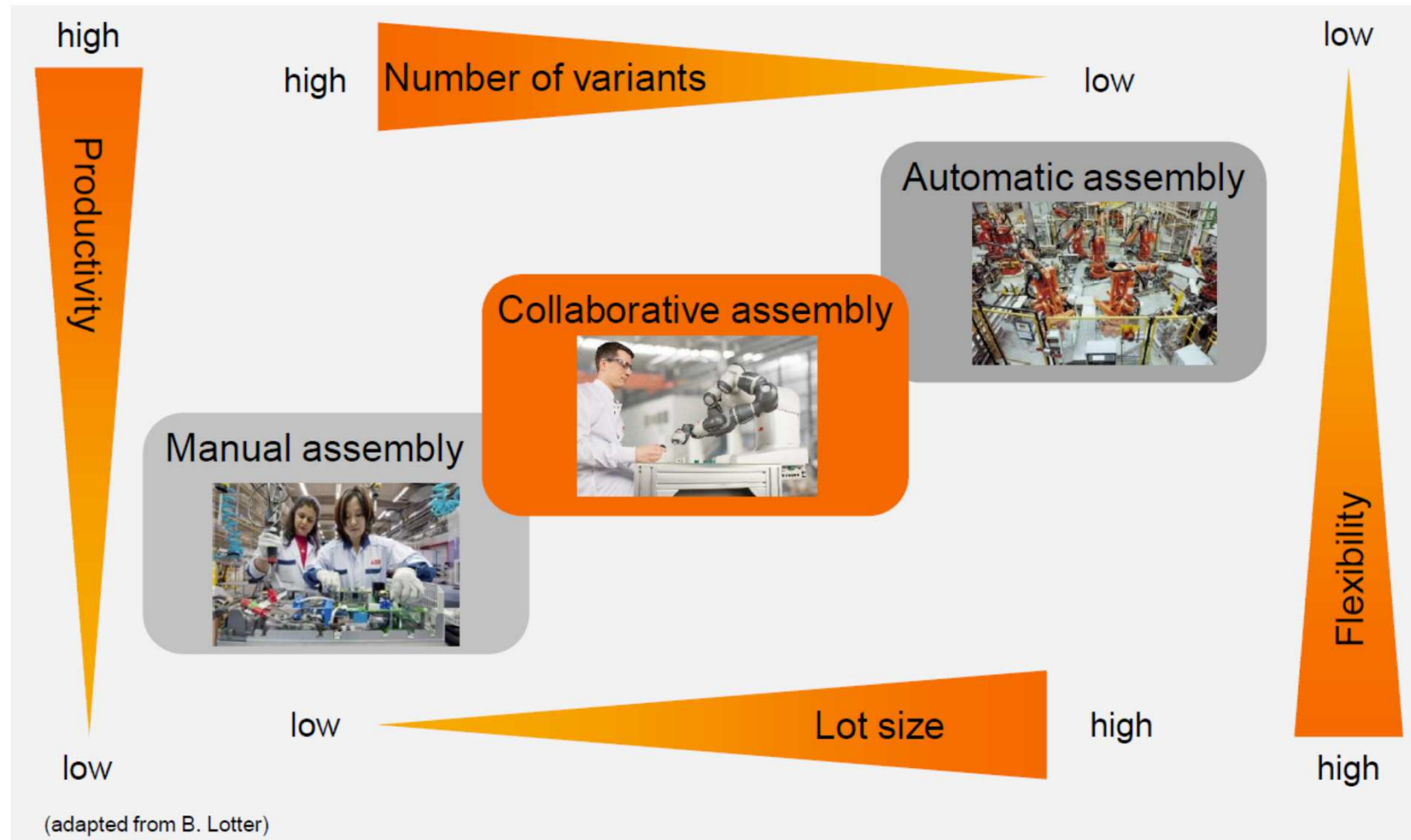


Source: ABB



Collaborative robotics

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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

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- 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

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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)



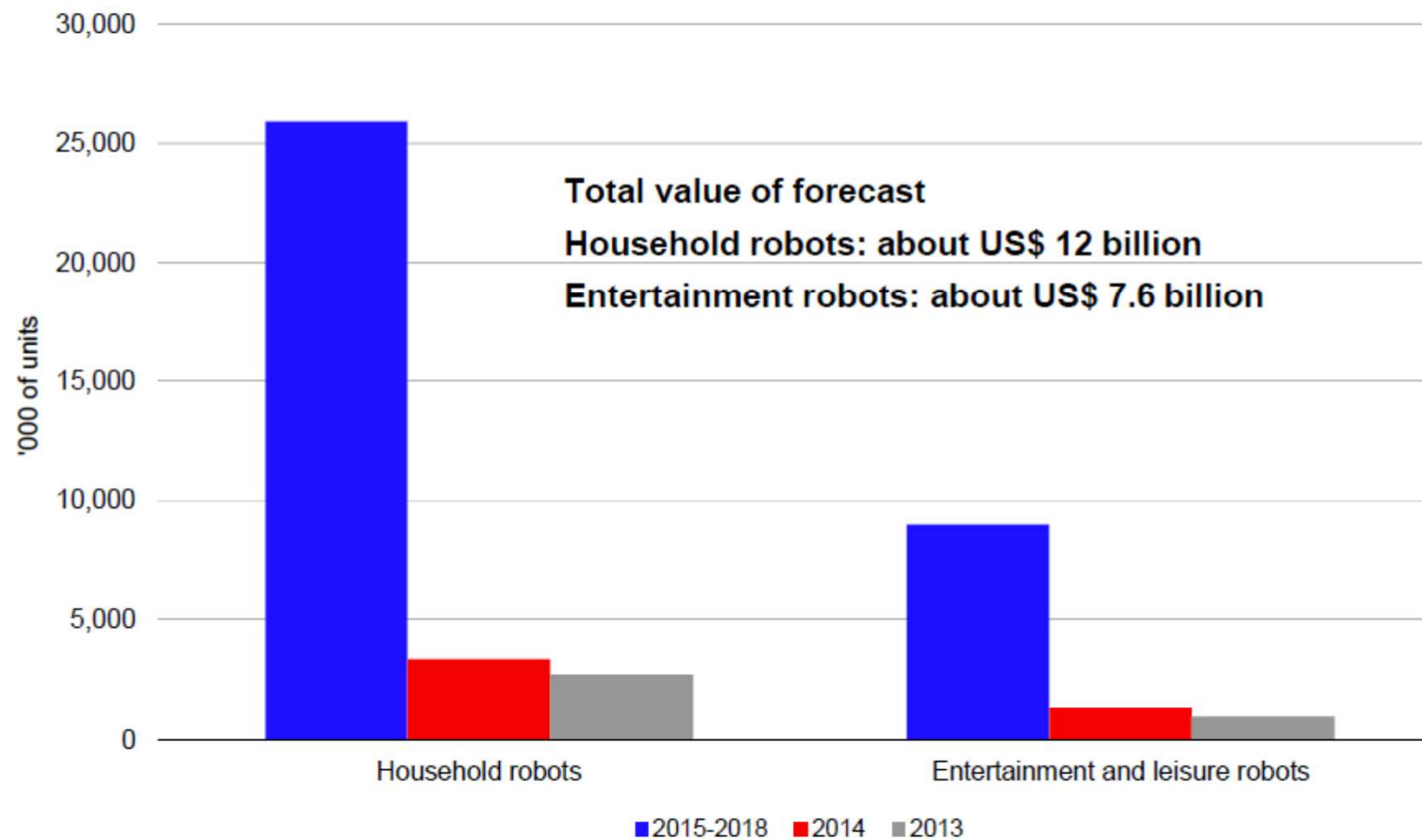
Source: RobotWorx



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



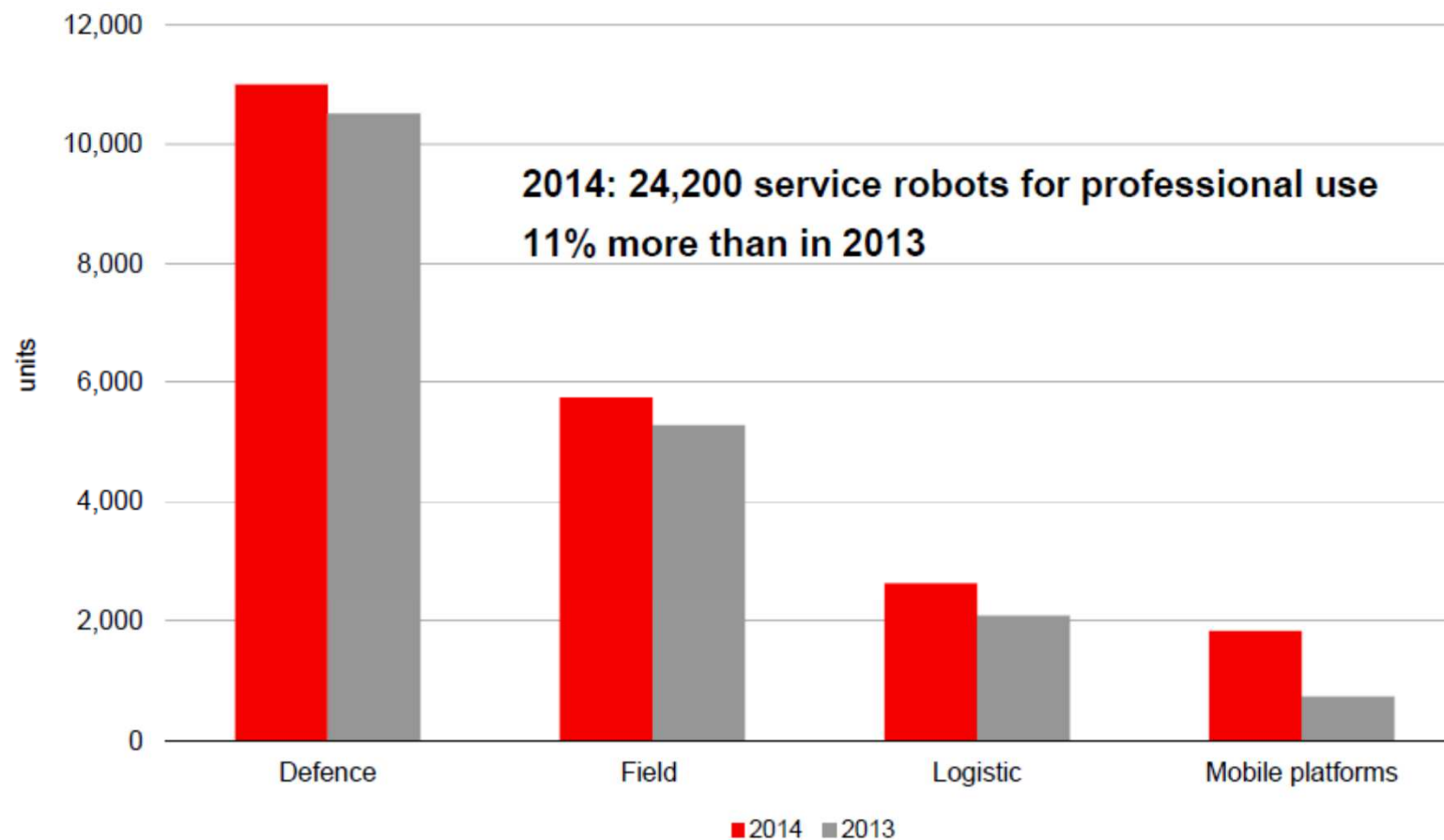
Source: Thymio



Source: Vorwerk



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?

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Source: Ufficio marchi e brevetti



Top ten keywords of the presented papers

Human-Robot Interaction

Unmanned Aerial Systems

Motion and Path Planning

Computer Vision

SLAM

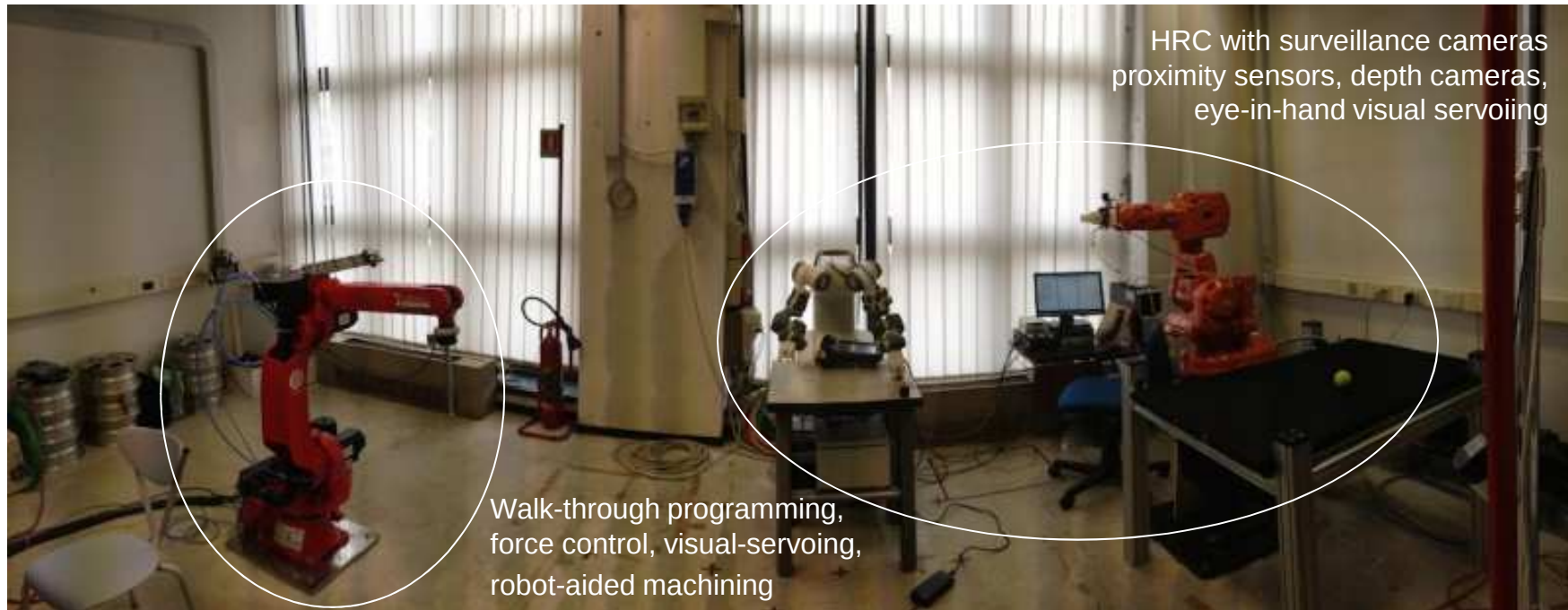
Surgical Robotics

Biologically-Inspired Robots

Force and Tactile Sensing

Mapping

Localization



merlin.elet.polimi.it

www.facebook.com/merlinpolimi

www.youtube.com/MERLINpolimi

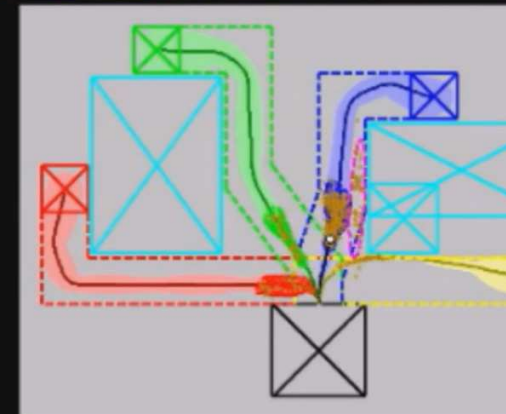




Human detection and intention estimation



Human is walking
towards the BLUE
destination





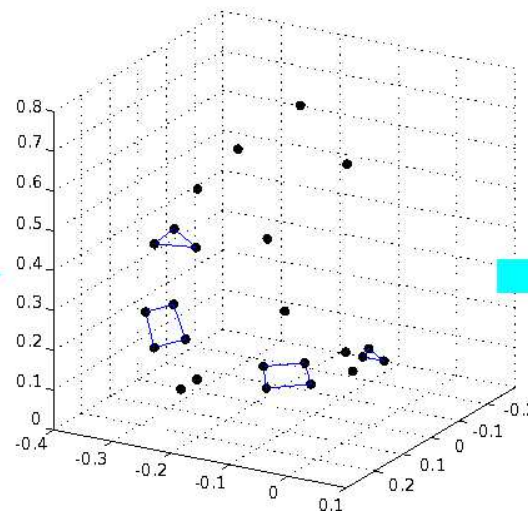
Human-like trajectories

30

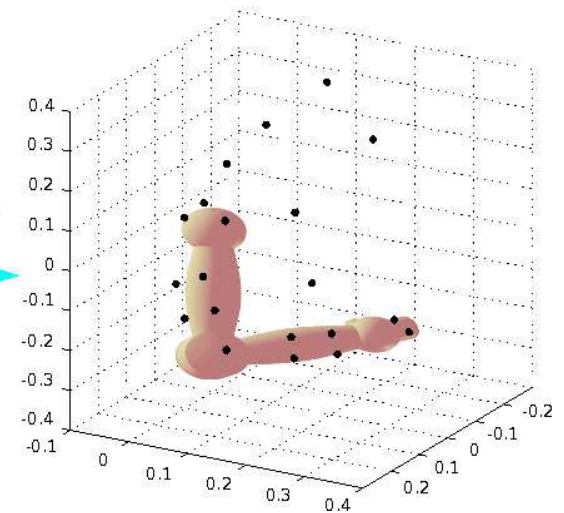
From marker to motion of an equivalent 7 dof arm:



MOTION
CAPTURE



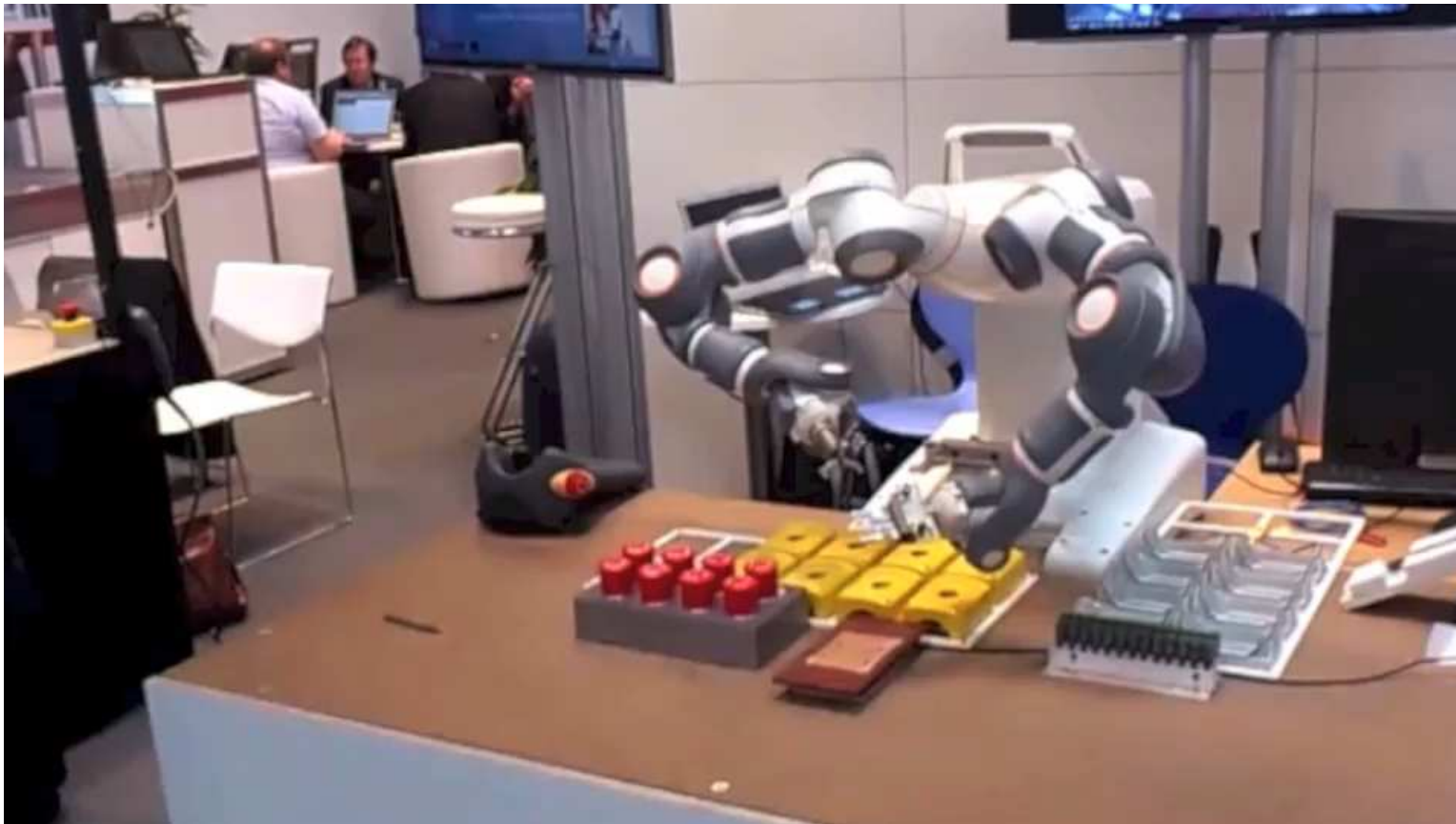
KALMAN
SMOOTHING





Human-like trajectories

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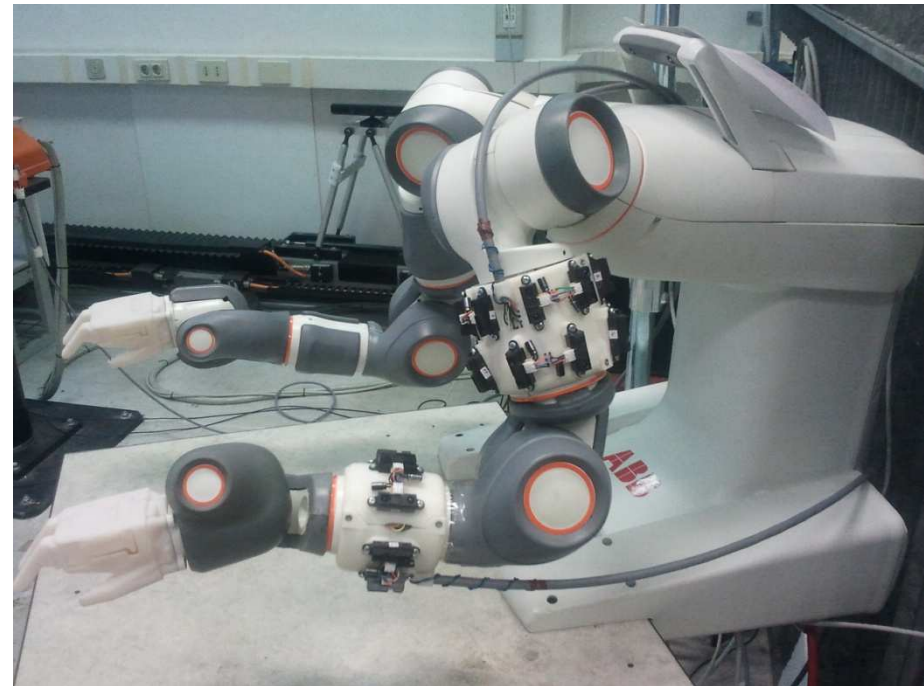


Sensor based reactive control

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





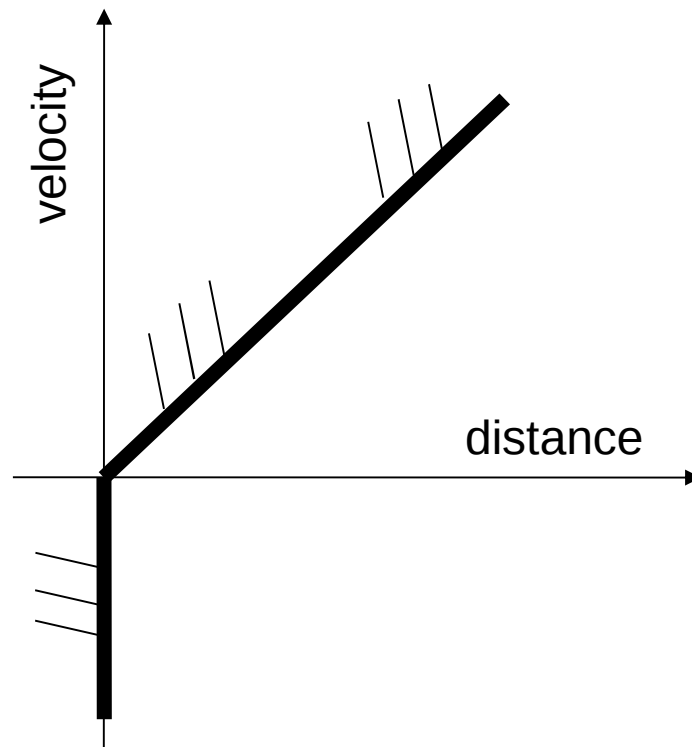
Sensor based reactive control





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

$$\text{Distance} \geq \text{Velocity} * \text{StoppingTime}$$



Productivity aims at maximizing the robot speed along the path

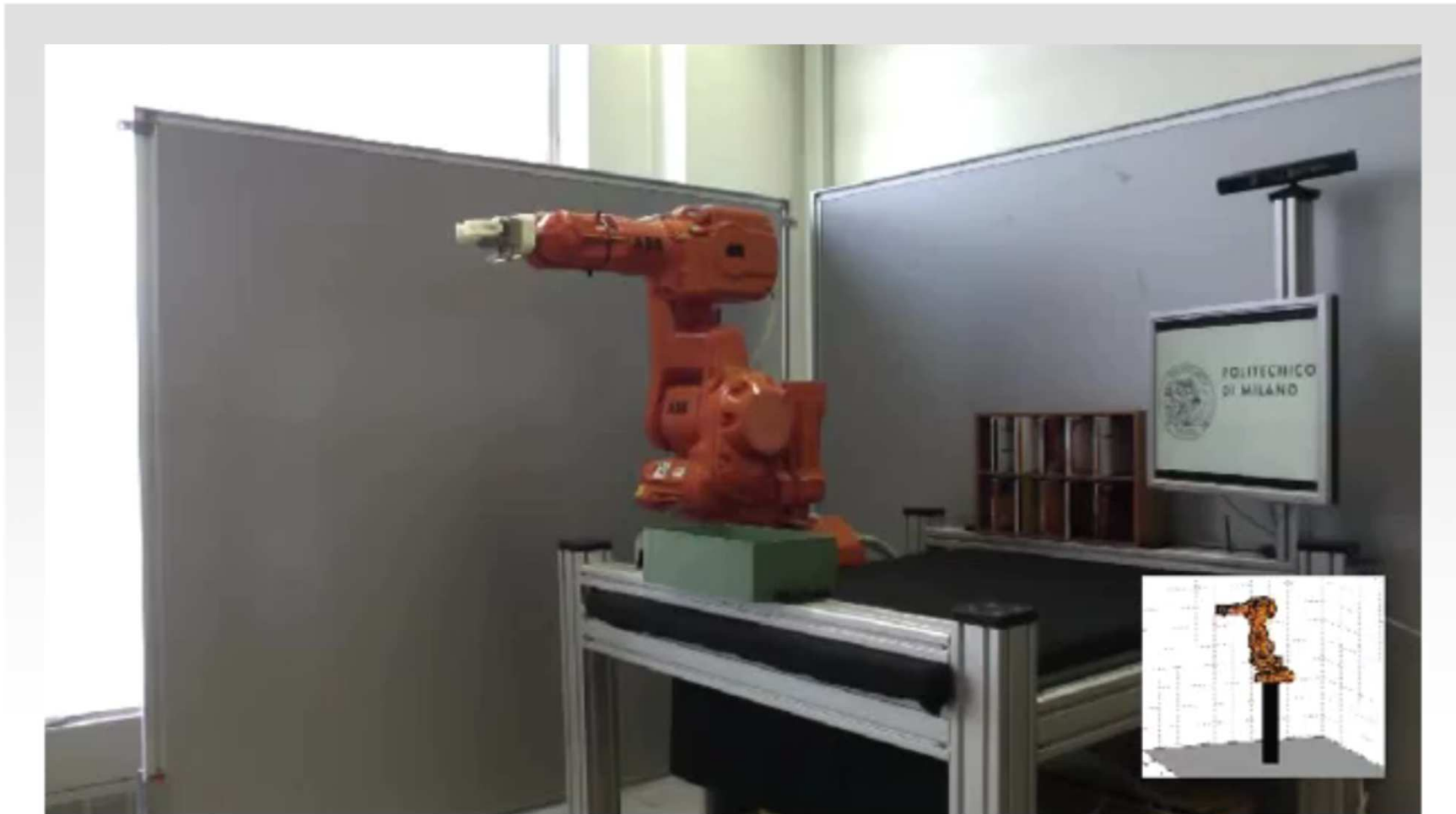


Safety constraints might require the robot to slow down on path



Safety as a motion constraint

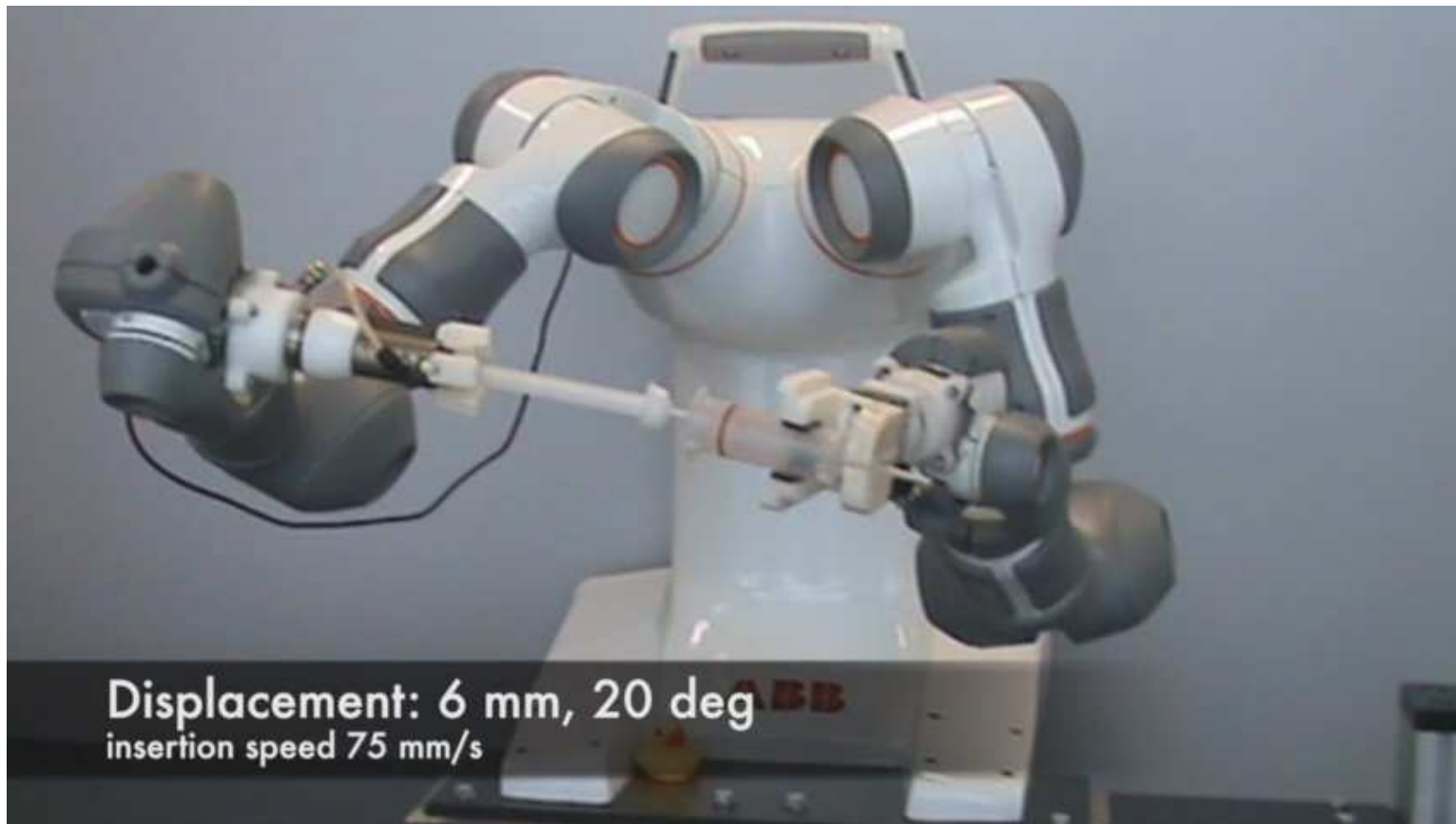
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New dual-arm applications

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