Robotics impacts Industry and Society: What are the Numbers and Trends?

ROS-Industrial Conference 2019; Stuttgart, 10-12 December 2019

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Fraunhofer IPA as part of the Fraunhofer-Gesellschaft

Fraunhofer Institute for Manufacturing Engineering and Automation IPA

- One of the largest institutes of the Fraunhofer-Gesellschaft
- IPA located in Stuttgart, the capital of federal state of Baden-Württemberg
- IPA: More than 1,000 employees
- 60 years of experience implementing innovations for the industry
- Main customers are equipment/ machinery and automotive industry
- 74 M€ Budget in 2018, 28 M€ industrial revenues
Diversity of Research Missions
Main Pillars

<table>
<thead>
<tr>
<th>Fraunhofer</th>
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</thead>
<tbody>
<tr>
<td><strong>Application oriented Research</strong></td>
</tr>
<tr>
<td><strong>Research and Education</strong></td>
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<tr>
<td><strong>Pursues the long-term research goals of state and society</strong></td>
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<tr>
<td><strong>Knowledge-driven and applied basic research</strong></td>
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<tr>
<td><strong>Basic research – curiosity driven</strong></td>
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</table>

Universities

**Fraunhofer**

**Universities**

**Helmholtz Gemeinschaft**

**Leibniz-Gemeinschaft**

**Max-Planck-Gesellschaft**
CyberValley  A cluster for artificial intelligence and robotics

- Europe’s largest research consortium for artificial intelligence
- Partners from academia, business, and society
- Attracts researchers from around the world
- Offers a European perspective

Spokesperson:
Dr. Michael J. Black
MPI for intelligent systems

Baden-Württemberg
MAX PLANCK
Gesellschaft
Universität Stuttgart
EBERHARD KARLS
UNIVERSITÄT TÜBINGEN
Fraunhofer
amazon
BMW
BOSCH
DAIMLER
Porsche
ZF
AI innovation center Learning Systems

Overview

Example from Max-Planck Institute for Intelligent Systems: Learning control
Technical equipment and laboratories
In tune with the times

- Application Center Industrie 4.0
- Motion laboratory
- Machine vision laboratories
- Biomanufacturing laboratory
- Factory planning and production laboratory
- Future Work Lab
- Electroplating laboratory
- Intervention room
- Labs for additive manufacturing
- Labs for cutting, joining and sawing
- Coating technology center
- n/CLAS Laboratory automation
- Cleanrooms & cleanliness rooms
- Robotics experimentation area
- Model factory for functional coatings
- Virtual Orthopedic Lab

Fraunhofer
Worldwide shipments of industrial robotics in 2018
Most relevant industrial application areas and processes

- Handling (42%)
- Welding (21%)
- Assembly (11%)
- Clean Room (10%)
- Machining (1%)
- Dispensing (3%)

World Robotics Report; [www.worldrobotics.org](http://www.worldrobotics.org), Sept. 2019
Industrial robot shipments (new installations)
All time high in 2018 and positive prospects

Robot density 2018: Number [units] of installed industrial robots per 10,000 employees in the respective domains

Increase 2018/2017: 6%
2020 robot stock estimated 3.15m
CAGR China since 2013: 23%
Collaborative robots: ~3%
Major growth applications:
• Automotive ~30%
• Metal industry 10%
• 3C (mainly Asia) 25%
• Food (on low volume) 3%

www.worldrobotics.org, September 2019, Fraunhofer IPA
Technology Trends in Industrial Robotics

Cost effectiveness

- Cost 1991 = 100%

- Labor cost (D): €3,5k (2017)
- Robot unit price: $42k (2017)

Human-Robot Collaboration

- Networked → Industrie4.0

- Cognitive capabilities

- Skill-based, intuitive robot instruction

Robot Optimization by AI/Machine Learning

1 Processes, tasks
  - Physical interaction
  - Learning control
  - Strategies, skills

2 Program generation
  - Planning
  - HMI
  - Behavior explanation

3 Robot performance
  - Accuracy
  - Dynamics
  - Durability etc.
Service Robots for Professional Use I
Service Robots for Professional Use II

Industrial and service robotics supply industries

Key figures Industrial Robotics IR (est.)
- US$16.5bn turn-over Industrial Robots (IR)
- 55 IR manufacturers worldwide
- 1k systems integrators
- $50-55bn total turnover IR industries
- 15% CAGR until 2020+ (estimated)
- Average unit price US$53k (2012) → 42k (2017)

Key figures Service Robotics SR
- >$12.9bn turn-over (US$9.2bn professional service robotics, 3.7bn in “domestic/personal”
- >750 suppliers/manufacturers of SR, ~25% start-ups (max. 5 years)
- 70% use ROS in one form or the other (estimated)
- 41% CAGR (estimation until 2022) for professional SR
- 46% CAGR (estimation until 2022) for domestic/personal SR
Statistics Scheme and Classification of Service Robots by Application Areas

- Size
- Age
- Status
- Region

Professional use
16-21 Field robotics
22-26 Professional cleaning
27-29 Inspection, maintenance systems
30-33 Construction and demolition
34-38 Logistic systems
39-42 Medical robotics
43-45 Rescue & security applications
46-50 Defense applications
51 Underwater systems (civil/general use)
52 Powered Human Exoskeletons
53 Mobile Platforms in general use
54-58 Underwater systems (civil/general use)
59 Other

www.worldrobotics.org, September 2019, Fraunhofer IPA
Service Robots for Professional and Domestic Use (Main Applications) Estimated Values 2017 and 2018; forecasts(*) 2019 - 2022

Professional Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>2017**</th>
<th>2018</th>
<th>2019*</th>
<th>2020*</th>
<th>2021*</th>
<th>2022*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logistics</td>
<td>2.4</td>
<td>3.7</td>
<td>5.7</td>
<td>6.9</td>
<td>14.1</td>
<td>22.5</td>
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<tr>
<td>Medical robotics</td>
<td>2.2</td>
<td>2.8</td>
<td>3.7</td>
<td>5.0</td>
<td>6.7</td>
<td>9.1</td>
</tr>
<tr>
<td>Field robotics</td>
<td>1.0</td>
<td>1.1</td>
<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Defense</td>
<td>1.0</td>
<td>1.2</td>
<td>1.3</td>
<td>1.5</td>
<td>1.7</td>
<td></td>
</tr>
</tbody>
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Domestic Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>2017**</th>
<th>2018</th>
<th>2019*</th>
<th>2020*</th>
<th>2021*</th>
<th>2022*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robots for domestic tasks</td>
<td>2.0</td>
<td>2.5</td>
<td>3.3</td>
<td>4.6</td>
<td>6.5</td>
<td>9.7</td>
</tr>
<tr>
<td>Entertainment</td>
<td>1.1</td>
<td>1.1</td>
<td>1.3</td>
<td>1.4</td>
<td>1.5</td>
<td>1.7</td>
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</tbody>
</table>

*forecast, **revised
Robotics Outside the Manufacturing Scenario

Service robot (SR) annual sales worldwide for professional, domestic applications in [bnUS$]

Number of service robot manufacturers (professional and domestic use) by country of origin (2019, excerpt)

Main applications:
- Logistics
- Agricultural
- Medical
- Public relations

2016: Drones taken out

Start-ups (aged max 5 years, with product on the market)

Total of 753 SR manufacturers

Source: World Robotics 2019; www.worldrobotics.org, Fraunhofer IPA
Number of service robot manufacturers by main types (professional use) and by region of origin, status 2018 (selection)
Business sizes of service robots of all types in numbers of employees (by region of origin, 2018)
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