INDUSTRIAL AND SERVICE ROBOTICS: STATE OF THE ART AND FUTURE TRENDS

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Past President IFR
SIRI Board Member
International Federation of Robotics
Representing the global robotics industry

- Robotics turnover 2017: about $50 billion
- More than 50 members:
  - National robot associations
  - R&D institutes
  - Robot suppliers
  - Integrators
- Sponsor of the annual International Symposium on Robotics (ISR)
- Co-sponsor of the IERA Award
- Primary resource for world-wide data on use of robotics – IFR Statistical Department

Source data August 2018
Structure of Presentation

- Industrial Robots
- Service Robots
Preview on World Robotics 2018

- Industrial Robots 2017
  - Global installations
  - Regions
  - Main Markets
  - Main Customers
  - Challenges of the Robotics Industry

Some figures of the presentation were taken from previous edition of World Robotics
The Birth of Real Industrial Robotics

- First robot installed
- 1961 in GM plant, Trenton NJ
- Handled various hot pieces of diecast metal and stacked them
- Weight 2 tons
- Hydraulically driven
- Controlled by a program on magnetic drums
- Developed by George Devol and Joe Engelberger, 2 pioneers of Robotics
2017: record growth of industrial robots

Estimated worldwide annual shipments of industrial robots

Source: IFR Statistical Department

Source data August 2018
2020: 3 million industrial robots in operation

Estimated worldwide operational stock of industrial robots 2015-2016 and forecast for 2017*-2020*

Source: IFR World Robotics 2017

*forecast

- 2008: 1.035
- 2009: 1.021
- 2010: 1.059
- 2011: 1.235
- 2012: 1.332
- 2013: 1.472
- 2014: 1.632
- 2015: 1.828
- 2016: 2.055
- 2017*: 2.323
- 2018*: 2.644
- 2019*: 3.053

+14% on average per year

N.1 1961
2017: electronics, automotive and metal industry are main drivers

Estimated annual supply of industrial robots at year-end by industries worldwide 2015-2017

- Electrical/electronics: 2017 - 121, 2016 - 91, 2015 - 65
- Metal: 2017 - 45, 2016 - 29, 2015 - 29
- Plastic and chemical products: 2017 - 201, 2016 - 201, 2015 - 201
- Food and beverages: 2017 - 10, 2016 - 8, 2015 - 7
- Others: 2017 - 23, 2016 - 15, 2015 - 8
- Unspecified: 2017 - 25, 2016 - 20, 2015 - 20

Source: IFR Statistical Department

Source data August 2018
2017: considerable increase in all regions

Estimated worldwide annual supply of industrial robots at year-end by regions 2015 - 2017

- Asia/Australia: 191,000 units (2017), 161,000 units (2016), 50,000 units (2015), +37%
- Europe: 56,000 units (2017), 50,000 units (2016), 41,000 units (2015), +18%
- America: 46,000 units (2017), 41,000 units (2016), 38,000 units (2015), +12%
- All others: 6,000 units (2017), 5,000 units (2016), 5,000 units (2015), +11%

Source: IFR Statistical Department

Source data August 2018
Top 5 countries represent 73% of total sales in 2017

Estimated worldwide annual supply of industrial robots at year-end main markets 2015 – 2017*

- **China**: 138,000 units (+58%)
- **Japan**: 87,000 units (+18%)
- **Rep. of Korea**: 41,000 units (-4%)
- **United States**: 46,000 units (+6%)
- **Germany**: 28,000 units (+8%)

*preliminary results of 2017

Source: IFR Statistical Department

Source data August 2018
China: Main driver of growth in 2017

Annual shipments of industrial robots in China 2007 - 2017

Source: IFR Statistical Department

Source data August 2018
Italy: double digit growth 2017 vs 2016 (IFR data) and first half 2018 vs first half 2017 (SIRI UCIMU data)

IFR data 2017 vs 2016 2015

SIRI UCIMU data 1st half 2018 vs 1st half 2017
Italy: focus on first half 2108 vs first half 2017
Source: Deformazione - PubliTec Ottobre 2018 on SIRI UCIMU data

<table>
<thead>
<tr>
<th>Source</th>
<th>Value</th>
<th>Value</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1° sem. 2017</td>
<td>3.870</td>
<td>5.072</td>
<td>31.1%</td>
</tr>
</tbody>
</table>

### Stima del mercato di robot articolati, scara, cinematica parallela, cartesiani, collaborativi e altri.

<table>
<thead>
<tr>
<th>TOTALE ROBOT ORDINATI</th>
<th>1° sem. 2017</th>
<th>1° sem. 2018</th>
<th>Var. 18/17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto</td>
<td>54</td>
<td>59</td>
<td>9.3%</td>
</tr>
<tr>
<td>Tier1/Tier2</td>
<td>231</td>
<td>283</td>
<td>22.5%</td>
</tr>
<tr>
<td>General Industry</td>
<td>509</td>
<td>564</td>
<td>10.8%</td>
</tr>
<tr>
<td>Robot ordinati tramite terzi</td>
<td>2.462</td>
<td>3.264</td>
<td>32.6%</td>
</tr>
<tr>
<td>Automotive/ Tier 1/ Tier 2</td>
<td>309</td>
<td>431</td>
<td>39.5%</td>
</tr>
<tr>
<td>General Industry</td>
<td>2.153</td>
<td>2.833</td>
<td>31.6%</td>
</tr>
<tr>
<td><strong>TOTALE ROBOT ORDINATI</strong></td>
<td><strong>3.256</strong></td>
<td><strong>4.170</strong></td>
<td><strong>28.1%</strong></td>
</tr>
</tbody>
</table>

### Robot antropomorfi e scara censiti (unità e quote % sul totale)

<table>
<thead>
<tr>
<th>Numero robot</th>
<th>1° sem. 2017</th>
<th>1° sem. 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antropomorfi</td>
<td>90.5%</td>
<td>89.6%</td>
</tr>
<tr>
<td>Scara</td>
<td>9.5%</td>
<td>10.4%</td>
</tr>
</tbody>
</table>

Arturo Baroncelli
Rep. of Korea: considerable increase since 2010

Estimated annual supply of industrial robots in the Rep. of Korea 2008-2016 and 2017*-2020*

Source: IFR World Robotics 2017

+5% to +10% on average per year

Source: IFR World Robotics 2017
Japan: significant recovery and continued growth

Estimated annual supply of industrial robots in Japan 2008-2016 and 2017*-2020*

Source: IFR World Robotics 2017
USA: considerable increase since 2010

Estimated annual supply of industrial robots in the USA 2008-2016 and 2017*-2020*

+15% on average per year

Source: IFR World Robotics 2017
Germany: moderate increase at record levels

Estimated annual supply of industrial robots in Germany 2008-2016 and 2017*-2020*

Source: IFR World Robotics 2017
2020: 1.9 million operating in Asian factories

Estimated worldwide operational stock of industrial robots 2015-2016 and forecast for 2017*- 2020*

Source: IFR World Robotics 2017*
2020: 950,000 robots operating in China

Estimated operational stock of industrial robots in China and in Japan 2015-2016 and forecast for 2017*-2020*

Source: IFR World Robotics 2017
Density of Robots

Density of Robots = Robots / 10.000 Manufacturing Employees

World average = 74

Republic of Korea at the top = 631

China = 49. Enormous potential to further growth.
Density of Robots

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World average = 74
Republic of Korea at the top = 631
China = 49. Enormous potential to further growth.

Source: World Robotics 2017
Today’s trends, tomorrow’s robots!
The Changing Nature of Manufacturing & Work

- Shift from high volume/low mix to low volume/high mix is having a profound impact on manufacturing.
- Many industries facing acute shortages of skilled labor.
- Quicker automation ROIs and rising wages bringing an end to labour arbitrage.
- Increasing focus on workplace safety.

Today’s Digital Generation doesn’t do “4D” Jobs!
Addressing these Realities: a Huge Opportunity

<table>
<thead>
<tr>
<th>The Trends</th>
<th>The Challenges</th>
<th>The Enablers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low volume high mix</td>
<td>Automation complexity and unpredictability</td>
<td>Collaborative automation for greater flexibility</td>
</tr>
<tr>
<td>Shorter cycles, faster launches</td>
<td>Shop floor disruptions and high engineering costs</td>
<td>Better software for engineering efficiency</td>
</tr>
<tr>
<td>Increased need for automation and scalability in SMEs</td>
<td>Lack of robot integration and programming expertise</td>
<td>Easier to use robots with more intuitive programming</td>
</tr>
<tr>
<td>Rising cost of downtime</td>
<td>Higher lifetime TCO due to increase in planned downtime</td>
<td>Advanced analytics and services for greater reliability</td>
</tr>
<tr>
<td>Increased and sporadic human intervention</td>
<td>Lost productivity to maintain safety</td>
<td>Collaborative automation to maintain safety and productivity</td>
</tr>
</tbody>
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The Answers to these challenges lie in Simplification, Digitalisation and Collaboration.
Robots which are easier to install, program and operate will unlock entry barriers to the large, untapped market of small and medium enterprises (SMEs).

- Trend towards having production closer to the end consumer driving the importance of standardisation & consistency across global brands.

Simplification critical to SMEs, but also important for large Global Manufacturers.
Industry 4.0, linking the real-life factory with a virtual one, will play an increasingly important role in global manufacturing.

Vision and sensing devices, coupled with analytics platforms, will pave the way for new industry business models.

Machine Learning will drive many robotics developments over the coming years.

Digitalisation

Big Data allowing People to make better Decisions about Factory Operations
Collaboration

• Collaborative robots are shifting the traditional limits of “what can be automated?”

• Collaborative robots increase manufacturing flexibility as ‘low volume high mix’ becomes the new normal

• Collaboration is also about productivity with increased human/robot interaction

Collaboration means different Things to Different People, but is changing the Face of Manufacturing
Self-optimising Production

Robots doing the same task connect across all global locations so performance can be compared and improved at the click of a button.

Self-programming Robots

Robots automatically download what they need to get started from a cloud library and then start to optimise through “self-learning”.

Connected & Collaborative Robots enable SMART Manufacturing for both SMEs & Global Enterprises
Structure Of Presentation

- Industrial Robots
- Service Robots
A **service robot** is a robot that performs useful tasks for humans or equipment excluding industrial automation application.

Note: The classification of a robot into industrial robot or service robot is done according to its intended application.

- A **personal service robot** or a service robot for personal use is a service robot used for a non-commercial task, usually by *lay persons*. Examples are domestic servant robot, automated wheelchair, personal mobility assist robot, and pet exercising robot.

- A **professional service robot** or a service robot for professional use is a service robot used for a commercial task, usually operated by a *properly trained operator*. Examples are cleaning robot for public places, delivery robot in offices or hospitals, fire-fighting robot, rehabilitation robot and surgery robot in hospitals. In this context an operator is a person designated to start, monitor and stop the intended operation of a robot or a robot system.
What is a service robot?

### Industrial Robots
- Industrial environments

### Service Robots
- **Professional Use**
- **Personal/domestic**
- Non-industrial environments

Picture source: Goldbeck, ;KUKA AG, Bosch Bonirob, Hetwin, SMP Robotics, Omron, International Submarine Engineering , Robert Bosch Hausgeräte , Wonder Workshop
Professional Service Robots

Source: IFR World Robotics
Professional service robots: significant growth

2016: almost 60,000 units, +24%

Forecast 2017: +17% -almost 79,000 units

Forecast 2018 -2020: about 400,000 units
20% to 25% on average per year
Professional service robots: increasing turnover

2016: 4.7 US$bn, +2%

Forecast 2017: +12% - 5.2 US$bn

20% to 25% on average per year
Main drivers: logistic systems

Service robots for professional use. Main applications
Units sales 2015 and 2016, forecast 2017*, 2018*-2020*

*forecast

Source: World Robotics 2017
Public relation robots and exoskeletons on the rise

Service robots for professional use. All other applications - 1 - Units sales 2015 and 2016, forecast 2017* and 2018*-2020*

<table>
<thead>
<tr>
<th>Category</th>
<th>2015</th>
<th>2016</th>
<th>2017*</th>
<th>2018*-2020*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public relation</td>
<td>66.1</td>
<td>10.3</td>
<td>7.5</td>
<td>3.2</td>
</tr>
<tr>
<td>Exoskeletons</td>
<td>41.0</td>
<td>8.1</td>
<td>6.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Medical</td>
<td>10.7</td>
<td>2.0</td>
<td>1.6</td>
<td>1.3</td>
</tr>
<tr>
<td>Construction</td>
<td>3.2</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
</tr>
</tbody>
</table>

*forecast

Source: World Robotics 2017
Good prospects for cleaning robots

Service robots for professional use. All other applications - 2 -
Units sales 2015 and 2016, forecast 2017* and 2018*-2020*

*forecast

Source: World Robotics 2017
Medical robots: most valuable

Service robots for professional use in main applications. Estimated values 2015 and 2016, forecast 2017*, 2018*-2020*

Source: World Robotics 2017*forecast
Public relation robots: significant increase of turnover

Service robots for professional use. All others
Estimated value 2015 and 2016, forecast 2017*, 2018*-2020*

Source: World Robotics 2017*
Professional service robots: more than 50% from the Americas

Service robots for professional use
Unit sales 2015 and 2016 by region of origin

Source: World Robotics 2017
Personal Service Robots

Main categories:
- Vacuum and floor cleaning
- Lawn-mowing robots
- Entertainment and leisure robots
- Robots for elderly and handicap assistance
Personal/domestic robots on the rise

Service robots for personal/domestic use. Unit sales 2015 and 2016 by region of origin.

Source: World Robotics 2017
2016 - 2019: 42 million new service robots for personal and domestic use

Total value of forecast:
Household robots: about US$ 13 billion
Entertainment robots: about US$ 9 billion

Figure 2.4 Service robots for personal/domestic use.
Units sales 2014 and 2015, and forecast 2016-2019

Source: IFR World Robotics 2016
• Dynamics of the service robotics industry
• Technological enablers
Number of service robot manufacturers of all types by region of origin (N=699)

Number of service robot manufacturers of all types (professional and personal/domestic use) by region of origin

- EU: 243
- CH, IL, NO: 50
- North America: 242
- Asia: 134
- Others: 30

Source: World Robotics 2017
Europe fares well in service robot start-up creation

Number of service robot manufacturers (professional and personal/domestic use) by country of origin

Criteria for Start-Up:
- Product/prototype on the market
- Business max 5 years of age
29% share of start-ups

Source: World Robotics 2017
75% of European service robot suppliers are SMEs

Business sizes of service robots of all types in numbers of employees
(by region of origin)

- Europe
- North America
- Asia

Source: World Robotics 2017

small and medium sized businesses
Start-up examples (I):
Service robotics in agriculture

Fresh fruit picking robot
Platform for vineyard maintenance
Robotic weeder for vegetable farms

FF Robotics (Israel)  WALL-YE (France)  Naïo Technologies (France)

Source: FF Robotics, WALL-YE, Naio Technologies
Start-up examples (II): Service robots in public-relations

Unity Robotics (D)  Bots and us (UK)  Promobot (RU)

Source: Unity Robotics, Bots and us, Promobot
Start-up examples (III): Service robots in logistics

Mobile Industrial Robots MiR (DK)  Fetch Robotics (USA)  Robotnik (ES)

Source: MiR, Fetch Robotics, Robotnik
Creating a European Eco-System in robotics

- **Robotic key-technologies**: perception, human-machine-interaction, mechatronics, safety, ...
- **Software**: Major cost-/performance factor in service robotics, 30+% cost share
- **Supply industry** for robotics key-components, software (computer vision, motion control, mobile navigation etc.) emerges
- **Open Source Software** systems hugely popular; e.g. >2/3 of all service robot suppliers use Robot Operating System ROS (and other OSS)
- With €700M in funding from EU 2014 – 2020, **SPARC** is the largest civilian-funded robotics innovation initiative in the world.
Conclusions

- Both Industrial and Service Robotics are expected to grow in the forthcoming years at double digit rate.
- Industrial Robots shows an impressive growth in particular in Asian markets. Simplification, digitalization and collaboration are the key developments.
- Service robots are expected to grow in all segments both professional and personal. Most robot producers represented by SME and start ups.
Thanks!

Arturo Baroncelli