Why has the robotic revolution not taken off yet?

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Many analysts have forecasted a bright future for robotics. According to some, the number of installed robots will increase twentyfold until 2025. While the industry is buzzing a lot, the numbers do not confirm the predicted significant increase. The landscape of robotics companies is changing quickly. Many new firms have entered the market, especially in Asia. China has identified robotics as one of the key drivers for the 2025 Made in China strategy and is counting more than 800 robotics companies in 2020.

New products are coming to market quickly. Collaborative robots are on the rise. Open source robot operating systems and advances in artificial intelligence provide additional growth.

On the other hand, if we view the application of robots in industrial environments, there are only limited areas, where the mechanical ghosts are omnipresent. Welding car bodies, gluing and assembly are key areas for robot application in Europe, mobile phone production in China and many service applications in Japan.

Additionally, the application of robots has grown significantly outside the industrial application field. Medical and service robots have been new key application areas while consumer robots have increased significantly in volume.

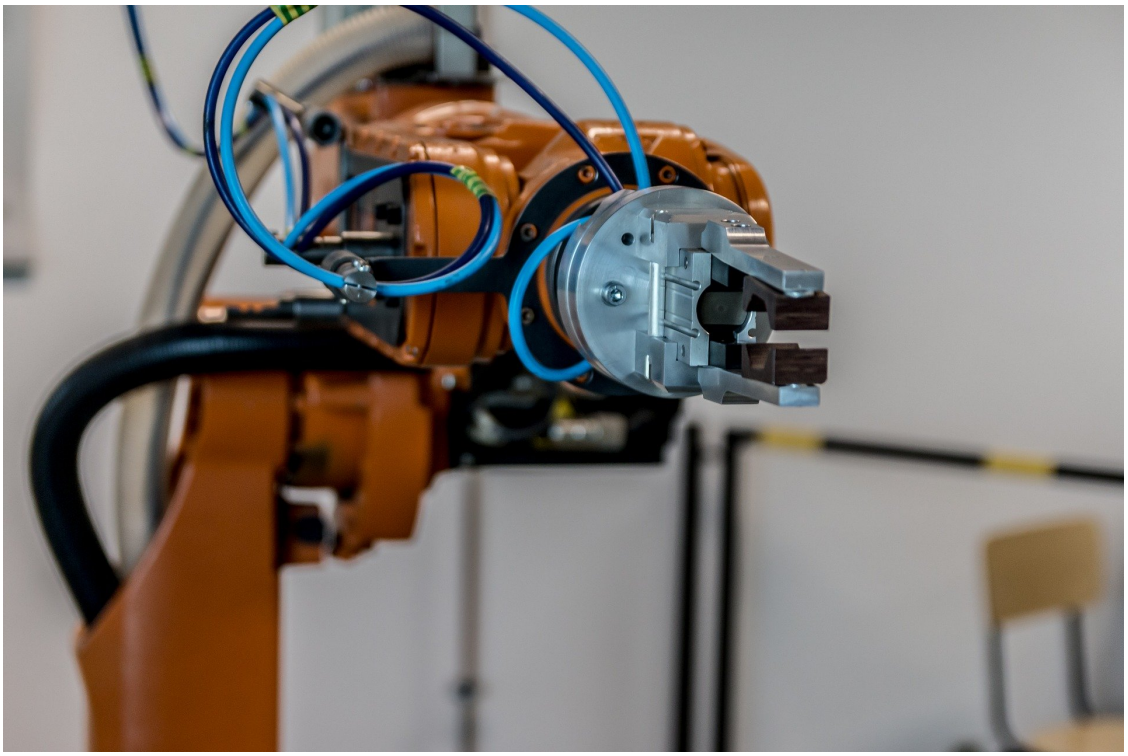

Figure 1: Industrial robot (Source: Jarmoluk)

Looking at the numbers reveals a different story about the success in the robot industry. If we look at the key challenges for the users, there are some obvious trends that will make it difficult for robot manufacturers to increase the volume in the forecasted amounts. This leads to some key activities needed for the robot industry and some key concerns for investors.

Looking at robots by the numbers

There are many very optimistic players in the market. As one robot company alone predicts to sell 1 million collaborative robots per year in 2025, this would increase the volume of installed robots by a factor of three with no competition. If we assume, that this company would achieve 25% of the total market share, the total volume would increase by 10 times.

According to the International Federation of Robotics study 2020, the number of installed units increased by 12% in 2019, while the compound annual growth was 13% since 2014. Since 2010, the number of robots has increased by a factor of 3.5 in Asia and by a factor of only 2.3 in Europe, with the Americas being in the middle ground.

While a twentyfold increase would require a more significant rise, actually the growth of robotic installations has slowed. Looking at yearly numbers, the number of installed robots decreased from 2018 to 2019 by 12% to 373.000 units. These numbers do not correlate with economic growth overall, e.g. the Chinese industrial growth increased by 5.7% in 2019 compared to the previous year with 6.1%.

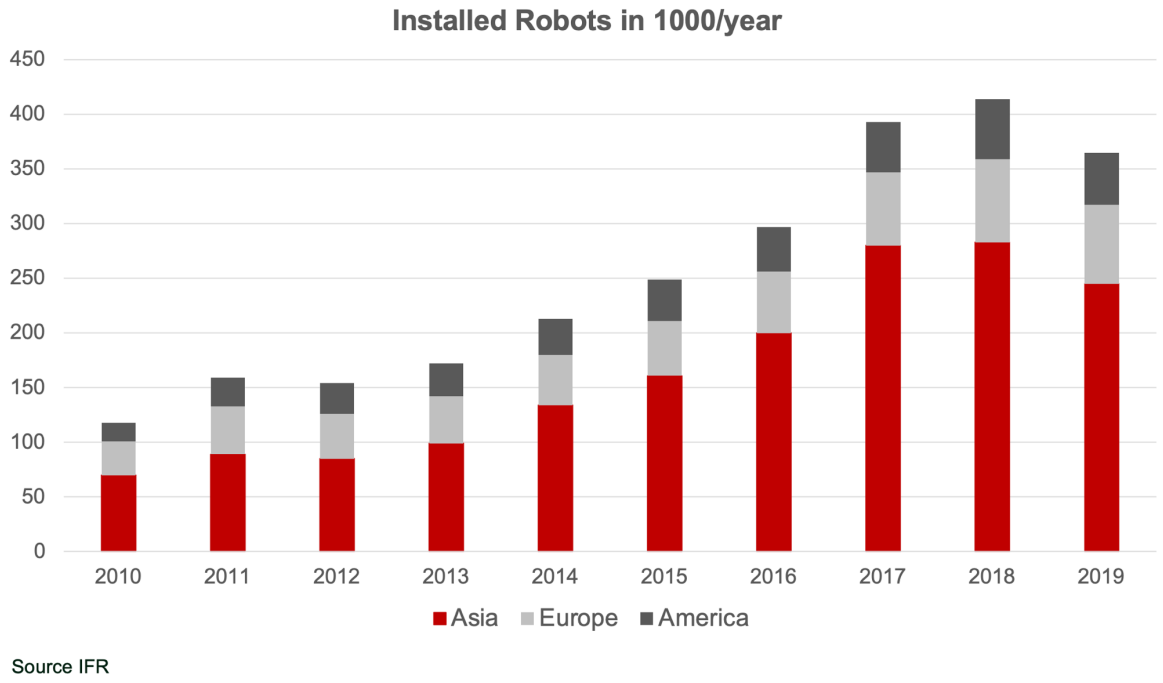

Figure 2: Installed robots per year in major regions

Although there has been tremendous engineering effort to bring down robot costs to a fraction of the original sales prices, the expected volume increase lacks behind many forecasts.

Many new entrants have challenged existing robot manufacturers and some have grown significantly over the past years. Nevertheless, while total volume has increased, many companies missed their volume targets significantly. This leads to many questions: Why are they missing the volume forecasts? Is the market not ready? Or are the products to immature? What is hindering the adaptation of robots?

Why are robot sales not skyrocketing as promised?

In the last years the robot market has been broken down into several key markets

- Industrial robots
- Medical robots
- Service robots
- Consumer robots

Let us review the list in reverse order:

Vacuum cleaning and lawn mowing robots have shown major sales increases in the past years and have grown steadily in volume. Consumer adopted one-tasks solutions very quickly and can choose nowadays from a variety of vendors. Low price, acceptable performance and simple implementation has led to high customer adaption rate.

Service robots are getting traction as well. The original French Pepper robot has been a well communicated robot model for many years and is now a part of Softbank Robotics. Different kind of service robots are showing up. Boston Dynamics robot dog Spot and the Atlas and Handle human like systems provide a glimpse, of what technology can do. Other dogs, such as Ghost Robotics Q-UGV, are following suite. Service robots are developed everywhere in the world: Omron in Japan, Halodi in Norway are showing new concepts for robotic use.

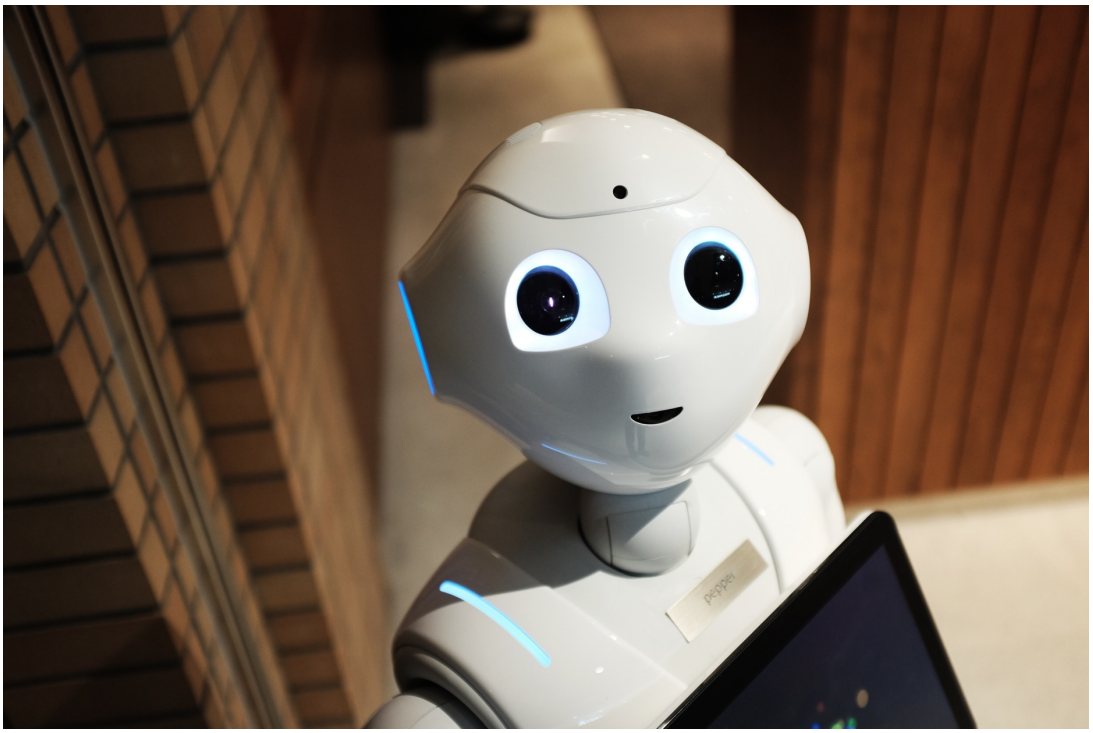

Figure 3: Service Robot

Medical robots have increased significantly in volume and competition is heating up. While Intuitive Surgical has a technology lead with its robots and covers a high price area, many competitors are starting to get traction in the market. These include many newcomers, such as Johnson & Johnson combining Verb Surgical and Auris into one venture, Medrobotics, Neocis, avateramedical, CMR Surgical, Corindus Vascular Robotics, and others. Medical robots are poised into a fast-growing market. If you add exoskeletons, such as Rewalk Robotics, Sarcos or Ekso, you see a swarm of companies backed by venture capital or large medical companies. As many countries have well-functioning health systems, growth in this market is easy to forecast since the systems improve quality of operations significantly.

Industrial robots have been the key application for robots in many industries. Seeing a car manufacturing line with many welding robots is a widely accepted picture. Applying adhesive, assembly and similar tasks have been done for many years with robots. In the recent years, new robots have changed the landscape. Universal Robots has created a new market with its low-cost robots with limited payload but much reduced cost. Many competitors world-wide have created other low-cost robots, such as Franka Emika, some ABB robots, Aubo, Estun Robotics, Shanghai Step Robotics, Siasun Robotics, Flexiv. China has identified robotics as one of the major strategic drivers for economic growth and there are at least 400 robotics companies estimated to be in China.

Here too, strategic alliances have started, e.g. the failed alliance Franka and Voith, as well as acquisitions, e.g. the purchase of Rethink Robotics first by Hahn and now by Siemens to redefine the market. A wave of concentration, as in other industries, is only to be expected when the market is more mature.

A special business field, that has emerged in recent years, are collaborative robots, robots that can interact with humans and do not require the same security set-up as other industrial robots. These robots have made it much easier to integrate robots into existing work places and will open up many new application areas.

Industrial robots are now cheaper than workers salary in a year and are an attractive investment. But the adoption rate is not in line with the expectations.

What is needed to create better selling robotic systems?

Although robots were original created to replace human workers, the dexterity of human labor is still much higher than even the most advanced robots can achieve. A human being with all the available sensors – tactile, eyes, ears – is far better equipped to deal with many tasks and the degree of freedom in a hand is far beyond the gripper capabilities. Plus a brain, that can deal with unforeseen conditions.

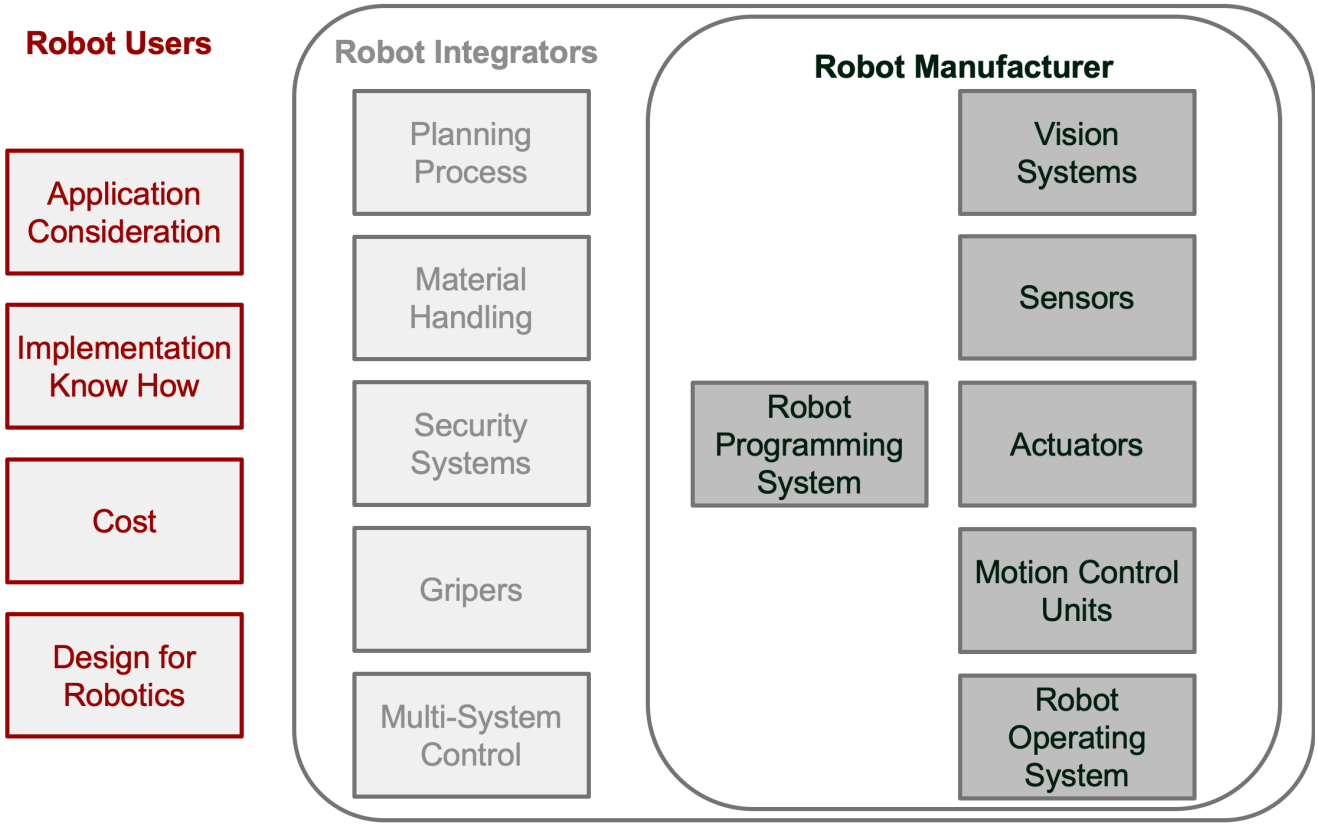

Figure 4: Improvement areas for robots

One key area, that requires significant change, is the need for better sensors. Optical sensors, that allow stereoscopic views will provide a better mechanism for control, than the existing sensors, that only deal with monitoring position at joints of a complex mechanical structure. Control architectures, that deal with this input will enable better motion control of a robot. At the same time, tactile sensors will become more important in the future. As of today, there is little tactile intelligence in most robots.

The existing actuators are not well designed for robots. Robots require a small size motor with low speed, high torque and low latency. Electric motors are large than required and provide high torque with higher speeds. Applications in robots require gearboxes and additional brakes for quick reactions, leading to large joint structures. Large joints lead to bigger robots while many application areas require small robots.

At the same time, the structure of typical robots is more comparable to one human arm than the two-armed solution of a person. While different structures – xyz linear systems, Scara systems and hexapod – have been used to overcome some shortcomings of the typical 6 separate rotary joint systems, only few robots have implemented two arm systems.

Programmable motion control units have come down in size, so they can be integrated inside robots and reducing the need for big control racks outside the robot. While the control capability has increased significantly in the past years and artificial intelligence will add to the capabilities even further, not all tasks can be controlled fine enough. A path optimization is more complex than the usual point-to-point-movement.

The next level of control – controlling multiple collaborative robots working on the same task – has not yet really been implemented as a standard. Even for two arms mimicking a human, this coordination is missing.

While volume increases will bring economies of scale, the systems will tend to be quiet expensive to produce because of the required size and precision of the mechanical structures.

With the Robot Operating System, an open source-based robot programming environment, there is simple real-time based programming environment available for builders of robots.

Robotics will remain an area of engineering delight, as many different areas will provide a lot of subjects for ingenious input. As described above, sensors, actuators, control units and mechanical structures have multiple optimization requirements. Innovation is expected to lead to new system designs.

What about robot programming?

Robot programming has changed significantly in the past years. While early systems were based on simple numeric control programming, this area has evolved a lot in the last years.

But still there are different programming languages by robot manufacturers. A change of robots requires learning a new programming dialect at best, a new language at worst.

Programming has several challenges. First, there is a process to be described. This can be done in different programming languages with different kind of support. Second, the process is aligned with multiple locations. Due to the inaccuracies in the physical structure of the robot, the key positions of the robot need to be taught to the system in real life.

New programming environment provide new paradigms. For a show and tell system, a user moves a robot through all steps and teaches process and position at the same time. With special motion libraries, standard tasks, such as palletization, can be implemented much quicker.

Google has gone a completely different way. With the Everyday robot, the company takes advantage of their artificial intelligence knowhow. The system can learn its own processes and learn how to operate simple processes. While the system requires quiet a lot of time to learn even simple processes, this system can become very productive, once learning from one robot can be transferred to all of the siblings and they know the same things.

Given the state of technology, robot programming deserves a C for applicability for most companies. Implementing robots requires still a lot of programming and is based on limited sensor input. Even a digital twin is not the solution for all requirements, as the final system needs teaching of positions in the final application.

Implementing robots is still a challenging task – mostly

One of the key factors for robots is their application. While robots were originally created as variable, programmable products, many new robots are one-purpose applications with limited programming capabilities. And these new robots are selling better than their multi-purpose cousins.

Why do these service robots, medical robots and consumer robots take off so quickly in volume? Because they are easy to install. They do not require elaborate implementation planning and high additional investment. And their value preposition is typically very limited: These robots solve one task especially well and provide a very simple return on investment calculation. Each operation of the robot saves a specific amount of money and in the lifetime of the robots, the savings lead to a high payback on the initial investment.

Buying such a robot is a simple operation: Once the robot arrives, the time to implement it is short and the payback can be generated quickly. The system may need simple adaptations, but is useful from day one.

Industrial robots have a different challenge. One of the reasons for the low adoption rates of industrial robots is the high effort for implementing the systems. The advantage of the universal solution is just this: Complexity. Finding the best way to use a system requires a lot more effort than the one-purpose solutions.

Figure 5: Low-cost industrial robot

For a typical industrial robot application, there is the additional need for a lot of periphery. Safety fences, material handling considerations, part feeders, special grippers and programming are some of the key elements required for getting a return on investment for the robots. While for the high cost robotic systems, the breakdown between robot and the integration was roughly 50%/50%, the cheaper systems lead to ratio of 20%/80%.

The effort for implementing a robot in a production environment is 5 times higher than the cost of the robot alone and is not as standardized as the robots.

For multi-purpose industrial robots to hit the quantity acceleration button, the installation issues need to be resolved. More standardized part and standard interface designs, standardized bins, standardized gripping features and keeping the orientation of parts in robot cells are key elements to simplify planning of the use of robots.

Summary

Robotics will continue to see a bright future. Single purpose robot quantities will outgrow multi-purpose robot installations in the next years. At the moment, the time and effort to plan and install robots will be the limiting factor for future growth. As single purpose robots are simple to implement, the complexity of installing and using an universal robotic systems remains high, inhibiting fast adaption.

As long as implementation effort remains high, industrial robots will not achieve the same growth rates. While there are many possibilities to improve the robot technology, this attention will optimize the technology further and make the robots a more viable solution. But any improvement will not yield the required volume increase, as long as the key bottleneck to implement more robots will be the effort for installation and implementation. If the average planning time for a robot reduces from 8 months to 2 months, a planner can implement 4 times more robots which will increase robot production volume a lot.

Focusing on better robot installations will identify new solution approaches and will require a much more modular system for part orientation and handling. Using feedback from such modules, the design of any industrial produced products can be improved for better robot assembly and increase robot quantities further.

Even if the most aggressive growth predictions will not be achieved, the robotics market will remain attractive for many years to come.

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*BEST*group Consulting GmbH is a management consultancy for high-tech companies. *BEST*group support company in innovation management, product strategy, supply chain management and process optimization in producing companies. More information at www.best-group.eu.

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Dr. Torsten Becker studied mechanical engineering at Aachen University of Technology. During his studies, he helped to develop a robot programming simulation tool, maintained a robot database and implemented a tool for Design for Assembly. He has worked intensively with robot manufacturers in Europe, Asia and the US in the past years. As a consultant, he supports companies in innovation management, supply chain management and market entry in new markets.

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