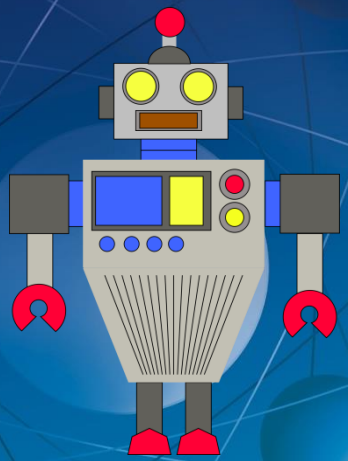
Advanced Manufacturing Technology (TechVision)



Collaborative Robots Aid in Industrial Production

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FROST & SULLIVAN

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Collaborative Robots–Overview

What are Collaborative Robots?

- *Collaborative robots are robotic systems designed to assist and sometimes replace humans in various tasks performed in industries and day-to-day life.*
- *In industrial settings, collaborative robots have enabled a higher degree of automation, replacing human labor in tasks where automation was not achieved earlier.*

Market Potential of Collaborative Robots

- *Collaborative robots provide greater flexibility and safety compared to traditional robots, and have been continually proving that robots can collaborate and cooperate with humans to bring greater efficiency and quality to industrial outputs.*
- *Enhanced quality of throughput and increased manufacturing time are some of the advantages that attract more industries to employ collaborative robots in their production environments.*

Market Drivers

- *Increase in quality of industrial output*
- *Shorter production/manufacturing time*
- *Wide range of application potential*
- *Suitable for various industries*
- *Faster return on investment*

Market Challenges

- *Cost factor*
- *Need for training existing staff for operating collaborative robots*
- *Socio-economic challenges arising from job cuts due to collaborative robots*
- *Energy efficiency*

Innovations in Collaborative Robots

Baxter–Smart Collaborative Robot

Rethink Robotics, USA

Tech Profile

Baxter is a smart collaborative robot designed by Rethink Robotics, USA. This robot is designed to provide an alternative to fixed automation systems in industrial environments, thereby achieving a higher degree of automation in industries.

Innovation attributes

- *Safe and compliant*
- *Easier third party hardware and software integration*
- *Flexibility for a wide range of applications*
- *Adaptive to variable industrial environments*
- *Cost effective with a price range suitable for SMEs*

rethink robotics

Competing Aspects

- *Highly Modular*
- *Cost Effective*
- *Manually trainable*
- *Wide range of applications*
- *Ease of operation*
- *High speed operation*
- *High precision in task execution*
- *Occupies less space*

Company Profile

Rethink Robotics is a robot company founded in 2010 with an intent to provide a novel automation solution to industries. They released their Baxter robot in mid-2012; and since then the robots have been upgraded to suit the growing automation needs of industries. Moreover, in 215, Rethink launched the Sawyer robot, which has a more mechanically-compliant actuator.

Impact & Opportunities

Wide-scale Adoption

Baxter is not only a simple-to-use and smart collaborative robot, but also occupies less space and is highly configurable in different production environments in various industrial verticals. These advantages present a very good scope for wide scale adoption of the Baxter™ robot in various industries.

Market Opportunity

Baxter robots are very useful in discrete manufacturing industries more than in process industries. At present, the manufacturing sector is looking for safe, convenient automation solutions due to increased cost of labor and scarcity of skills in the market. Baxter is expected to fill in this gap over time.

Technology Convergence

Baxter robots combine a range of technologies to achieve various functionality, including ability to react based on the force exerted on a joint.. Sensors such as motion sensors, gyros, temperature and heat sensors, work in tandem with wireless and other communication technologies to effectively help humans in factories.

One Arm, Six Axis Robot

Universal Robots, Denmark

Tech Profile

Universal Robots (UR) makes three types of collaborative robots for industrial automation: the UR3, UR5 and UR10. All these robots have six articulation points. These robots are produced to mimic the actions of the human arm and perform most of the industrial tasks that are usually performed by humans using their hands.

Innovation Attributes

- *Payload from 3 Kg (UR3) to 10 Kg (UR10)*
- *Precise and efficient force control*
- *Easily programmable*
- *Enhanced safety system for seamless operations*
- *High payback period (~200 days)*
- *Highly Flexible*

Market Opportunity

UR's collaborative robot series is conveniently made in 3 sizes to suit the needs of various industries, such as automobile assemblies, equipment manufacturing, food processing, plastics, agriculture, metals and machining. The size variations for various payloads will serve as a market differentiator for UR as it gives more benefits to customers.

Competing Aspects

- *Quick setup*
- *Easy-to-configure patented software*
- *Wide range of application fields*
- *Easy re-deployment*
- *Faster Return on Investment*
- *Suitable for operations of varied complexity*

Company Profile

Universal Robots was founded in 2005 in Denmark to produce flexible robots to help automate tasks in industries. The company was initially funded by Syddansk Innovation. Later, The Danish State Investment Fund joined Syddansk in funding UR. Today, UR operates and supplies robots in Europe, North America, and Asia.

UNIVERSAL ROBOTS

Wide-scale Adoption

The number of applications of UR's collaborative robots bodes well for wide-scale adoption in diverse application areas for its operational versatility and capability to work on a wide range of payloads.

Technology Convergence

Convergence of various technologies is central to industrial automation. UR's collaborative robots efficiently combine various technologies, such as sensor technologies, wireless communication and other communication technologies, to achieve automation of tasks that have tended to elude effective automation.

P-Rob® 2–Collaborative Robot for Industrial Applications

F&P Robotics AG, Germany

Tech Profile

P-Rob® 2 is an improved version of its predecesor P-Rob®. P-Rob® 2 is a collaborative robot with improved communication when working cooperatively with humans. It is designed to look like an arm with 4 joints that can perform varied tasks in multiple industries

Innovation attributes

- *Safe and modular configurations*
- *Highly configurable software*
- *Attractive physical appearance*
- *Integrated Intelligent speech capability for communication with humans*
- *Integrated I/O functions and communication protocols.*

F&P Personal Robotics

Competing Aspects

- *Highly modular*
- *Enhanced gripper for holding objects*
- *High-speed operation*
- *High precision in task execution*
- *Occupies less space*
- *Work load up to 3 Kg*
- *Works as personal robot*

Company Profile

F&P Robotics was started in 1996 under the name "Neuronics Früh & Partner" as a spin-off company from the Artificial Intelligence lab of the Zurich University. Since its inception, F&P is producing cooperative robots to cater to the automation needs of various industries.

Impact & Opportunities

Wide-scale Adoption

The P-Rob robots are very suitable for applications in flexible environments where the robots work closely with humans. The light-weight robots have opportunities for significant adoption in collaborative, flexible environments.

Market Opportunity

F&P's robots are beneficial for applications such as pick & place, assembly, testing, and machine tending.

Technology Convergence

Technologies related to F&P's robots include sensors. The grippers in the company's robots can be optionally equipped with sensors for specific tasks, such as position, proximity, or torque sensors.

Open Unit Robot 2 (OUR-2)

Smokie Robotics, USA

Tech Profile

OUR-2 (Open Unit Robot 2) is a second-generation collaborative robot developed by Smokie Robotics Inc., USA. An improvement over Smokie's OUR-1, OUR-2 has 4 joints and can be configured to have 3 to 6 degrees of freedom, depending on the requirement. Other improved features of OUR-2 include 360 degrees rotation of every joint and a rotation speed of 180 degrees per second.

Innovation Attributes

- *Payload up to 5kg.*
- *Weight –18Kg*
- *Easily programmable and high operational precision*
- *Operates in temperature ranges from 5 to 65 degrees C.*
- *Highly Flexible*

Market Opportunity

OUR collaborative robots are lightweight and offer a configurable operation in terms of its degrees of freedom, a desired feature in electronics manufacturing and automobile assembly. Over time, OUR robots will see increased adoption among electronics OEMs, electronics parts manufacturers and find use in automobile assembly plants.

Competing Aspects

- *Quick setup*
- *Low-cost industrial robot*
- *Wide range of application fields*
- *High Precision*
- *Integration with computer/machine vision*
- *Highly sensitive force control system*

Company Profile

Smokie Robotics Inc. is a robotics company founded with an intent to develop lightweight, multi-functional and open unit robots (OUR) that cost less and are reliable in various industrial operations. Smokie Robotics is striving to create affordable collaborative robots for numerous industrial applications.

Wide-scale Adoption

The number of application areas of OUR collaborative robots in electronics and automobile manufacturing can provide opportunities for wide-scale adoption in these industries.

Technology Convergence

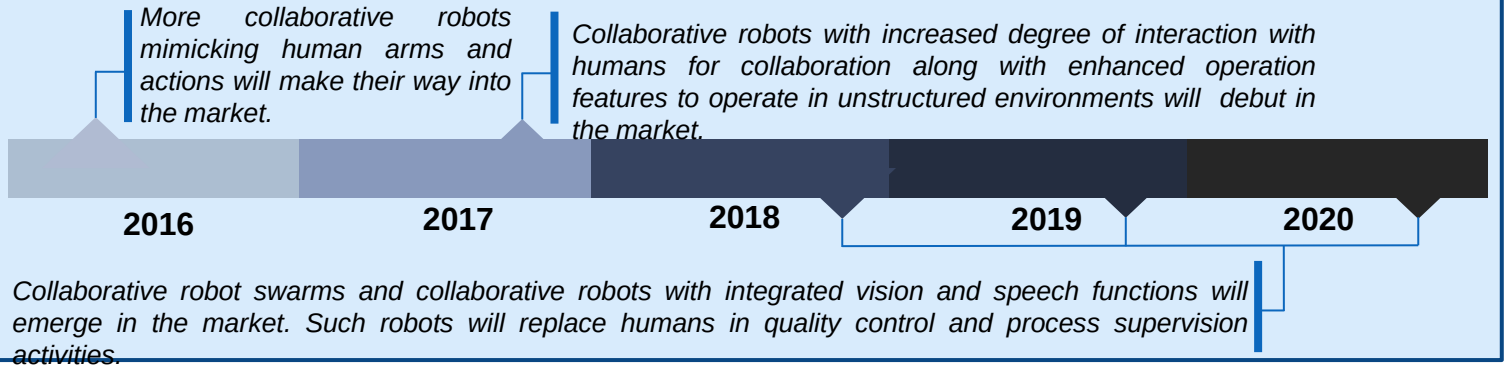
The OUR robots utilize various technologies, including integrated computer vision.

Strategic Perspectives

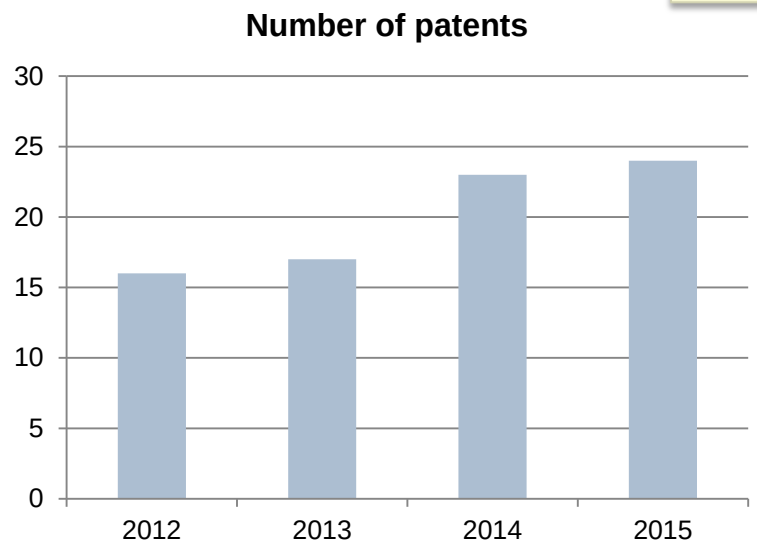
Technology Roadmap and IP trends

Collaborative robots are increasingly replacing assembly lines in electronics manufacturing and automobile assemblies. In the future, collaborative robots have opportunities to replace humans in production environments for applications, such as simple or precise repetitive tasks, machine tending, circuit board testing, and so on.

Technology Roadmap



Intellectual Property (IP)



- The patent filing trends in the last 4 years indicate relatively minimal intellectual property activities in collaborative robots.
- This minimal IP activity can be attributed to the fact that collaborative robotics is an emerging field of research and many commercially available collaborative robots are manufactured by rather large robotic companies.
- Collaborative robotics has a fairly good amount of research and development activities going on in various universities. However, there are opportunities for new breakthroughs and innovations.
- Continuous research and aligning the research to address current industry challenges will lead to more innovations and consequent IP activity in collaborative robotics.

Strategic Insights

The 2020 Scenario

- *In 2020, collaborative robots will essentially see wider adoption among manufacturing industries across various industrial verticals.*
- *During this time advanced collaborative robots with more intelligence will help humans in industrial environments.*
- *In 2020, collaborative robots featuring machine vision and speech capabilities might make a market debut.*

Growth Potential

- *The number of application areas and industries that collaborative robots will have an impact on are numerous. Several new applications of collaborative robots are increasing over time.*
- *Meanwhile, there is an increased need for automation in various industries owing to increased labor wages and shortage of skilled workforce. Collaborative robots will certainly occupy a strategic position in industries and fulfill the current and future demands of industrial manufacturing.*

Funding Focus

- *Funding support by governments and venture capitalists is expected to accelerate the commercialization of prototypes and products. Technology developers would be able to bring innovative ideas to the market with financial support.*
- *While venture capital firms and other funding agencies continue to fund collaborative start-ups, government grants and loans are helping more research and product development in universities across the globe.*

R&D Focus Areas

Research and development is key to propel the growth of any technology. In the area of collaborative robotics, there are several shortcomings in R&D. Some areas of research that require more attention are

- *Motion sensors; tactile sensors*
- *Battery technology for robots*
- *Machine vision and speech integration*
- *Artificial intelligence integration*
- *Performance enhancement*

Appendix

Key Patents - World

No.	Patent No.	Publication Date	Title	Assignee
1	**WO/2015/185442**	10.12.2015	HUMAN-ROBOT COLLABORATION WORKSTATION WITH A MOUNTING DEVICE	KUKA SYSTEMS GMBH
	The invention relates to a human-robot collaboration workstation, comprising a robot (1) which has a robot controller (3) and a robot arm (2) comprising a plurality of joints (4) and members (5-12) connecting said joints (4), the joints (4) of said robot arm being adjusted automatically by the robot controller (3) in order to move or hold in space a tool (14a) or workpiece (14b) held by the robot arm (2) by adjusting the joints (4) of the robot arm (2). Said human-robot collaboration workstation further comprises a mounting device (17) which has a stationary base frame (19) and a fixing device (18) that is configured to hold in place a workpiece (14b) or a tool (14a) such that the workpiece (14b) and/or tool (14a) held on the mounting device (17) is/are to be mounted and/or machined in interaction with the robot arm (2), wherein the mounting device (17) has a mechanical adjusting device (20) and a triggering device (21) that can be controlled by the robot controller (3) and the adjusting device (20) is configured to automatically adjust the fixing device (18) in relation to the base frame (19) from an operating position to a safety position if the triggering device (21) is activated.			
2	**WO/2015/059241**	30.04.2015	COLLABORATIVE ROBOT FOR VISUALLY INSPECTING AN AIRCRAFT	AIRBUS GROUP SAS
	The invention relates to a device (100) for visually inspecting the external surfaces (90) of an aircraft, which comprises an inspection area for receiving an aircraft, at least one visual inspection robot (10), and a control center (50). A movable platform (11) of the robot supports a turret (12) having observing means (13). The robot comprises processing means (20) which guide the movable platform (11) and process the data received from the observing means (13). The processing means (22) of the robot are suitable: for autonomously controlling the robot (10) during the visual inspection of the external surfaces of an aircraft (9) parked in the inspection area; for interrupting a visual inspection in the event of a detection of an anomaly on the external surface of the aircraft; for transmitting visual inspection data to the control center; and for receiving instructions from the control center.			

Key Patents - China

No.	Patent No.	Publication Date	Title	Assignee
3	**CN 104742125**	01.07.2015	External force judgment method and external force judgment device of human-collaborative industrial robot	FANUC CORPORATION
	The invention provides an external force judgment method and an external force judgment device of a human-collaborative industrial robot. The external force judgment method includes a reference value acquisition step of acquiring a reference value of a relative position or angle of a second member with respect to a first member when a robot on which no external force is acting or on which a known external force is acting is assumed to be operated by a predetermined command in advance; a measured value acquisition step of acquiring a measured value of a relative position or angle of the second member with respect to the first member when the robot is operated by the predetermined command; and a judgment step of judging the presence or absence of an external force acting on the robot based on a difference between the reference value and the measured value and a predetermined threshold value.			
4	**CN 104215206**	17.12.2014	Base coordinate calibration method of two-robot collaboration system	SOUTHEAST UNIVERSITY
	The invention discloses a base coordinate calibration method of a two-robot collaboration system. The base coordinate calibration method comprises the steps of firstly, establishing geometric constraint between the base coordinate systems of two robots according to a coordination transformation relation between the two robots in the collaboration system, secondly, performing a plurality of handshake action experiments of the two robots by use of a calibration finger mounted on the tail end of a tool hand to obtain the coordinates of the handshake sampling points of the two robots under the own coordinate systems, respectively, thirdly, building a calibration model according to the handshake sampling points and the robot base coordinate constraint, and finally, solving by use of a singular value decomposition algorithm to obtain a rotation matrix and a translation vector between the base coordinates of the two robots, and consequently, completing the calibration of the two-robot collaboration system. The base coordinate calibration method of the two-robot collaboration system does not rely on other external special measuring devices, and is simple and easy to implement; besides, the base coordinate calibration method is high in calibration accuracy by use of a numerical solution method, and also has excellent error fault-tolerant capability, and therefore, the processing level and the production quality of the two-robot collaboration system can be well improved.			

Industry Interactions

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