



COLLABORATIVE ROBOT EBOOK

– FIFTH EDITION –

**PROB – ROBERTA (ABB) – SPEEDY-10 – BAXTER – SAWYER
ABB YUMI – KUKA IIWA – PF 400 – PP100 – NEXTAGE
UNIVERSAL ROBOTS (UR3, UR5, UR10) – APAS – BIOROB**

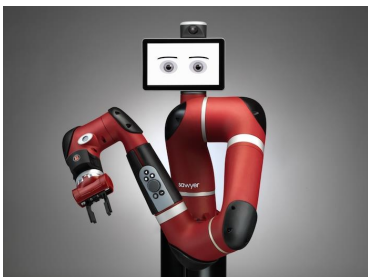
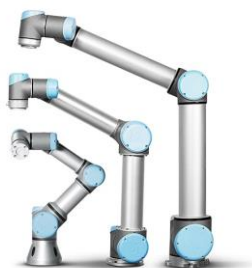
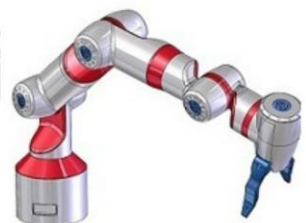


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INTRODUCTION

A new kind of robot has made its way in the industry changing all our preconceived thoughts about robotics. Their main feature is the ability to work safely alongside humans. Therefore, human-robot collaboration is the new wanted characteristic for robots. There is a lot of talk about them on the web, but what are they really?

Up to now, robots have always been big, strong and robust devices that work on specific tasks designed for them. They were surrounded by fences and guards for safety purposes. Their bright color was used to warn the surrounding workers about the danger they represented. A lot of programming skills were also necessary to set up these robots.

Collaborative robots are in fact the opposite of the industrial robots. They are compact, lightweight and dexterous. The new technologies allow them to have up to 7 degrees-of-freedom which allows more configuration of the arm.

Moreover, these robots have integrated sensors, passive compliance or overcurrent detection as safety features. The integrated sensors will feel external forces and, if this force is too high, the robot will stop its movement. Passive compliance is made by mechanical components. If an external force acts on a joint, this joint will submit itself to this force. So, in case of a collision, the joint will move in the opposite direction avoiding any injury. Also, an overcurrent can be detected when a collision occurs. This is another safety feature because the software can generate a security stop when it detects a current spike.

Some collaborative robots can be taught very easily by demonstration instead of using a deep knowledge of programming. Thus, they can be implemented very easily and brought on-line fast since no big setup is needed (no fences or guards). Also, they are less expensive than the big robots used in hard automation. The majority of collaborative robots can also be moved around the factory floor with ease in order to make it do another task at another station.

Being more dexterous and flexible, they can perform more tasks and even do whatever a human can do. They also now have more soothing colors inspiring confidence in the humans who work with them.

In brief, collaborative robots are the new ideal co-worker. Discover all kinds of collaborative robots. Moreover, a technical comparative chart of the robots is included to help you make your choice among these robots.

N.B. Robot manufacturers claim their robots to be safe according to the safety requirements for industrial robots stipulated by the ISO standard 10218. Even by assuming that the robot is safe, a risk assessment is necessary to make sure the robot's environment is fully secured.

TERMINOLOGY

Before going too far in the collaborative robot details you may want to learn the different terminology that is used in the robotic world. It may sometimes be confusing (even for us) when speaking to somebody else that has a different terminology. To make a long story short, many people use the terms interchangeably, thus the confusion between Force Limited Robots, Collaborative Robots and Cobots. Actually they all have the same general purpose, but can be interpreted differently.

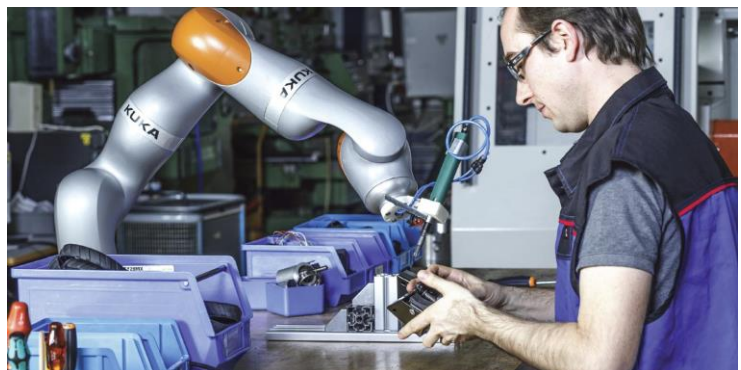
PURPOSE

All this terminology means the exact same thing, a robotic device that is made to work in collaboration with humans. The principle is to re-create a co-worker. One that will help the human worker to execute tasks that are too hard on his body, such as lifting heavy weights or doing repetitive tasks. A virtual infinity of applications can be done by robotic co-workers.

FORCE LIMITED ROBOTS

There is a huge difference between force limited robots and collaborative robots. In fact, a force limited robot is a robot that is specially designed to work alongside humans. They have built-in force torque sensors that detect impact and abnormal forces. The sensors stop the robot when overloaded. This means that if the robot's arm hits something like...the worker, it automatically stops to protect its co-workers. These features aren't present on industrial robots and this is the reason why force limited robots can work alongside human without any fencing. Regular industrial robots need to be isolated because they don't feel or monitor their environment.

Force limited robots also tend to have rounder shapes than regular industrial robots. This means that they are less harmful when an impact occurs. A round shape, spreads the force over a bigger surface and reduces the pressure applied on the body part. Most of the force limited robots also have cushioned shells that absorb shocks and reduce the effect of deceleration on the body, which results in a less harmful impact.



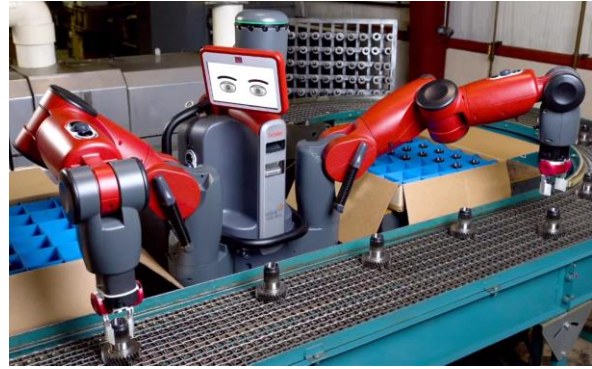
COLLABORATIVE ROBOTS

The term 'collaborative robot' most of the time is a misnomer. In fact a collaborative robot is designed to work alongside humans, but the device itself is not necessarily force limited. This means that the robotic cell used is monitored and is safe for human co-workers, but the cell might be composed of a heavy weight industrial robot. The term collaborative robot is unique to the fact that humans and robots work with each other, force limited or not.

An example of a collaborative robot can be observed in this [video](#). These kinds of cells are monitored by lasers, vision systems or other sensors to allow humans to work with them by using reduced or absent fencing systems.

COBOTS

Cobot is a slang term to describe a collaborative robot. Once again, the term Cobot most of the time is used when talking about force limited robots. So basically, a force limited robot is a collaborative robot. An industrial robot can be used for collaborative tasks but is not usually force limited and these types of robots tend to need supplementary monitoring devices to execute tasks alongside humans. The misnomer is so wide spread that even we confuse them at times in our publications.



So the following document is about force limited robots since they all have force sensors to avoid or reduce impact. We do call them collaborative robot because they are collaborative robot and they are used in collaborative mode.

A FLEXIBLE DUAL ARM FOR SMALL ASSEMBLY

ABB - YUMI

Formerly known as FRIDA (which stands for Friendly Robot for Industrial Dual-Arm) is a dual-arm robot with 14 axes of freedom (7 in each arm). The size of this industrial robot is similar to a small adult. This concept has been created in response to requests from ABB's customers who desired a robotic solution for manufacturing environments where robots and humans have to work together.

Originally built for the consumer electronics industry this collaborative robot has been designed to be as compact as possible. In fact, it takes the same work space as a human. Compact, this robot is portable and can easily be carried around the production floor, as well as mounted onto different work stations. Its controller is integrated into its torso making its installation and change of location even easier.

YUMI: KEY FEATURES

The size and the look of this robot really clash with the usual ABB robot. Instead of being massive and orange (meaning: hey I'm big and tough, so don't come too close), YuMi is small, compact, lightweight and its colors are different shades of gray.

Here are the key features of this collaborative robot:

- Harmless robotic co-worker for industrial assembly.
- Padded dual arms ensure safe productivity and flexibility.
- Lightweight and easy to mount for fast deployment.
- Agile motion based on industry-leading ABB robot technology.



TARGETED APPLICATIONS

[YuMi](#) is a collaborative, dual-arm small parts assembly robot that includes flexible hands, camera-based part location and advanced robot control. It can collaborate, side-by-side, with humans in a normal manufacturing environment enabling companies to get the best out of both humans and robots, together.

- Small Part Assembly
- 3C (Computer, Communications and Consumer electronics)
- Consumer Product
- Toy Industry
- Watch Industry (they are Swiss after all)

SPECIFICATIONS

- **Payload:** 0.5 kg (1.1 lbs) per arm
- **Reach:** 559 mm (22.1 in)
- **Accuracy:** 0.02 mm (0.0008 in)
- **Weight:** 38 kg (83.8 lbs)



So from these specifications, you can tell that the robot is literally design around electronic assembly applications. The robot is very accurate and has a small payload. This means that it was designed to take small parts and place them in a precise location. Only the future can tell us the popularity of this robot since it only been launch on April 2015.

TENDON ROBOT BASED ON HUMAN ARM

BIONIC ROBOTICS - BIOROB

[Bionic Robotics GmbH](#) was initially a spin-off from the Darmstadt University of Technology. Their robot arm called BioRob is designed to match the rising demand of cost-effective and easy to use automation solutions. They target more specifically small and medium enterprises looking for new ways of automating, since traditional industrial robots often do not match their requirements.

BioRob Arm

The low deadweight, the compliant drivetrain and the low energy consumption lead to an inherently passive safety system allowing the user to run the collaborative robot without any additional safety equipment, such as light barriers or fences even with its high speed movements (although safety assessments are always highly recommended). The robot's movements can also be taught by hand, the setup and programming of the BioRob takes only a few minutes.

The lightweight robot BioRob is used for industrial automation, especially for pick and place, inspection and co-worker applications. Interesting fact: it is based on a patented, antagonistic, elastic actuation which is inspired by the elastic muscle-tendon apparatus of the human arm.



Mimicking the Flexible Mechanics of Biology

Tendon-driven systems mimic the flexible mechanics of biology, and could result in a new class of robots that are lighter, safer, and move in a more natural way. Mimicking human movement is ideal for a robot designed to take on human tasks. But such robots can also help researchers explore how biomechanics can give rise to more intelligent behavior, a field known as embodied intelligence or cognition.

According to the MIT Technology Review, one of the biggest obstacles for tendon-driven engineers is finding a way to effectively model the human body's complex motions. But it's also difficult to ensure that the robots can accurately position themselves, as the tendons are prone to slack and stretch. The calibration of the tendons is also a challenge, which is often compensated by the integration of extra sensors.

FIRST CERTIFIED ROBOTIC ASSISTANT

BOSCH - APAS

Bosch [APAS](#) is the first collaborative robot to be certified as an assistance system, which allows direct collaboration with people without additional shielding. This one of a kind robot has some really impressive specifications and is comparable to other collaborative robots on the market today.

Superior Protection

The robot has a one of a kind look too with a protective leather coat. Even if its look invokes 'rock and roll', it is probably the safest collaborative robot out there. The leather is actually a tactile skin to detect impact. Since the robot will be used in collaboration with humans, the sensors will give instant feedback to the controller when any unusual force is detected.

The robot also has a security perimeter that slows down the robot once a person gets too close to it, essentially invisible shielding. The robot will resume its regular speed once the person has left the security perimeter.



This device must have been seriously tested to get the certification of the German employers' liability insurance association. The robot concept seems to be really focused on security and we think they have actually achieved something unique with this [robotic assistant](#).

Built-in Devices

The robot has integrated cameras. The system can be delivered with a 2D or 3D vision system. These devices allow the robot to get instant feedback from the grasping end effector. It can tell if the part is grasped or if it missed it. That is a good feature to have in your workshop.

APAS also comes with a built-in 3 finger gripper. This gripper can be used for a very wide variety of objects. Having three fingers instead of the regular two fingers that are on many collaborative robots allows you to have more stability on round parts for example. Though the fingers are such that it can't offer an encompassing grip.

Of course the robot comes with a teach pendant that is easy to use and user-friendly. This kind of teach pendant is now very common in the collaborative robot industry. The robot can also be moved around and be reprogrammed in a few seconds using hand-guiding.

To get the [robot specifications](#) go to the [BOSCH](#) website and see if the robot might suit your application.

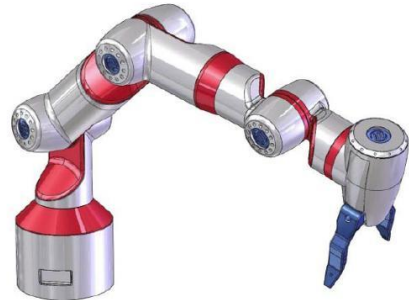
THE VERSATILE LIGHT-WEIGHT ROBOT ARM

F&P PERSONAL ROBOTICS - PRob 1R

The PRob 1R collaborative robot was developed to make customers' lives easier. In fact, when most people think about robotics, they are usually afraid of programming complex routines with a non-intuitive platform. This is what F & P Personal Robotics focuses on with its newest platform.

The robot includes a simple, user friendly, online software for programming. All devices that can support HTML5 and Java Script can be used to program the robot. In fact, most smartphones, tablets and laptops are able to control the different aspects of this collaborative robot. Since a lot of devices are supported by the software, it is easy to monitor or change different aspects of the program on the go.

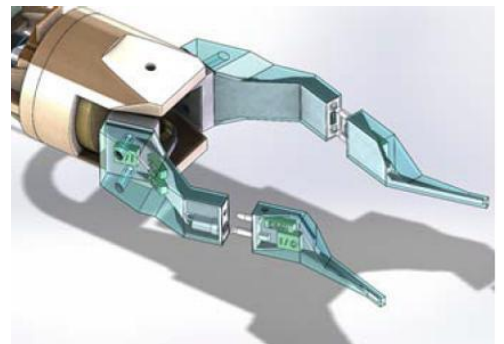
The robot also supports ROS (Robot Operating System) and can be programmed with all kinds of 4th Generation Software Packages (LabView or MatLab/Simulink), as well as all major programming languages. The software architecture is focused on adaptive behavior. Thanks to its deep learning network, including neural and Bayesian probability network algorithms, the robot can adapt to a specific task and improve its performance based on feedback.



PProb Collaborative Robot Advantages

- Easy to program and monitor
- Built-in gripper and tool changer
- Possibility to change gripper configuration
- Learning capability

The other interesting thing about this new collaborative robot is the built-in 2 finger gripper (PGrip 1). The modular end effector is made of a soft material which makes it safe for humans. The fingers are easy to change using only 2 screws. A fingertip exchanger can be added into the robotic cell to adapt the end effector. The switch is made through a patent-protected interface that engages a mechanical and electrical connect-disconnect operation. The fingertips of the robot gripper can be adapted for your specific application and are easy to switch once the robot is in operation. The end effector is incredibly safe and has a large opening range (60 degrees). This allows the user to grasp big objects such as a 1.5 L water bottle.



PProb stands for the family name of the innovative and versatile lightweight robot arm manipulator. The PProb 1R weighs only 10 kg and has an operating range of 700mm. Its payload is low at only 1.5kg. The robot is dedicated to performing human-robot collaborations. Like most collaborative robots, the PProb includes soft material, rounded shapes, limited forces and stop functions. PProb can be integrated into your actual working environment without any risk of injury to humans. This collaborative robot comes with different peripherals, such as a camera and a movable base. With all of this equipment, you can bring PProb onto the assembly line and get started in a very short amount of time.

THE FLEXIBLE AND EFFICIENT ROBOT ARM

GOMTEC – ROBERTA (ACQUIRED BY ABB)

Note that in April 2015, ABB group announced [the acquisition of Gomtec](#) GmbH to expand its offering in the field of collaborative robots. Gomtec's technology platform will strengthen ABB's development of a new generation of "safe-by-design" collaborative robots. At the time that this review was written we had no information about whether or not the company would continue to sell the robot as is or create an ABB version. Further information will be available about it in the next eBook update.

This 6-axis collaborative robot from Gomtec, called Roberta, was designed to suit small to medium sized enterprises who want to achieve flexible and efficient industrial automation. The design was focused on building an agile and lightweight robot that could easily be moved around the shop floor. With a weight of 19.5 kg, it can handle a payload as high as 8.0 kg. A payload like this means that Roberta has a good payload to structural weight ratio. Thanks to the highly optimized weight and power servomotors, which for a given torque, reduces power losses by half compared to a conventional motor. Roberta has a lower energy consumption for the equivalent operation. Gomtec states that Roberta's movements perform more quietly than most of its robot competitors.

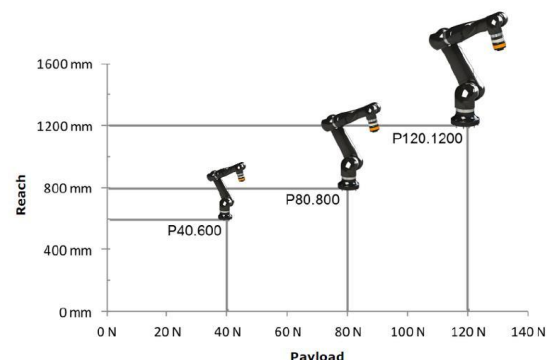


The software and firmware have been developed to simplify the programming and provide complete liberty to the robot. In fact, with the RoboCommander device, the 6 axes of Roberta can easily be moved to any point in the working area with any desired orientation for the end effector. The joints allow unrestricted rotation, which means that the robot can always take the shortest route to its next desired position without passing through singularity points. This collaborative robot is delivered with a graphical user interface software that is very intuitive to program. Programming is done by demonstration. The only difference with other robots is that the robot wrist is equipped with an illuminated rotating ring that provides information about the different points or motions by showing a color-coded acknowledgment.

Robot Main Characteristics

- Lightweight
- 6 degrees of freedom without singularity points
- Good payload to structural weight ratio
- Inexpensive

Roberta has several integrated safety concepts. It has characteristics such as safety nodes on each axis and dual safety nodes for overall robot monitoring functions. The robot can be fitted with a specific gripper that is safe for human-robot collaboration. In fact, because it is camera equipped, the system can detect the presence of abnormal objects in the robot gripper, such as a hand or tools. The end effector is also equipped with fingertip force sensors.



The Gomtec robot gripper vision devices is also designed to see the object that it is handling. With the force sensor and camera, the robot is able to feel and see its payload. This can be used to guide the end effector to the right position, but also to react if something goes wrong during the motion. Roberta comes in 3 different sizes with payloads of 4.0 kg, 8.0 kg and 12.0 kg. The main difference between the models are its reach and payload; all other characteristics remain the same.

THE NEXT GENERATION OF INDUSTRIAL ROBOT

KAWADA INDUSTRIES - NEXTAGE

Now, we wanted to introduce you to NEXTAGE, a collaborative robot from Kawada Industries in Japan.

NEXTAGE: CHARACTERISTICS

Its overall design includes a “head” with two cameras, a torso, two 6-axis arms and a mobile base. Its “head” is equipped with stereo vision just like a human. This means that NEXTAGE can attain 3D coordinates with high precision. Moreover, the “head” has two degrees-of-freedom allowing it to adjust its field of vision with the workflow.

Its torso has a LED display to assure visibility of the robot status. Its overall height can also be adjusted by changing the height of an element in the torso.

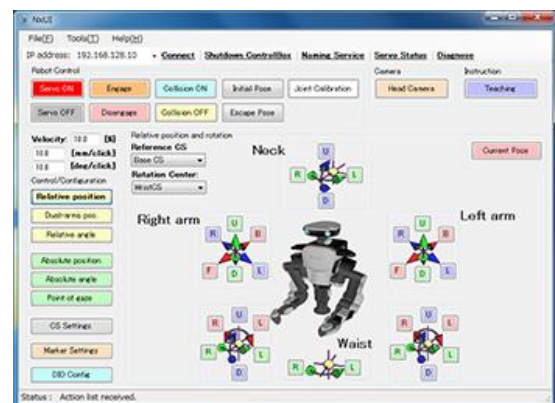
NEXTAGE has two hand cameras that can capture 3D information of an object by taking different pictures of it from different angles. The cameras bring precision to the robot’s work. Its base has wheels, so it can be moved around and rapidly reassigned to another workstation. Its base contains all its control systems such as the image recognition system through an integrated PC.



Its software uses GUI which helps to operate the robot intuitively with graphical elements. The source code for the software is licensed by GNU General Public License. This means the general public can download, distribute and duplicate it.

NEXTAGE: SAFETY SYSTEMS

NEXTAGE has a very interesting feature. Its elbows won’t ever move outward from its working environment, thanks to its axle structure. This is a safety feature unique to NEXTAGE. Even if both arms are in movement, the robot is not likely to bump into a human with its elbows. Moreover, its 15 operational axes (6 per arm, 2 for the head and 1 for the torso) use low-power motors of 80 watts to move, preventing harmful forces.



Additional safety certified sensors can be installed to allow the robot to detect an approaching human. This system will make NEXTAGE stop what it is working on when necessary.

THE LIGHTWEIGHT ROBOT

KUKA - IIWA

KUKA introduced to the world in 2013 the next generation of Lightweight Robot, LWR 5, designed for industrial applications. KUKA's goal was to develop a lightweight robot for industrial duty. This is why this robot is also named IIWA for "Intelligent Industrial Work Assistant". This flexible and sensitive robot enables new possibilities in automation. IIWA can be used to automate complex and delicate assembly tasks that presently robots cannot do.



IIWA: KEY FEATURES

Its design is based on a human arm with seven axes. It has integrated sensors at each joint that allow for control of position and sensitivity. It can fulfill delicate jobs due to its built-in-high-performance collision detection algorithms. Relatively slim and low weight, it can work in tight spaces and it can be integrated on assembly lines quite easily. Since IIWA is presented as a collaborative robot, no fences are needed for its implementation.

IIWA presents the same physical features as its previous version, ([the LWR 4+](#)) but has a completely new controller architecture. This new controller is called KUKA Sunrise. Its programming paradigm is completely new and it now uses the mainstream programming language, Java. In the past, KUKA's controllers were using KRL, which is a company language. Moreover, the plugin tools of the KUKA Workbench, based on Eclipse, make it easy to integrate hardware modules such as an electric end effector.

IIWA: CAPABILITIES

KUKA's IIWA showcased its capabilities at 2013 Hannover Messe in four different demonstrations:

- **Basic Functions:** The first one was about showing how fluid and sensitive the arm is. Visitors could handle the arm and move it around to experiment with these features directly.
- **Weight:** Its delicate touch was demonstrated by making the arm hold a ten kilogram weight over a scale in order to make it read only four kilograms.
- **Water Glass:** In another exhibit, the arm was following a path and someone would place a glass of water in its way to see how it would react. The arm was able to stop without spilling a drop, due to its collision detection system. This demonstrated its sensitivity.
- **Industrial Application:** In the last demonstration, visitors could see an assembly cell on a manufacturing line where IIWA had to position a piece over a pin to precisely assemble the two parts.



Through this type of robot, KUKA offers a flexible solution to any shop floor. This is also the goal that Robotiq aims for; we want to make automation accessible to any company, either big or small. Since our products are synonymous with flexibility, the integration of our end effectors with the KUKA IIWA would be an all-in-one solution for companies.

THE SWISS LIGHTWEIGHT ROBOT

MABI - SPEEDY-10

MABI AG is manufacturing two different robot types: Speedy-10 and Max-150, we will take a look at the first one, which is the collaborative one.

The small Swiss family business manufactures machines for sheet metal transformation and just released what looks like a twin of the UR10. The Speedy 10 is similarly priced, but uses an 18-bit absolute encoder and a KeMotion controller by KEBA. Furthermore, it has a simpler wrist that causes no mechanical interferences (when no tool is attached).



The requirements of flexible manufacturing are the rationale behind the development of Speedy-10, which is based on a lightweight design with excellent damping characteristics. This 6-axis kinematic system with standard wrist is a lightweight in its class; nonetheless, it offers high precision positioning for high-speed applications thanks to a high-resolution, absolute feedback encoder. The robot is controlled through an intuitive graphic user interface, which all operators will find easy to understand.

Features:

- Lightweight design
- 6-axis kinematic system with standard wrist
- High-resolution 18-bit absolute encoder
- High precision positioning
- Intuitive graphical user interface

THE FIRST COLLABORATIVE SCARA ROBOT

PRECISE AUTOMATION – PF400

Precise Automation is a company founded in 2004 and their main goal is to help customers “automate with ease”. They are interested in collaborative robots and want to develop products that could be safely integrated into work-cells. They have spotted a market where automation would be appreciated, but has not yet been developed; laboratories. In factories, it is common to see big robotic cells working behind barriers, but in a laboratory there are certain limitations. The major one is space. So, this particular market needs a robot with a small footprint. Moreover, the product needs to be safe to work around, without any barriers to allow proximity of other workers. Also, the majority of laboratory applications don’t require the largest and most powerful robots. So, they designed a tabletop robot: the PF 400. According to its creator, the PF 400 is extremely compact and safe to use in desktop applications even without shields.

PF 400: KEY FEATURES

Controller

Its embedded controller enables all its special features. Precise Automation designed a controller especially for science lab automation named, Guidance 1400. This device is a 4-axis motion controller and has all the features of bigger and more powerful ones. However, its price, size and power profile are perfect for laboratory use. Talking about size, it can fit in the palm of your hand. They decided to build the controller into the robot in order to reduce the space required. So, no external devices are needed, except for one AC power cable and an Ethernet communication cable.



Their controller also offers kinetic teaching with a gravity balance mode. Programming is done by simply moving the robot by hand from start to end position. Using a simple communication protocol, Ethernet interface (PC control via an open source TCP/IP command server), the robot can be controlled locally with a PC, a wireless tablet or remotely from anywhere in the world.

The other features of the PF 400 are:

- Low-cost
- Quiet
- Lightweight
- Can be combined with a vision system



THE FIRST COLLABORATIVE CARTESIAN ROBOT

PRECISE AUTOMATION – PP100

Compared to the other robot on this eBook, the PP100 is one of a kind. In fact, [Precise Automation](#) has been working on a "new" kind of collaborative robot, theirs is a cartesian robot.

Cartesian?

The PP100 is the first cartesian robot to claim collaborative robot status. Cartesian robots are generally represented as 3-axis robot. So basically, X, Y and Z axes. Or to put it another way, the robot can't rotate any of its joints. It is just a linear actuator that allows for the movement of the robot. The same as a laser cutter or a 3D printer. However, the robot is designed to pick and place stuff. So if your applications need to pick and place objects on a flat surface it might be the perfect robot for you. The targeted applications seem to be laboratories or simple light assembly tasks. Notice that a rotating axis and a gripper can be added to the robot.



PP 100 Specifications

Precise Automation claims that their cartesian robot is safer than a regular collaborative robot, because all the axes are force limited in all situations. And they have a point there, some collaborative robots presently on the market require the exertion of a sufficiently high level of force on the first joint (or the base joint, depending on your nomenclature) to stop them.

Another cool aspect of the PP100 robot is the built-in electronic control, harnesses and power supply. This creates a more compact robot which allows you to carry it from one table to another. The lightweight PP100 comes out of the box fully assembled. It can be carried by one person, mounted on a table and, just by plugging in an AC power cord and an Ethernet cable, it is ready to operate.

On the top of that, algorithms enhance the collaborative nature of the robot and the Guidance Motion Controller (which is embedded in the robot base) provides many advanced features such as: kinematics for simplified programming; gravity balanced free mode teaching that allows the robot to be taught by manually leading the end effector; a vision interface for advanced sensing; absolute encoder servo motor control for quiet operation and motionless homing; and an embedded web server that permits the robot to be operated locally via a standard browser executed on a PC, a wireless tablet or remotely from anywhere in the world.

Key Features:

- **Payload:** 3 kg (1 kg with gripper option)
- **Maximum speed:** 1.5 m/sec
- **Gripper:** 0-23 N force range
- Impact sensors for all axes

Since this is the first cartesian collaborative robot we've seen to date, I guess more robot manufacturers will eventually produce more variants of this type of device. Unfortunately none of our present Grippers can be fitted on this robot particularly because of its low payload. However, their gripper seems to work well for the jobs that can be done by a collaborative cartesian robot. We will have to wait and see the place this robot finds in the collaborative robot market.

SINGLE-ARMED ENHANCED BAXTER

RETHINK ROBOTICS - SAWYER

[Rethink Robotics](#) seems to have found the right balance with their effort to build a more robust and more complete solution for users that were looking for a smaller robot than Baxter but with all its proven sensors and safety features.

New and Enhanced Platform

As you can see, Sawyer has many things in common with Baxter, but there are also major differences. The same elastic actuators are used to allow the robot to be mechanically compliant. However, the actuators have been slightly redesigned to enhance the rigidity of its joints. Baxter uses springs made out of “C”-shaped pieces of steel, whereas Sawyer uses springs made out of titanium in the shape of a symmetrical, curvaceous “S.” The spring redesign (and running cables through the joints) allows Sawyer’s arm to be made considerably smaller. You can also notice that the joints are more integrated into the robot shape which reduces the possibility of sharp edges and gives a smoother look (and feel) to the robot. One major upgrade has been done to the arm's vision system, which now includes a built-in light. This allows for clearer vision and limits any obstruction a camera might have had with the gripper. The same easy-to-program devices are integrated into the robot arm. The smiley Baxter interface remains mostly the same with small graphical upgrades. Notice that Sawyer is not designed to be mobile, as Baxter was, it is a fixed robot.

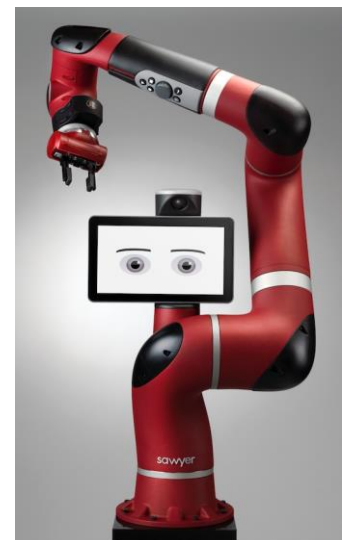


In this [short video](#) you can detect right away the rigidity difference between Sawyer and its older brother. Baxter was looser and shakier, and it always looked like it was just barely able to reach its targeted position. Now with Sawyer's more enhanced platform, we see a more rigid system that leads to a more accurate robot. Since the robot is designed for applications such as electronic assembly, you surely want to design a more precise robot arm!

Sawyer has a smaller and more robust platform to be able to achieve tasks such as machine tending and small assembly, tasks that Baxter wasn't able to do since it was such a big robot. The fact that the bulky Baxter had a big footprint and big segments, was a huge downside when it came to entering small spaces like those required for CNC machines.

SAWYER: Key Specifications

- **Weight:** 19 kg (42 lbs)
- **Payload:** 4 kg (8.8 lb)
- **Reach:** 7 degrees of freedom and 1-meter reach.
- **Force sensing:** High-resolution force sensing embedded at each joint.
- **Vision:** Camera in the head for wide field of view and Cognex camera with built-in light source in the wrist for precision vision applications.
- **Body:** Sealed against dust and spray [Baxter isn't].



THE ROBOTIC CO-WORKER

RETHINK ROBOTICS - BAXTER

Intended to support a rebirth of domestic production, Baxter is aimed at making North American manufacturing more competitive by lowering production costs in the US and thus avoiding the need to outsource to lower wage countries. Targeting a range of businesses – from small job shops to major manufacturing players – this robot from Rethink Robotics is intended to automate repetitive tasks actually done by humans in an environment of high-mix production.

This is also coupled with the idea of breaking the usual barriers between the robot and the end user by:

- Making robotic programming as intuitive as possible for the people on the plant floor.
- Making the robot itself an accessible tool in the production process (i.e.: not having the robot surrounded by fences and signs warning about the danger of getting too close).



So instead of having people doing work which doesn't add value to the process, we would now have someone who does not have in-depth knowledge of programming managing a group of robots who are doing this no value added work.

BAXTER: Key Features

- **No Programming:** Rethink Robotics highlight that Baxter can be trained in minutes without in-depth programming knowledge.
- **No Integration:** Being a complete system, Baxter requires no integration. Only minimal training to be able to teach tasks to the robot.
- **Works Intelligently:** Baxter is designed and programmed to perform a wide range of manufacturing and production tasks; it is aware of its environment, and can automatically adjust to changes.

BAXTER: Challenges

Bringing the cost where it needs to be.

At a starting price of just above \$ 20k, it represents a good value for your investment. However, reaching this price point, while Rethink and their distributors make money, is a real tough design and manufacturing challenge. As their sales pitch is about reshoring manufacturing in the US, they have to “walk the walk and talk the talk” and produce their robots domestically, which they do. Baxter has a lot of features and is a big piece of hardware. In several talks that Rethink's founder Rodney Brooks has given in the past, he showed examples for the cost of a bearing 30 years ago and it is the same as today's price for the same bearing. Since material costs are not cheaper today, the trick is to have lower end mechanical costs and to compensate by having clever software and electronics. For this reason, we can envision that the Baxter will evolve continuously as its software does.

THE LITTLE BROTHER

UNIVERSAL ROBOTS – UR3

UR3 from Universal Robot

The Danish robot manufacturer Universal Robots just released its newest version of collaborative robot: The [UR3](#). Universal Robots has had a huge success with their UR5 and UR10 in many different kinds of applications because of its safety features, flexibility, easy to use specifications and fast payback. The missing link was a smaller robot that met these same requirements to complete the robot family. Following its two older and larger brothers, the UR3 is more compact and designed for smaller applications.

As you can see, the [UR3](#) is literally a scaled down UR5. The goal of bringing a smaller robot to their product line was to target smaller applications, such as electronic assembly and general dispensing applications. With more and more electronic assembly tasks being done autonomously, it was a logical move for UR.



UR3 Specifications

Since it is a scaled down version of the other UR robots, you can figure that the specifications are pretty much the same as its older brothers. Notice that the same teach pendant and controller are used for this new version. The user-friendly built-in programming software remains Polyscope. It uses the same specifications and programming methods. Here are the key features for the new robot.

- **Weight:** 11 kg (24.3lbs)
- **Payload:** 3kg (6.6lbs)
- **Reach:** 500 mm (19.7in)
- 360 degree rotation on all wrist joints, infinite rotation on end joint
- 15 adjustable, advanced safety settings; force limit: Default 150 N , can be adjusted down to 50 N
- Improved force control

UR3 Targeted Applications

- Soldering
- Gluing
- Screwing
- Painting
- Pick and place
- Operating hand tools
- Laboratory work



THE COST EFFICIENT COBOTS

UNIVERSAL ROBOTS – UR5 & UR10

Universal Robots initially entered the market with a new vision for robotics. When the industry is surrounded by big, heavy and expensive robots, they decided to provide low-cost, flexible and easy-to-use automation solutions for all kinds of companies. Whether you are a small company making small batches or a large company with a huge manufacturing process, robots from Universal could be a good fit for you.

Their robots consist of a six-axis arm that allows them great flexibility to do a variety of tasks. They offer two products: the UR5 and UR10 that can handle 5 and 10 kilos respectively.

UNIVERSAL ROBOTS: Key Features

- Low-noise and energy efficient robots
- UR can be very precise (± 0.004 in)
- The programming is simple. You just have to move the arm and record points for the trajectory. Then you use the touch-screen tablet (12") to set different options. The software has a graphical interface that makes it easy to use.
- Compact and light weight design give them good portability around the plant floor. So they can be assigned to other tasks easily and rapidly.
- Universal Robots can work with humans without risk. In case of collision, the robot delivers less than 150 Newtons (33.72 lbs) of force and this amount of force is acceptable according to the "force and torque limitation" set by the ISO Standard.
- Universal Robots' starting price is pretty low. They can also be customized. On average, according to the company, the payback period is a relatively short 6 to 8 months.



ROBOTIQ GRIPPERS NOW PACKAGED FOR UNIVERSAL ROBOTS



Since the release of Universal Robots' UR5 and UR10, we are compelled to admit the great fit of these robots with our 2-Finger 85 and 3-Finger Adaptive Robot Grippers. Indeed, this spring, robots from Universal have become one of the most popular platforms (in terms of sales) for [our electric Grippers](#).

Considering the popularity of our Robot Grippers and UR's robots, the engineers at Robotiq have designed a package for this collaborative robot which includes: A Robotiq Adaptive Gripper, software component and a "How-to" Guide to easily and quickly program our

[2-Finger 85 Adaptive Gripper](#). This package is another way for Robotiq to pursue its mission of making automation more and more accessible for end-users, while helping them to maximize their ROI by providing tools that reduce costs related to tooling, programming and changeovers. **You can get the [free Robotiq package for Universal Robots here](#).**

CONCLUSION

Even if all these robots offer a lot of different features, they are all part of the same family and have one goal in common, which is to work alongside humans helping them in their tasks. They are safe and very flexible. This new kind of robot arrives just in time for manufacturers because the industry is evolving. Production tends to be more versatile and flexible today than it used to be. High mix production with a low volume of parts is the new challenge for manufacturers in order to stay competitive. Collaborative robots are flexible and affordable tools to help big or small companies.

To conclude, having a flexible robot is only one part of the solution, because to perform any task a robot needs the right end effector. Robotiq's adaptive end effectors are becoming the reference for flexible automation and the preferred end effectors for collaborative robots.

Come visit our website: www.robotiq.com

ABOUT ROBOTIQ

Robotiq makes tools for agile automation; flexible Robot Grippers to handle a wide variety of parts and a robotic teaching device that makes robot programming easier.

Our goal is to enable all manufacturers — especially those dealing with a high mix of products — to take full advantage of robotics.

Robotiq has sold product in more than 30 countries, through our global network of distributors.

TO LEARN MORE

For any questions concerning robotic and automated handling or if you want to learn more about the advantages of using flexible electric handling tools, contact us.

Phone (USA and Canada): 1 888 762-6847 extension 122

Phone (Anywhere in the world): 1 418 380-2788 extension 122

Email: info@robotiq.com

Website: www.robotiq.com

Blog: <http://blog.robotiq.com/>

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APPENDIX 1

COMPARATIVE CHART OF COLLABORATIVE ROBOTS

		Number of Axes	Payload	Reach	Weight	Speed	Targeted Application	Vision & Sensors
ABB - YuMi		Dual-arm 7-axis arms	0.5 kg (1.1 lbs) per arms	500 mm (19.7 in)	38 kg (83.6 lbs)	1.5 m/s	Small Part Assembly 3C Consumer Products Toy Industry Watch Industry	Optional end-effector vision system
Bionic Robotics - BioRob		One 4-5 axis arm with joint elasticity in A1-A4	0.8 kg (1.8 lbs) nominal load 0.5 kg (1.1 lbs) in cooperative operation	956 mm (37.6 in)	6 kg (13.2 lbs) incl. control, moving arm from shoulder only 2 kg (4.4 lbs)	130°/s (A1), 80°/s (A2), 90°/s (A3- A4), 330°/s (A5) Up to 1,3 m/s at end effector	Palletizing Machine Tending Product Testing Laboratory automation	Joint torque sensing using joint elasticity in A1- A4
BOSCH - APAS		6-axis arm	2 kg (4.4 lbs)	911 mm (35.9 in)	230 kg (506 lbs)	Arm: 0.5 m/s	Machine Tending Pick-and-place Process Application Assembly Packaging	2D monochrome overview camera, 3D calibrated stereo camera, touchless triggering sensor
F&P Personal Robotics - Prob 1R		6-axis arm	1.5 kg (3.3 lbs)	700 mm (27.6 in)	10 kg (22 lbs)	90°/sec	Quality Control Assembly Service Robotics Health care	The fingertips are optionally equipped with task specific sensors
Gometec - Roberta (acquired by ABB)		6-axis arm	8 kg (17.6 lbs)	800 mm (31.5 in)	19.5 kg (42.9 lbs)	110 °/s	Inspection Mobile Platforms Human- Machine Interaction	Flexible force-torque sensor / independent force sensors in each fingertip
Kawada Industries - NEXTAGE		Dual-arm robot 6-axis arms	1.5 kg (3.3 lbs) per arms	N/A	130 kg (286.6 lbs)	Joints: 133°/s to 300°/s - according to the joint	Pick-and-place Assembly Process Application	Integrated Stereo Vision and hand cameras
KUKA - IIWA		7-axis arm	7 kg (15.4 lbs) 14 kg (30.8 lbs)	7 kg : 911 mm (35.9 in) 14 kg : 931 mm (36.7 in)	7 kg : 22.3 kg (49.2 lbs) 14 kg : 29.5 kg (65.0 lbs)	Joints: 7 kg - 90°/s to 180°/s 14 kg - 70°/s to 180°/s	Machine Tending Pick-and-place Process Application Assembly Packaging	Integrated position and torque sensors in each joint
MABI - Speedy 10		6-axis arm	10 kg (22 lbs)	1384.5 mm (54.5 in)	28 kg (61.6 lbs)	120°/s (A1-A3) / 180°/s (A4-A6)	Machine Feeding Handling Assembly	N/A

		Number of Axes	Payload	Reach	Weight	Speed	Targeted Application	Vision & Sensors
Precise Automation - PF400		4-axis SCARA	0.5 kg (1.1 lbs)	576 mm (22.7 in) Extended Version: 731 mm (28.8 in)	20 kg (44.1 lbs)	End Effector: 1 m/s (39.4 in/s)	Laboratory Assembly	Embedded Guidance Vision-Guided Motion Controller
Precise Automation - PP 100		3-axis Cartesian	1 kg (2.2 lbs) including gripper	X: 635 mm (25 in) Y: 300 mm (11.8 in) Z: 225 mm (8.85 in)	20 kg (44.1 lbs)	1.5 m/s (59 in/s)	N/A	Guidance Motion Controller (which is embedded in the robot base)
Rethink Robotics - Sawyer		7-axis arm	4 kg (8.8 lbs)	1026 mm (40.4 in)	19 kg (42 lbs)	N/A	Machine tending, circuit board testing, material handling	1 arm integrated camera, integrated force sensors, front camera for human detection
Rethink Robotics - Baxter		Dual-arm 7-axis arms	2.3 kg (5 lbs) (including gripper)	1041.4 mm (41 in)	75 kg (165 lbs) without optional pedestal	End Effector: 1 m/s (39.4 in/s)	Pick-and-place Case Packing Kitting Process Application Packaging	1 integrated camera per arm, Integrated force sensors, 360 degrees sonar and front camera for human detection
Universal Robots - UR3		6-axis arm	3 kg (6.6 lbs)	500 mm (19.7 in)	11 kg (24.3 lbs)	End Effector: 1 m/s (39.4 in/s)	Soldering Gluing Screwing Pick and Place Operating Hand Tools	Not integrated Arm stops if an overcurrent, like a collision, is detected
Universal Robots - UR5		6-axis arm	5 kg (11 lbs)	850 mm (33.5 in)	18.4 kg (40.6 lbs)	End Effector: 1 m/s (39.4 in/s)	Machine Tending Pick-and-place Process Application Assembly Packaging	Not integrated Arm stops if an overcurrent, like a collision, is detected
Universal Robots - UR10		6-axis arm	10 kg (22 lbs)	1300 mm (51.2 in)	28.9 kg (63.7 lbs)	End Effector: 1 m/s (39.4 in/s)	Machine Tending Pick-and-place Process Application Assembly Packaging	Not integrated Arm stops if an overcurrent, like a collision, is detected