

Traditional robotic set-up

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Coexisting with cobots

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In 1942 Isaac Asimov wrote a short story titled 'Runaround' and which was later included in the 1950 collection 'I, Robot'. In that story, the author devised a set of rules or principles commonly known as the three Laws of Robotics or simply Asimov's Laws. Quoted as being taken from the Handbook of Robotics, 56th Edition 2058 A.D., it is now scarily close to our times. Robots of any kind should comply with these rules in their coexistence with humans. These laws state that a robot may not injure a human being or, through inaction, allow one to come to harm (First Law), that it must obey the orders given it by human beings except where such orders would conflict with the First Law and, finally, that it must protect its own existence so long as such protection does not conflict with the other two laws.

As alien as they may sound, these laws were a source of inspiration for many other science fiction authors and novelists and, to a large extent, they provide a general foundation for what is coming to be known as 'robo-ethics', namely a set of ethical rules that states what robots, capable of taking

autonomous decisions in the presence of humans, should stick to. In all scenarios there is a clear common point. In future, robots and humans will live together, sharing spaces and tasks and so, as in all forms of coexistence, they must learn to know and respect each other.

One may wonder what all this has to do with robotics as it is commonly seen and known in its industrial applications. This is certainly a legitimate doubt because, so far, we are used to seeing robots in factories in very specific configurations, where they are separated from humans by physical infrastructures and do repetitive tasks with no interactions with human workers. The focus here is on the efficiency of the process rather than on the overall flexibility of the robot/worker team. I sometimes refer to these machines as the 'inhabitants of dark factories', thinking of what was the dominant vision of automated factories in the late eighties. These were full of automated machines and robots diligently and relentlessly executing their tasks with no need of human intervention up to the point that the lights could have been turned off leaving the machines to carry on in the dark by themselves.

WHAT IS A COBOT?

Though examples of this kind do actually exist, this is certainly not the most common situation in modern factories. The model that is gaining relevance today looks at a smarter collaboration between robots and workers, one which calls for a new generation of robotic arms that are designed to work together with them in new forms of cooperation. We are thus at the dawn of a new era: the 'cobot invasion'.

Let us start with the name itself. Cobot stands for precisely collaborative robots and conveys the full meaning of how these machines are designed. While we may think of classical industrial robots as the inhabitants of dark factories, cobots are the founding elements of smart factories.

In essence, collaborative robotics mean that humans and robots can collaborate at the same task, with no need of protective fences to separate them, making these machines particularly attractive because of their simple installation, reduced foot print and lower costs. In addition, cobots can be redundant dual arm manipulators characterised by low inertia and low

payload, reducing the risk in case of impact with operators, yet retaining a high level of precision in the execution of their tasks. They also come with new and intuitive programming interfaces that offer an overall reduction of deployment time and cost, all features that make them particularly attractive for small and medium enterprises, as most of the world's footwear companies are, particularly in western countries.

Cobots therefore imply new forms of Human Robot Cooperation (HRC), so it is interesting to see how this interaction has evolved over time. Between 1960 when the first robots appeared in manufacturing and 2000, workers and robots were kept in their respective workspaces separated by physical barriers and with no contacts possible. Robots required significant investments and programming skills. In 2000 the word cobot first appears in a citation from the *Wall Street Journal* as a 'collaborative robot designed to help workers on the job instead of (merely) replacing them'. New approaches to collaboration become possible, such as sharing work spaces but with exclusive motion where only the robot or the worker moves, as in the case of industrial robots functioning as handling assistants. In 2005, Universal Robots was founded in Denmark to develop an affordable, low cost collaborative robot. Their UR5 model was launched in 2008 and certified by TUV in 2014 and, today, the UR family of cobots is one of the most successful in the market.

PROTECTIVE BARRIERS

With the development of protective light barriers (also known as laser scan),



Cobots and operators can work together on many assembly tasks.

CREDIT: UNIVERSAL ROBOTS

collaborative robotics took another step forward. There were no more physical safety fences, just virtual ones where contact with the robot is very unlikely. These kinds of barriers are now commonly used—in conjunction with essential safety electronic components in the automation system—together with normal industrial robots. In 2012, Rethink Robotics was founded in the USA with the purpose, as the name so clearly says, of completely rethinking robotics. Soon after, the company presented Baxter, the first model of a dual arm robot with an innovative human like man/machine interface that could show emotions so that workers could anticipate what the robot's next action would be. Robots and workers shared work spaces where contact was possible (and not harmful for

the humans), but not desired. The company recently went bankrupt and ceased its operations.

The way forward was, however, clear and in 2013, Kuka launched its first cobot (LBR iiwa) as the top class reference machine for a true sharing of workspaces where both robots and workers can move at the same time and where contacts between them are both possible and desired. It is the final confirmation of the birth of a new breed of robotic machines. ABB followed in 2015 with YuMi, a dual arm cobot with a 500gm payload and the acquisition of Gomtech whose range of relatively greater payload machines make them attractive for more heavy-duty activities. In 2016, ISO eventually released a set of standards to specify

Cobots, such as the UR e-series family are simple to install, have a reduced footprint and lower costs.

CREDIT: UNIVERSAL ROBOTS



the official safety requirements cobots must comply with in order to be used in the presence of workers. This finally confirmed them as manufacturing machines and, in a certain sense, the formal industrial equivalent of Asimov's laws of robotics.

It was enough to visit the Automatica exhibition in Munich in June last year (one the most important worldwide fairs dedicated to automation and robotics) to be convinced that this is not going to be a passing fashion, but rather a founding step in the evolution of robotics. Cobot models were counted in dozens, with all the most important European, Korean, Taiwanese and Chinese producers showing their latest offerings. Among them, German start-up company Franka Emika, with its commercial counterpart Voith Robotics, presented its Panda cobot, a 3kg, seven degrees of freedom machine, with a very intuitive and innovative programming environment; certainly one of the stars of the German fair.

CAPABILITIES

Cobots certainly do have a specific place in manufacturing operations, one that is mainly for the execution of manipulation and assembly tasks but, of course, also taking their limitations as well as their advantages into clear consideration. Collaborative robots, in fact, do tend to be slower in order to show their friendly and safe attitude with regard to the workers around them and to operate at lower acceleration and to carry smaller loads. All these aspects must be taken into consideration when choosing their specific application domain. To put that in the correct perspective, let us consider typical assembly operations where productivity and lot size are the driving parameters.

For very small lots and low productivity, manual assembly is the winning approach, delivering the best output along the two main axes. This also matches perfectly with the additional demands of the very high flexibility needed to cope with a similarly high number of variants. At the opposite side of this quadrant, namely for high productivity and very big lots, we have traditional automated lines where industrial robots are perfect. They are not so flexible but, since the number of variants these setups have to



Cobots such as PANDA allow the closest and safest collaboration between robot and operators. CREDIT: VOITH ROBOTICS

deal with is normally low, that is not the key parameter. That said, the ideal positioning of what we may call 'collaborative assembly', that is a scenario where assembly operations are shared between human workers and collaborative robots, is exactly central between these two extremes: moderate productivity with average size lots, harvesting the intrinsic flexibility of these machines that make them the ideal choice when the number of variants grows.

RELATIVE COSTS

One other distinctive aspect for cobots is their cost or, better still, how their overall deployment cost is composed. In fact, when buying a conventional robot, the cost of the machine itself accounts for no more than 15% of the total purchase and implementation cost, with other items such as engineering of the robotic solution, additional parts, programming and testing accounting for the remaining 85%. The lion's share in this case is taken by engineering and programming that can represent as much as 40% of the total. It must be noted that both these activities require a high level of skill and a strong technical background that is not normally easy to find in companies that only need to use the robots, hence the need to pay for the services of system integrators to put their automation system in place.

For cobots, the picture is totally

different. In this case the major cost (around 50%) is the robot itself and programming and engineering together do not exceed 25% of the total. If we put all these elements together we can understand why technology experts see such a rosy future for this family of machines. In a survey completed in 2015, their market potential was forecast to grow from the mere 3,000 units sold in that year to more than 40,000 annually by 2020, surely an interesting market both for suppliers and users.

Robots are certainly key components in the manufacturing vision of Industry 4.0, the often-mentioned fourth stage in the evolution of manufacturing from craftsmanship to industry. In this vision the integration of machinery, warehousing systems and production facilities in what are known as Cyber Physical Systems (a kind of intermingling of the digital and physical world in a holistic and seamless way) is a key element in the future of manufacturing. Once more, cobots with their flexibility, cost effectiveness and productivity are the target technologies for the future smart factories. In research laboratories around the world, scientists are developing ideas such as self-optimising production where robots doing the same tasks connect across all global locations so that performance can be compared and improved at the click of a button. Also envisaged are self-programming robots that can automatically download what they need to get started from a

cloud library and then optimise it through 'self learning', so bridging the gap between robotics and artificial intelligence/machine learning.

SAFETY FACTORS

As we have said, safety in the presence of workers is one of the key features of collaborative robots. This aspect nevertheless deserves further comment. It is, as can be expected, clearly regulated by international standards that indicate under which conditions a robot can be considered safe; in particular, a recent ISO safety standard (TS15066) is specifically dedicated to cobots. Yet it must be remembered that the robot is simply a component in a final collaborative system and is not in itself sufficient for safe collaborative operations. Such operations are in fact dynamic and will be determined by the global risk assessment performed during the application system's design. What is interesting to mention here, is that there are a number of different technologies that can complement a cobot in order to make the entire system safe for

operators as well as allowing classical industrial robots to be safely positioned in areas that workers can access.

One class of such equipment uses light-based sensors. These normally monitor 2D areas where light curtains note whether one or more beams have been interrupted by a worker which determines a corresponding safety action by the robot causing it to slow down or come to a complete stop when the worker gets too close. Another family is vision-based. In this case, one or more cameras create a safety 'field' around the robot and detect when a worker intrusion takes place causing the robot to react in the same way. One last interesting class of devices are so called capacity skins. Here, instead of avoiding contact with the robot in motion by stopping it before it can cause any harm, the robot arm is covered with a kind of soft skin, full of sensors that can very quickly sense any contact and immediately stop the motion with no risk to operators.

As usual, boundaries are never that rigid and clear, and we see situations in which industrial robots can also

somehow get closer in terms of safety to cobots, while all the other advantages that typically drive the decision to go for a cobot rather than a traditional industrial robot, still hold. What about shoemaking then? We are definitely witnessing a deeper and deeper penetration of robots in many different areas of shoe production, both as processing machines as well as smart manipulators. Will cobots find their place in a shoe factory however? It is true that the weight of a typical shoe processing tool or of a last and upper generally exceeds the payload of at least the smallest cobots and so we might be tempted to say that industrial robots would win the match in this instance. At the same time, it is also true that new manufacturing schemes are appearing that follow the simplification that the shoe itself as a product is undergoing and that call for a different organisation of the fabrication process and possibly to other forms of relationship between humans and shoemaking robots. These are likely to become the 'sweet spot' for footwear cobots. 



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