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Collaborative Robots: A Gateway Into Factory Automation

by Jeremy A. Marvel, National Institute of Standards and Technology | September 3rd, 2014

There is a misconception that robotic work cells are not compatible with custom or small-batch manufacturing common with small and medium-sized enterprises. But human-robot production environments, made possible with safer and collaborative-style robots, are tangible and lower-cost entreesÂ to automation for such companies.

Manufacturing is an integral part of a nationâ€™s fiscal stability and prosperity. Nurturing and growing the manufacturing infrastructure is a critical goal for building and maintaining an economically competitive edge, reducing unemployment, and improving quality of life. Automation â€“ robotics in particular â€“ is a key to this goal.

Industry sources estimate that about 90 percent of U.S. companies that could benefit from robotics are not taking advantage of this technology.Â There are over 300,000 small and medium-sized enterprises (SMEs) in the United States, and this number is growing. These companies represent the greatest potential for increasing the use of robotics, yet many of them must overcome several challenges to add robots to their manufacturing processes.

There are many reasons for this situation, not the least of which is the impression that robots are not compatible with a companyâ€™s business model. Another common impression is that robotic work cells are ad hoc and custom-built for specific applications. Such installations are not compatible with one-off or small-batch manufacturing common with SMEs.

Successfully using robots requires expertise beyond the initial integration. Such expertise includes programing and troubleshooting the robots, and verifying and validating that they are working toward their manufacturing goals as intended.

Robots are also dangerous machines. Accommodating occupational safety requirements requires careful planning of process flows, shop floor real estate layouts, and protective measures. All of these take time, experience with identifying and minimizing hazards, and detailed knowledge of safety requirements. Until the safety of a robot has been validated, the performance on that production line is negatively impacted.

Ultimately, the biggest factor when deciding whether to integrate robots into a manufacturing process is money. Robots are expensive, and integrating robots into historically manual processes requires a considerable capital investment. A typical, off-the-shelf robot costs between $30,000 and $60,000. This is roughly equivalent to the annual salary of an average factory worker. However, purchasing the robot is only the first of many expensive, and often time-consuming, steps.

The robot still needs to be installed. Robot operators need to be trained. Safeguards and fences have to be installed. Custom grippers have to be designed, constructed, and tested. Sensors need to be installed, calibrated, and registered to the robot such that the motions of the robot are aligned with the sensorâ€™s inputs. Then the robot has to be programmed to actually do the work. The list goes on and on.

The total cost of installing and integrating robots in a production line can be four to 10Â times the actual purchase price of the robot. There is an understandable degree of sticker shock associated with automating manufacturing processes using robots.

The alternative to full-scale automation is human-robot collaboration. Such collaborations, however, have historically been more about cutting costs than they are about adding capabilities. Cost is directly proportional to the percentage of automation. The more automated the process, the more expensive the solution. The end-user selects a price he/she is willing to pay, and this value determines the percentage of the work that will be done by automation. The remaining percentage of the work is done by manual labor. In this system, human-robot interaction and collaboration are a compromise of economy.

Rather than being a concession, human-robot collaboration should be viewed as a possible goal for manufacturers.

Another way of looking at collaboration is by considering the different degrees of separation on the shop floor. In traditional robot workcells, the robots are physically separated from the rest of the world. Their tasks, workpieces, and workflows are completely independent of the processes around them.

Through advancements in technology and the acceptance of lean practices, the state-of-the-art features a co-mingling of workflow processes. Now, both workers and machines, though still physically separated, are sequentially operating on the same production line on the same workpieces as part of the same workflow. As safety technologies advance further, even the physical separation will be optional.

In the past few years, new collaborative robot designs have been introduced to the marketplace. These robots are built to be easy to use and to safely work alongside people. This built-in safety decreases the infrastructural requirements and integration costs. This makes automation more affordable and reduces the time to bring a new workcell online. When validated with new safety standards specific to collaborative robots, the necessity to physically separate workers and machines dissolves. Now robots and people have the potential to work in the same environment â€“ even on the same workpieces â€“ at the same time.

These new robots are not without their limitations, however. Compared to their conventional industrial brethren, current collaborative robots are smaller, lighter, slower, and have a lower payload capacity. Some of these robots use passive mechanisms such as springs in the joints to ensure safety. These robots are inexpensive, but are less accurate and repeatable, and cannot lift as much as other robots in the same weight class. Other collaborative robots use advanced sensors and controls to provide safe actions. These designs do not suffer from degradations in accuracy, repeatability, or lift capacity, but are considerably more expensive, and their safe functionality is more difficult to validate. Knowing the capabilities and the limitations of collaborative robots is an important step in maximizing their effectiveness in manufacturing processes.

Further advancements in enabling technologies will make robots even more capable and easier to use, further lowering the barrier to entry. This allows the initial investment into robotics and automation to be more palatable for small and medium-sized enterprises, and enables a faster return on capital and intellectual investment.

Ultimately, collaborative robots are not intended to replace people on the shop floor. Rather, these robots are meant to complement people by providing a safe, functional, and adaptive tool. Such tools perform the menial and repetitive tasks, freeing workers to better leverage their creativity, problem-solving skills, and agility in their job functions. As robot technologies improve, collaborative robots will become even better, more capable assistive tools. This will make their coworkers even more productive and valuable as contributors to the manufacturing goal. If this productivity is intelligently leveraged, manufacturing performance will be enhanced, thereby making a company more economically competitive.

Top photo: Baxter from Rethink Robotics is a type of collaborative robot that is safe to operate directly next to people.

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