IFR International Federation of Robotics

Positioning Paper

Demystifying Collaborative Industrial Robots

published by

International
Federation of Robotics
Frankfurt, Germany

Updated October 2019

WHAT IS A COLLABORATIVE INDUSTRIAL ROBOT?

Collaborative industrial robots[1] are designed to perform tasks in collaboration with workers in industrial sectors. The International Federation of Robotics defines two types of robot designed for collaborative use. One group covers robots designed for collaborative use that comply with the International Organization for Standards norm 10218-1 which specifies requirements and guidelines for the inherent safe design, protective measures and information for use of industrial robots. The other group covers robots designed for collaborative use that do not satisfy the requirements of ISO 10218-1. This does not imply that these robots are unsafe. They may follow different safety standards, for example national or in-house standards.

There is considerable variance in the types of collaborative robots meeting the above specifications, and the level of contact between robot and worker in collaborative applications. At one end of the technical spectrum are traditional industrial robots operating in a separate workspace that workers can enter periodically without having to shut off power to the robot and secure the production cell beforehand – a time-intensive procedure that can cost thousands of dollars per minute of machine downtime. The robot's workspace can be fitted with sensors that detect human motion and ensure the robot works at very slow speeds or stops when a worker is within the designated workspace.

At the other end of the spectrum are industrial robots designed specifically to work alongside humans in a shared workspace. Often referred to as 'cobots', these robots are designed with a variety of technical features that ensure they do not cause harm when a worker comes into direct contact, either deliberately or by accident. These features include lightweight materials, rounded contours, padding, 'skins' (padding with embedded sensors) and sensors at the robot base or joints that measure and control force and speed and ensure these do not exceed defined thresholds if contact occurs.

ENSURING SAFETY

Like any other piece of industrial machinery, collaborative robots must be safe. The International Organization for Standardization (ISO) has developed standards for robots operating in four types of collaborative mode. Compliance with these standards means the robot can in principle be used safely.

However, a safe robot does not guarantee a safe collaborative application in practice. A process in which a safe cobot wields a sharp tool is unsafe no matter how slowly the cobot operates. End-users must conduct a risk assessment of the intended application to be certain they meet the legally binding standards for health and safety at work in their country. The assessment covers the entire application, including the workspace, the robot, end-effector, tools, workpieces and other elements such as cabling and lighting, that could pose hazards.

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[1] The International Organization for Standardization (ISO) defines robots according to their intended use. According to ISO 8373:2012, an industrial robot is '*an automatically controlled, reprogrammable, multipurpose manipulator programmable in <u>three</u> or more axes, which can be either fixed in place or mobile for <u>use in industrial automation application</u>'.* This paper focuses only on collaborative industrial robots. Automated Guided Vehicles (AGVs) are classified as service robots and are not included.

TYPES OF HUMAN-INDUSTRIAL ROBOT COLLABORATION

Human-industrial robot collaboration can range from a shared workspace with no direct human-robot contact or task synchronisation, to a robot that adjusts its motion in real-time to the motion of an individual human worker (cf. Figure 1).

Currently, IFR members find the most common collaborative robot applications are shared workspace applications where robot and employee work alongside each other, completing tasks sequentially. Often, the robot performs tasks that are either tedious or unergonomic – from lifting heavy parts to performing repetitive tasks such as tightening screws. Case studies presenting real-world collaborative applications of different collaboration intensity can be found on the IFR's website (https://ifr.org/).

Applications in which the robot responds in real-time to the motion of a worker (altering the angle of the gripper to match the angle at which a worker presents a part, for example) are the most technically challenging. Since the robot needs to adjust to the motion of the worker, its movements are not completely predictable and therefore the end-user must be sure that the full parameters of its potential scope of motion meet safety requirements. Examples of responsive collaboration in industrial settings are unlikely to appear soon in most manufacturing sectors, which rely on precision and repeatability to achieve productivity gains.

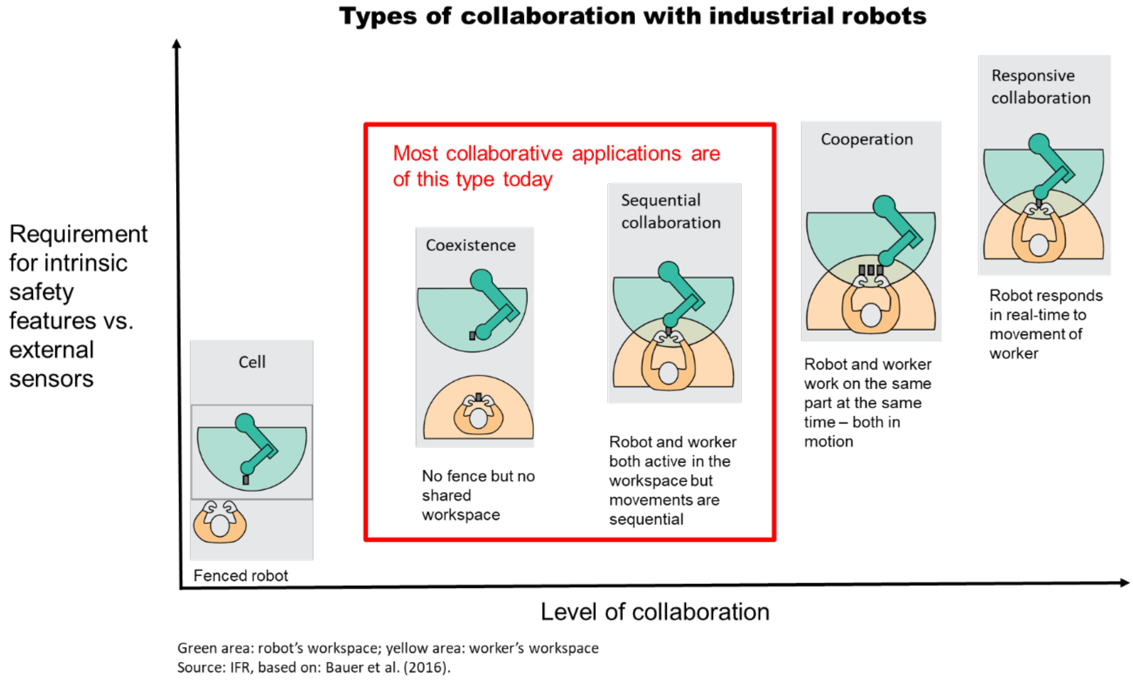

Figure 1: Types of Human-Industrial Robot Collaboration

BENEFITS OF COLLABORATIVE ROBOTS

Collaborative robots provide an economically-viable entry-point to robotic automation. They can be used to automate parts of a production line with minimal changes to the rest of the line, providing companies that have not yet automated production processes - such as small-to-medium-sized manufacturers – an entry to the productivity and quality improvements offered by robots.

For companies such as automotive manufacturers that have already automated the production of car bodies, the additional use of collaborative robots offers the opportunity to support workers in completing final assembly tasks that are often the source of chronic back injuries. Collaborative applications enable manufacturers to automate parts of processes that are tedious for humans – from fetching parts and feeding machines, to quality inspection which is hard for humans to do consistently well over long periods of time.

In the past, systems integrators and internal robot experts have been required to install, programme and operate industrial robots. Programming interfaces are now increasingly intuitive in both traditional robots and newer cobots. Systems integration experts are still needed for complex applications and those requiring a re-design of the entire production process. For simpler, stand-alone applications, workers with minimal robot training can now easily re-deploy the robot to a new task. This is particularly important for manufacturers that operate short production runs and need to be able to quickly re-task the robot for a new run. Cobots are usually lightweight and can be easily moved around the factory. They generally take up less factory floor space - a significant cost factor for manufacturers. This combination of features addresses a market of end-users that are new to robotic automation and do not have, nor plan to gain, expert automation capability.

Industrial robots often operate from a fixed mounting, but there is demand for mobile industrial robots that combine a mobile base and a (collaborative) robot. These robots can, for example, carry materials from one workstation and unload them or feed a machine at a second workstation.

The right choice of robot – traditional or collaborative – is determined by the intended application. When speed and absolute precision are the primary automation criteria it is unlikely that any form of collaborative application will be economically viable. In this case, a traditional, fenced industrial robot is – and will remain – the preferred choice. If the part being manipulated could be dangerous when in motion, for example due to sharp edges, some form of fencing will be required. This applies even for cobots that stop on contact. Another factor influencing economic viability is the extent to which the robot must be integrated with other machines in a process. The more integration needed, the higher the cost of the robot installation.

Collaborative industrial robots are tools to support employees in their work, relieving them of many heavy, unergonomic and tedious tasks such as holding a heavy part steady in the required position for a worker to fit screws. However, there are still many tasks that are easy for humans but hard to automate, for instance dealing with unsorted parts, and irregular or flexible shapes. Finishing applications such as polishing and grinding applications that require continuous fine-tuning of pressure applied to the surface are also difficult to automate cost-efficiently. Collaborative robotics enables manufacturers to improve productivity by using robots to complement human skills (see also IFR Positioning Paper: Robots and the Workplace of the Future for more information on how robots support workers in manufacturing, logistics and healthcare).

FUTURE TRENDS IN COLLABORATIVE ROBOTICS

The market for collaborative robots is still in its infancy. End-users and systems integrators are still gaining experience on what works and doesn't in the design and implementation of collaborative applications. Technology developments in sensors and grippers hold promise for expanding the range of actions that the robot end-effector can perform. Programming interfaces will continue to become more intuitive, not just for cobots, but also for traditional industrial robots.

IFR ACTIVITIES

Predictions of growth in the collaborative robot market vary widely and some do not distinguish between the manufacturing and professional service sectors. The IFR began in 2019 to produce statistics and forecasts on the market for collaborative industrial robots, based on sales figures of robot suppliers.

In 2018, less than 3.24% (14,000 out of more than 422,000) industrial robots installed, were cobots, an increase of 23% over 2017.

REFERENCES

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