A Collaborative Dual-arm SCARA Robot, duAro, Provides a Production System That Allows Human Beings and Robots to Work Together: Development Concept and Applications

The collaborative SCARA robot, duAro, is a product created as part of our committed pursuit of ease of use. Its development concept is based on two key terms: "easy to use" and "human and robot collaboration and cooperation."

This allows robots to be installed in industries and fields that were considered to be difficult to automate due to limited preparation period and installation space, as well as cost effectiveness issues. This is a production system that effectively addresses the issues of reduced workforce and aging of population.

Introduction

As phenomena such as a decreasing birthrate, an aging population, and a decrease in the working age population advance in Japan, robot technologies hold the potential to solve social issues by solving worker shortages, alleviating workers of excessive work, and increasing productivity in a broad range of fields, including production sites in the manufacturing industry, medical and nursing care sites, and work sites in the agriculture, construction, and infrastructure fields.

1 Background

In the past, industrial robots have been introduced and developed mainly in mass production fields with long product lifecycles, such as the automotive industry. On the other hand, in fields in which product lifecycles are short and model changes occur every few months, such as the electric and electronic fields, automation has been considered difficult due to the limited preparation period and cost effectiveness issues, even though the introduction of robots has been desired.

In addition, although it is said that 300,000 robots have been introduced throughout the more than 40-year history of industrial robots in Japan, most of them were adopted only by major businesses in reality.

In order to solve countrywide labor shortages, it is indispensable that robots be introduced in small- and medium-sized companies, which account for 99.7% of all companies. However, the spread of conventional robots that require safety fences, as well as the acquisition of special handling knowledge, has been difficult.

2 Development concept of the Collaborative Dual-arm SCARA Robot duAro

The collaborative dual-arm SCARA robot duAro has been developed based on the key development concepts "easy to use" and "human and robot collaboration and cooperation."

In order to lower the barrier to the introduction of robots in industries or fields in which automation has been considered difficult due to limited preparation periods and installation space, as well as cost effectiveness issues, duAro has been designed to replace production line workers without any modification. By making it possible for duAro to collaborate with humans, the need for safety fences, which were mandated to prevent collisions for conventional industrial robots, has been eliminated.

(1) Collaboration with humans

In order to enable collaboration between humans and robots, safety was sufficiently ensured through the use of low power motors with an output of 80 W or less and a

† Simplifies peripheral equipment through safety functions that enable collaboration with humans and flexibility achieved by collaborative dual-arm operation. Radically reduces the start-up time through easy introduction.

speed reduction function by area monitoring, after conducting a risk assessment.

The speed reduction function by area monitoring allows the robot operation range to be set to low-speed and high-speed operation ranges, as illustrated in **Fig. 1**. The robot can be operated efficiently by operating the robot at a low speed near areas where humans are working and at a high speed in areas away from humans.

Even if the robot contacts or collides with a human while working, it can be stopped by the collision detection mechanism.

In addition, the robot has a rounded design and arm covers, which conventional robots do not have. The arm covers are made of foamed urethane to provide a cushioning property, enabling humans to collaborate with the robot with a sense of safety.

(2) Space conservation

Each duAro arm is designed to be 76 cm in length, which is approximately the same as the working range of a person, so that it can be installed in a space intended for one person and perform tasks performed by a human using both arms in a single-person space. As illustrated in **Fig. 2**, the robot is designed so that it can be installed in a single-person space by controlling two arms arranged on the same axis by one controller. This coaxial dual-arm configuration allows duAro to perform cooperative operations using two arms that cannot be realized by using two conventional SCARA robots.

(3) Easy installation

The duAro's controller can be stored on a cart to which the arms are attached in order for it to be introduced

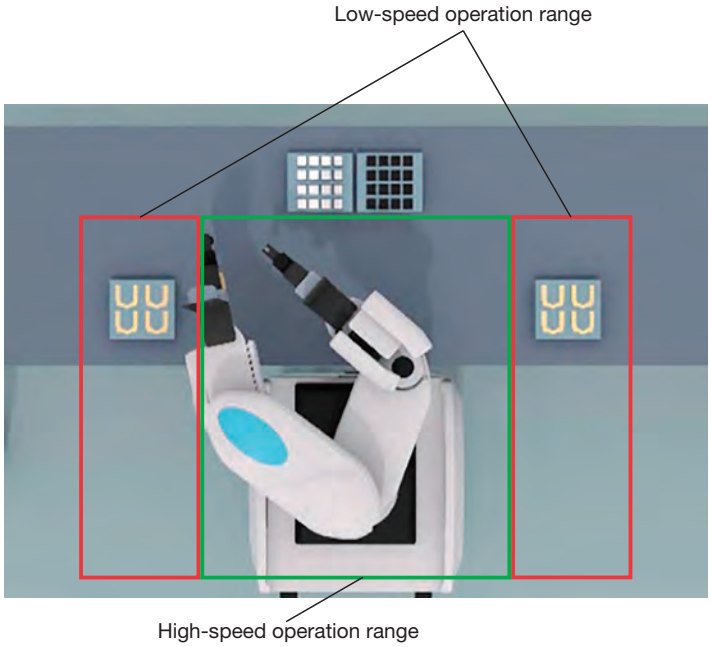

Fig. 1 Speed reduction feature using area monitoring

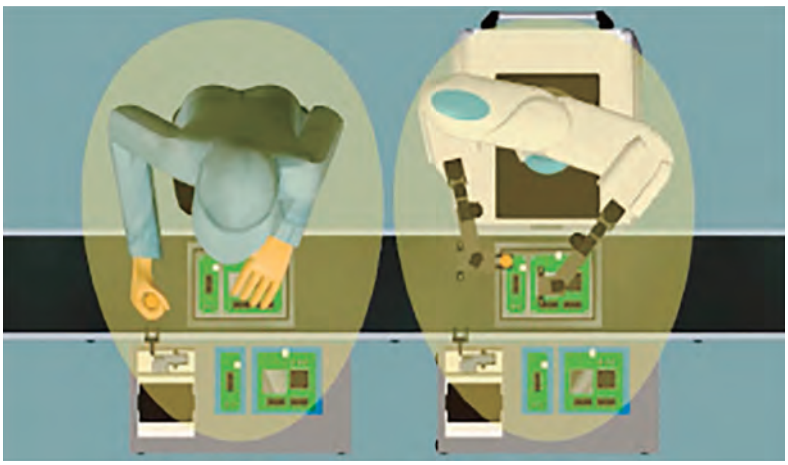

Fig. 2 Co-operation between people and duAro

without modifying the production lines. By moving it with a cart, it can be easily installed in the position where it will be used. This makes it possible to replace a worker at any position on the production line, as illustrated in **Fig. 3**.

(4) Easy teaching

When introducing a conventional robot, it was necessary to teach the work procedures to the robot by strictly defining them using a program. However, with duAro, the teaching operation has been simplified by the direct teach function, as well as by utilizing a tablet.

The direct teach function teaches the robot by moving the robot arm in simulation of the actual movements, as illustrated in **Fig. 4**. Gravity compensation of the direct teach function is set so that the arms can be smoothly moved for teaching not only in the horizontal direction but also vertically. Gravity compensation enables smooth movement on the Z axis according to the weight of the end effectors attached to the extremities of the arms by calculating the compensation value, which done by adding the end effector weight.

In addition, usability is enhanced in duAro by transferring the teach pendant function to a dedicated Android tablet, eliminating the teach pendant used for conventional industrial robots.

(5) Easy introduction at low cost

Many customers who desire automation request that the work environment of the workers that are to be replaced by robots remain unmodified. Therefore, in

Fig. 3 Install robots without production line modification

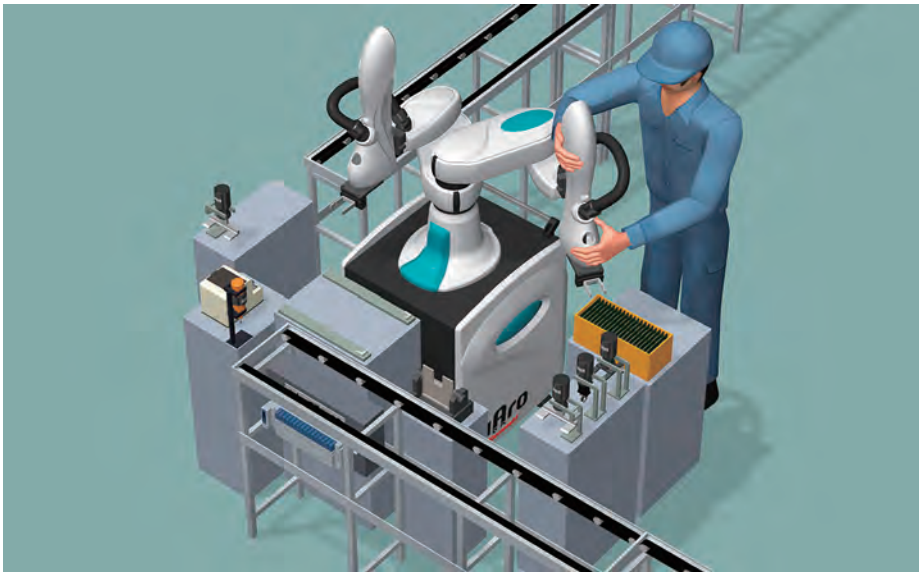

Fig. 4 Direct teaching function

consideration of the types of work that are performed by duAro it is necessary to have an understanding not only of how the workers perform work, but also what kinds of tools they use and how the tools are used.

In addition, some customers desire that the tools or jigs that are currently used by the workers continue to be used to reduce the cost of introduction. With duAro, the tools or jigs used by the workers can be used by attaching the base-chuck shown in **Fig. 5**, which is provided as a standard interface part, to both arms. With the base-chuck, it becomes possible to efficiently switch between different tools or jigs by attaching a part called a conversion adaptor to each tool or jig.

In addition, general single-arm robots cannot perform work properly unless the parts are placed in certain positions when they perform assembly or transport. Therefore, it was necessary to position parts using a different mechanism or supply parts to the specified positions using special jigs. However, duAro can position parts using both arms or perform work with one arm while assisting with the other arm.

For example, when tightening the screws of a printed circuit board into a PC, as illustrated in **Fig. 6**, duAro can tighten the screws while supporting the PCB with one arm as humans do. This eliminates the need for a unit to support the PCB that was necessary with conventional robots.

Moreover, when transporting workpieces of different

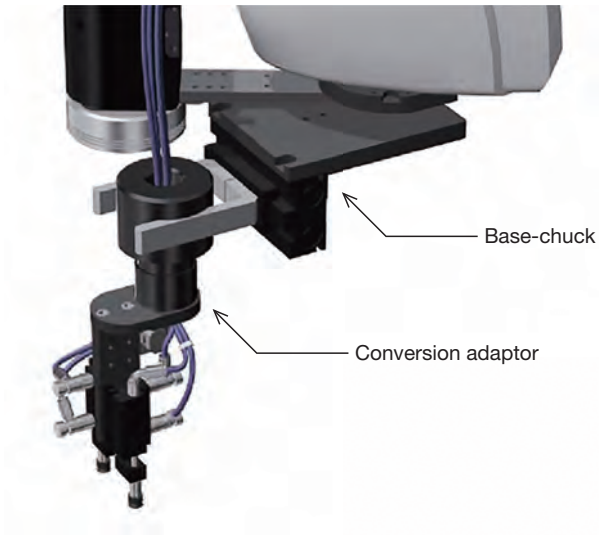

Fig. 5 Base-chuck and conversion adaptor

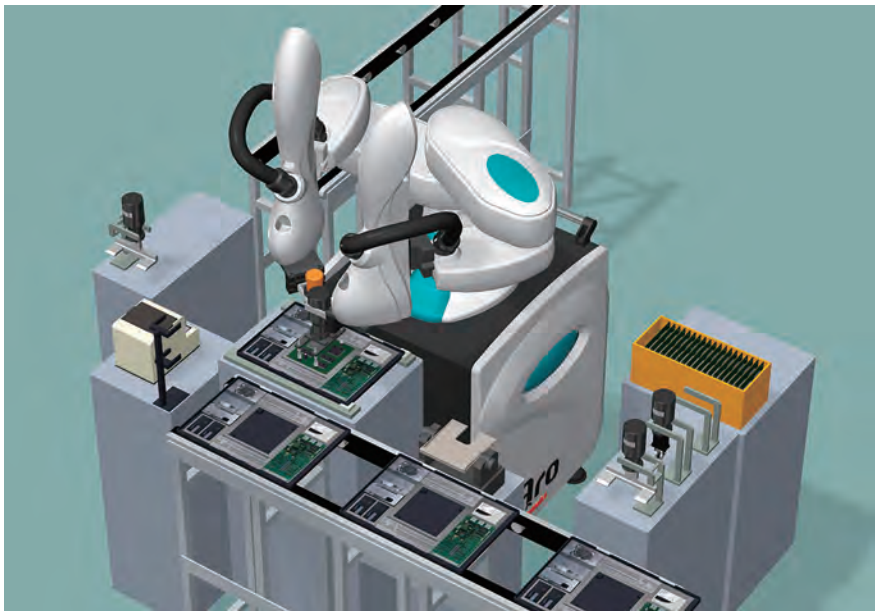

Fig. 6 Tighten the screws of printed circuit board to PC

sizes, it was necessary to design and fabricate dedicated hands for conventional robots for each workpiece size. However, since duAro has a dual-arm configuration, it can perform actions such as "scooping" or "sticking" regardless of the size of the workpiece and transport large workpieces or workpieces of different sizes just using its general hands.

3 Example applications of duAro to production systems

Example applications of duAro in actual work sites are introduced below.

(1) Screw tightening process (collaboration with humans)

When applied to the screw tightening process, "human-robot collaboration" has been realized, and work is shared between the duAro and workers. In this application example, a duAro has been introduced in place of the worker who was originally in this position, and it tightens screws with the electric screwdriver that the worker previously used while supporting the workpiece with one arm.

The introduction of duAro has brought various benefits. Taking cycle time as one example, work that used to take 14 seconds when performed by a human worker is performed in 9 seconds after introducing the duAro.

(2) Loading/unloading (easy installation)

When applied to loading/unloading for the pressing machine illustrated in **Fig. 7**, "easy installation" has been realized.

In this application example, duAro loads and unloads an automobile part called a sleeve yoke into/from a pressing machine. Since the pressing machine requires mold

Fig. 7 Application of loading/unloading for pressing machine

Fig. 8 Application to rice ball packaging

changes depending on the part type, there was a problem in which the mold change operation became a hassle when a loading/unloading mechanism was installed for automation. However, since the duAro can easily be transported with the cart, it can easily be pulled out of the pressing machine when changing the mold.

(3) Rice ball packaging in food trays (space conservation)

In the food industry, the reduced workforce and aging population have become issues, and there is a pressing need for automation. However, it is often the case in food factories that many workers and pieces of equipment are arranged side by side in a limited space and there is not enough space to introduce machines. Due to these circumstances, the space duAro can save is attracting attention, and many inquiries.

In the application to rice ball packaging in food trays illustrated in **Fig. 8**, the work of packing triangular hand-rolled rice balls transported from upstream into food trays is automated while saving space.

In addition, food-grade grease is used in duAro to ensure sanitation. Moreover, it is also possible to cover duAro with a clean suit for robots.

Conclusion

The spread of co-existing, cooperative robots is accelerating, and it is believed the that production system realized by duAro, which allows human beings and robots to work together, will become an effective countermeasure against the reduced workforce or aging population in the future. We are planning to further shorten the preparation period for the introduction for applications that are frequently requested by offering duAro packaged cells. We will continue to work to realize greater production to allow humans and robots to work together.


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