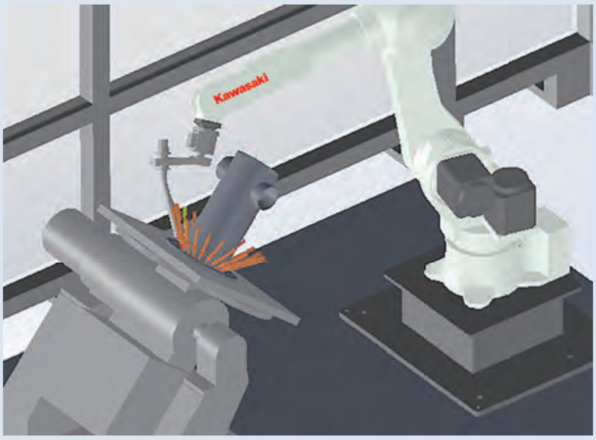
Efforts for Automated Teaching in Order to Expand Applications: Increasing the Sophistication of Offline Teaching Software Utilizing 3-dimensional CAD



While more support for fields of application where robots could not be used previously is being demanded, products to be produced are also becoming more complicated and diversified. In these circumstances, demands for offline teaching where robots are taught using simple operations are increasing.

To expand the applications, we have worked on increasing the sophistication of offline teaching software utilizing 3-dimensional CAD.

Introduction

More and more companies are starting to use industrial robots to address the shortage of workers caused by the falling birthrate and the aging population and to reduce the variations in quality that manual production causes. Combined with the technical innovation in technologies related to robots, the application of robots is expected to expand to fields that were impossible to automate in the past.

1 Background

The manufacturing industry is currently experiencing a movement toward mass customization to address individual customer requirements such as variable production amounts of diversified products that have a complicated shape. In this context, one of the challenges for expanding the application of robots is how easily you can operate the robot in producing increasingly complicated and diversified products.

More and more customers use offline teaching software that leverages 3-dimensional CAD to solve this issue. The offline teaching software allows the user to examine the layout of robots and peripheral equipment and generate robot operation programs based on the 3-dimensional CAD data on the PC. The software can automatically create robot operation programs even for complicated shapes and reduce variations in quality and working hours by workers.

2 Teaching simplified by the offline teaching system

We developed the automatic robot operation program generation software, KCONG, and the robot layout examination simulator, K-ROSET as offline teaching software to support the introduction of robots. Using these software applications on a case-by-case basis, we provide robot systems with the optimal configuration for customers.

The following section describes KCONG.

3 Automatic robot operation program generation software, KCONG

(1) Concept

KCONG is offline teaching software that can automatically create robot operation programs with intuitive operations, that is, selecting working positions on 3-dimensional CAD data of the product and teaching it the process conditions.

(2) Overview

KCONG is offline teaching software that includes 3-dimensional CAD. Therefore, you can start using KCONG at the product design phase. That is to say, you can seamlessly design the product shape and teach the robot how to work on the product for robotic processing as shown in **Fig. 1**.

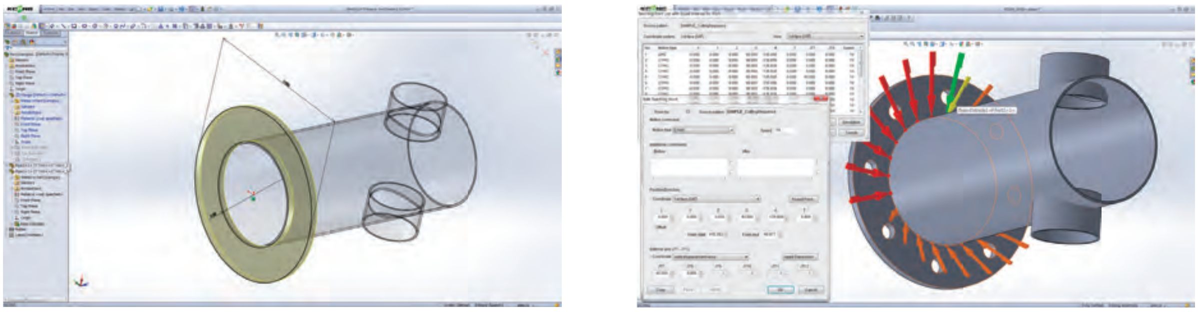
The user finds the work procedure that will achieve the best quality when processing products. With KCONG, you can save how to create teaching positions and process conditions as construction rules in the database in order to make use of it later, and accumulate data obtained by trial and error as expertise. Furthermore, you can refine them into better processing methods as the use frequency increases. The procedure when KCONG is used is shown in **Fig. 2**.

In addition, KCONG has a robot simulation function that includes an interference check as shown in **Fig. 3** and contributes to vertical startup in field applications as the user can examine the configuration and check operations before installing the equipment.

(3) Features

(i) Automatic posture determination function covering external axes

From the beginning of development, we have used KCONG to address user needs by developing functions for tasks such as arc welding, cutting, and chamfering. As it is difficult to cover complicated product shapes in the operating range of the robot alone, it is required to have a system that has external axes that move the robot or rotate the product. As KCONG has a function to automatically determine the operation control of external axes other than the base axis of the robot, you can easily teach it to weld parts with complicated shapes as shown in **Fig. 4**.



(a) Product shape design

(b) Teaching

Fig. 1 Seamless design and teaching

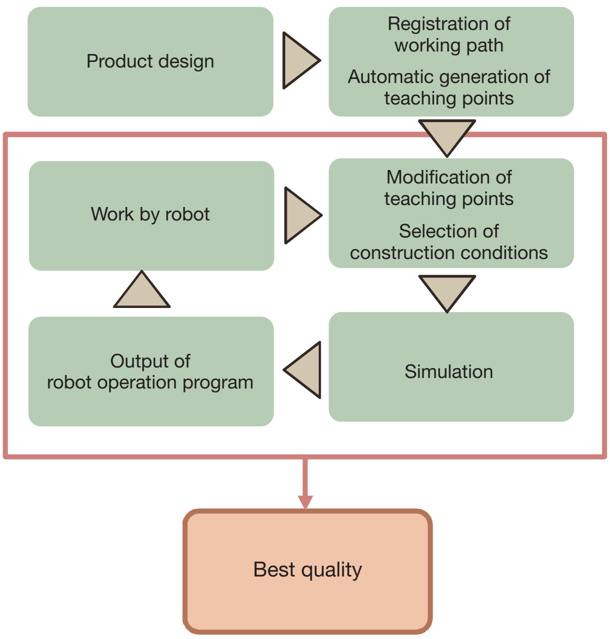


Fig. 2 Procedures for KCONG is used

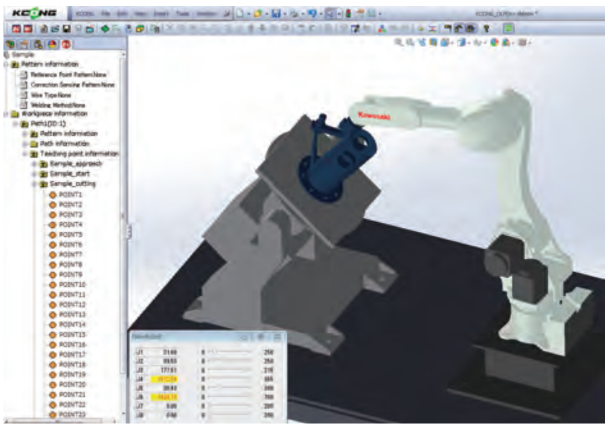


Fig. 3 Robot simulation function with interference check

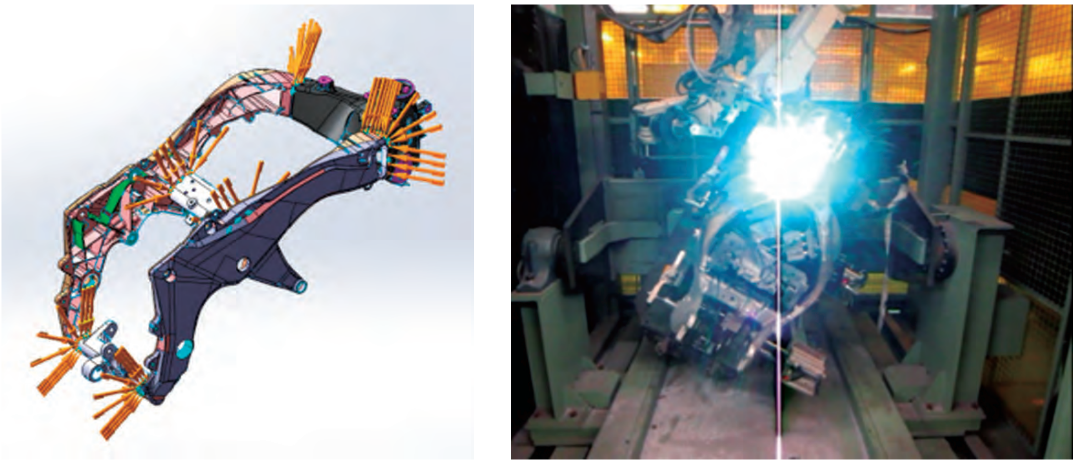


Fig. 4 Motorbike frame joining

(ii) G-code conversion function

KCONG has a function to convert the industry standard format known as G-code, which is output from the CAM software used in NC machine tools, into the operation program for our robot. This function allows our robot to perform the same tasks as NC machine tools. The accuracy is lower because robots are less robust than NC machine tools. However, they are less expensive than NC machine tools, which become expensive in proportion to the size of the object being processed. In addition, the robot can flexibly address system changes. These advantages really set it apart from recently developed 3-dimensional printers. Our robots have been adopted by companies that manually manufacture large objects as shown in **Fig. 5** based on these advantages[1].

Robots are also used for evaporative pattern casting of prototype molds for industrial machines, camera or printer patterns, and woodwork.

4 Efforts for increasing new applications

When implementing robots in the past, the work accuracy was often an issue or it was cumbersome to teach surface processing. In addition, customers increasingly want to use the DMU (digital mock-up) tool that they had used when introducing the robots.

(1) Speed reduction function (measure for accuracy)

Now that G-code can be used, we receive an increasing number of requests from processing manufacturers to introduce robot systems. However, the accuracy could be a challenge. To solve this challenge, it is effective to improve not only the rigidity of robots, but also the operating characteristics. For example, the accuracy tends to drop due to operating characteristics when the robot arm moves backward or if the angle of the processed

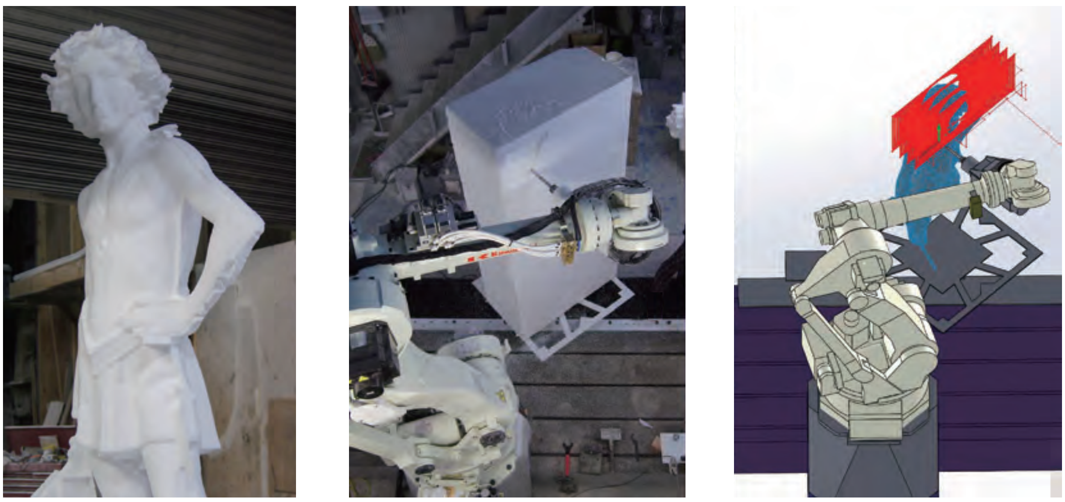


Fig. 5 Tridimensional formative cutting for theme park

curved surface is largely changed. The accuracy drops particularly when these operations are performed above a certain speed. Therefore, we improved this part by adding the automatic deceleration function.

(i) Features

The speed reduction function can be used to specify the speed reduction range. This function changes the operating speed by automatically entering the deceleration command into the robot operation program when the robot is in a posture that would affect the quality.

(ii) Effects

The color map in **Fig. 6** shows the result of applying the speed reduction function to the G-code output from CAM. You can see that the speed changes in straight sections and corner sections. This function allows G-codes, which are CAM data output for NC machine tools, to be used by robots while maintaining necessary accuracy.

(2) Surface treatment function

As force sensors are now available at low prices, it has recently become realistic to use robots for surface treatment such as polishing though it was difficult only with position control. Although surface processing such as polishing was addressed by making the most of advanced CAD operations in the past, we developed a new function that simplifies this operation.

(i) Features

The user selects the working range on 3-dimensional CAD. Then, the user creates a robot operation program by entering data such as the distance between teaching points on the working path as process conditions. Next, the user set parameters required to adjust surface treatment such as the working speed and the overlap amount. Smoothing can be executed to prevent the posture from largely changing between teaching points. This function can be applied to not only polishing but also painting and other treatment as the offset distance from the product surface can be set.

Because this function supports shape data in the versatile STL (Standard Triangulated Language) format, data on products not designed with 3-dimensional CAD can be captured with the 3-dimensional scanner and used.

(ii) Effects

Although an appropriate overlap amount is affected by the difference between individual workpieces, you can achieve desired polishing as shown in **Fig. 7** by feeding back the force measured with the force sensor attached at the tip of robot and adjusting the processing speed and overlap amount with this function.

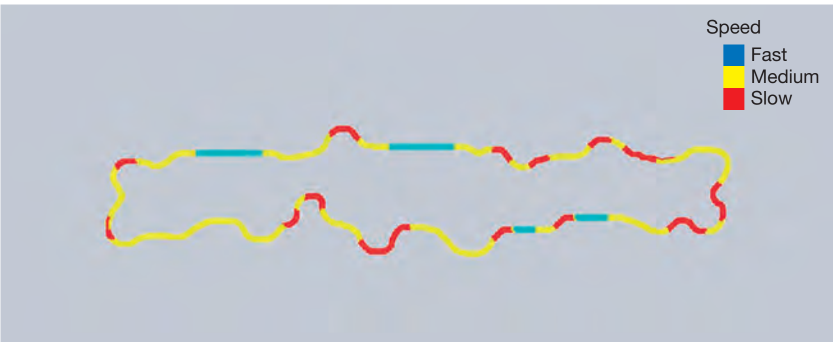


Fig. 6 Result of application of speed reduction function

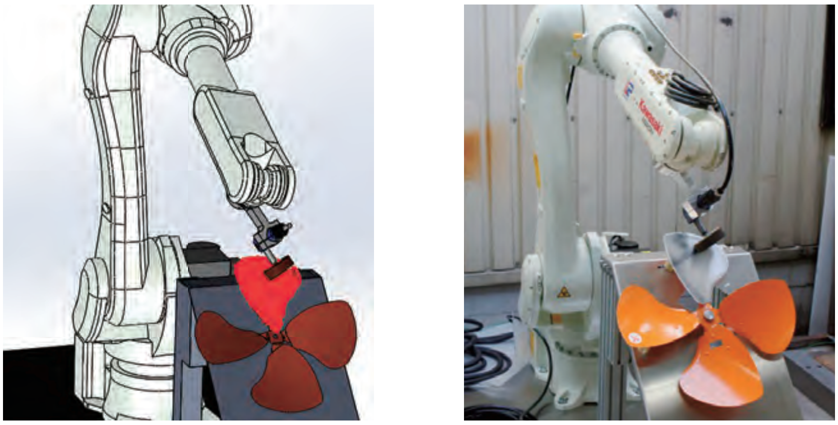


Fig. 7 Polishing operation

(3) Assembly procedure specification function

Since products from home appliance manufacturers have relatively short life cycles, manual work is more applicable and efficient than robot production. For this reason, not many home appliance manufacturers have adopted automation.

Recently, more and more users use the DMU tool to solve quality problems when assembling multiple parts in the upstream design process. The DMU tool enables the user to check the assembly procedure in animation using the 3-dimensional CAD by specifying the layout of parts, assembly order, and used tools. By applying assembly information configured with this DMU tool to creation of robot operation programs, you can reduce the startup time of robot system.

(i) Features

As the DMU tool is mainly intended to improve the efficiency of human work, we developed the function to specify information on tools required for robot automation and product assembly positions.

The workflow is as shown below.

① Prepare 3-dimensional CAD data of the product.
② Load the CAD data into the DMU tool and specify the assembly procedure.
③ Check the assembly procedure with simulation.
④ Specify tool information and product assembly positions.
⑤ Output the assembly procedure.
⑥ Simulate the robot operation including interference based on the assembly procedure.
⑦ Transfer the verified robot operation program to the real controller.

(ii) Checking the assembly operation

When examining the assembly work, you must break it down into processes to assemble parts, fixing the product. When operating the robot operation program output from the DMU tool in the system that uses two robots, the collaborative dual-arm scalar robot, duAro, is suitable for processing such as assembly. This is because duAro is equipped with two arms, which can be moved coordinating with each other's operation. The result of operation check using duAro is shown in **Fig. 8**.

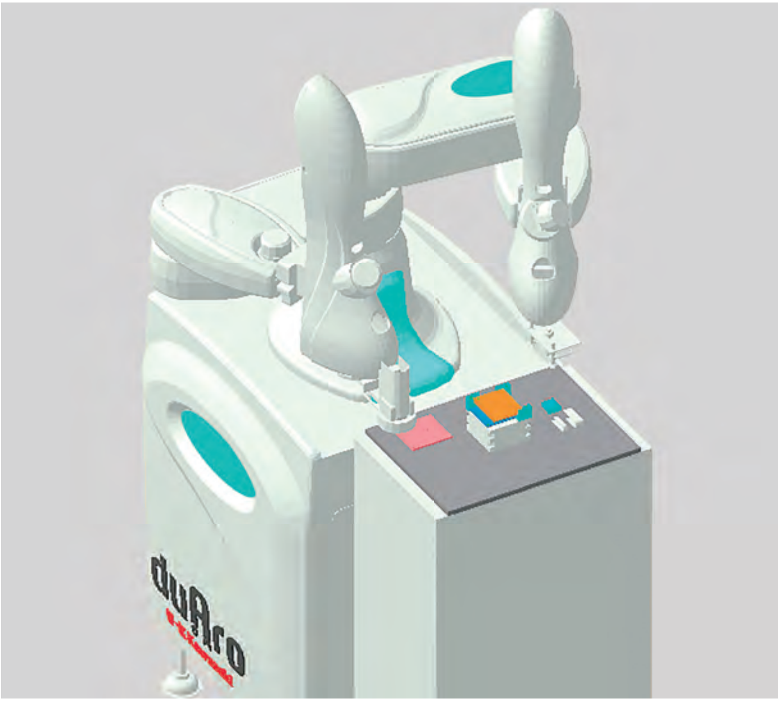


Fig. 8 Assembly using duAro

Conclusion

Tablets and other new input media are recently widespread and leveraged, replacing PCs. It is expected that new application fields of robot will increase as the offline teaching technology develops, absorbing these technologies. Using the offline teaching software as a differentiator from other robot manufacturers, we will continue to sophisticate teaching automation, responding to market needs. We will advance automation of teaching that users can use without being aware of robots.

Reference

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