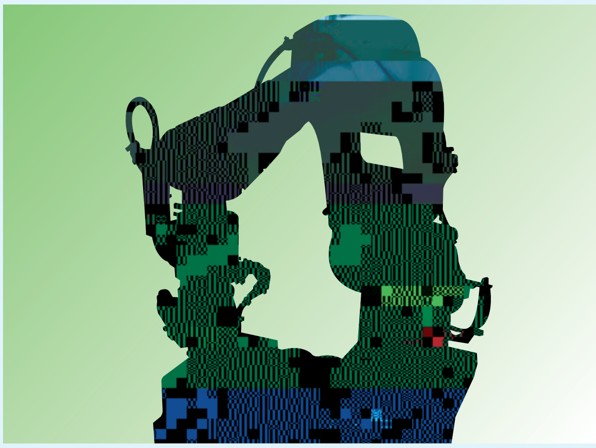

To reduce labor and maintain product quality at production plants, complicated assembly operations need to be automated. This paper describes our approaches to the development of elemental technologies toward realization of assembly robot systems. In addition, we present examples of in-house applications using these technologies.

Preface

In the industrial sector, introduction of robots to production lines to improve productivity has progressed steadily. In the welding and painting lines in particular, where robot automation has been actively pursued, there is an extremely large number of robots in operation. In recent years, moreover, efforts have begun to introduce robots into new areas where automation has been lagging. One of these new areas is automation of assembly operations.

Behind this demand for automation of assembly operations is the need for a response to multiple-item variable-volume production. The manufacturing industries in advanced countries produce a wide variety of products, including customization of standard products, in order to respond to wide-ranging customer needs. This trend has raised the skill and knowledge levels demanded for assembly operations, increasing the burden on operators. Moreover, and particularly in Japan, a declining labor force population due to fewer children and more seniors has made it more difficult to ensure a stable supply of operators and transfer of skills to younger workers. Use of robots to automate assembly operations is expected to provide a possible solution to these issues.

In emerging countries, meanwhile, as represented by the BRICs, manufacturing has centered on mass production items, backed by a relatively low-cost labor force. In the future, however, as their local economies develop, they will be unable to avoid product diversification. When this happens, large costs will necessarily be incurred in manual operations and quality maintenance for each product. The introduction of robots will have major benefits since the automation of assembly processes will ease tooling changes and quality maintenance.

For these reasons, we can expect expansion of the market for automation of assembly operation using robots. But because assembly involves a combination of diverse operations, there are many difficulties to overcome in using robots. Therefore, robot manufacturers are engaged in research and development toward their practical application

We at Kawasaki also continue to be engaged in elemental technologies development centering on hand technologies for assembly that can enable diverse operations, with the goal of realizing an assembly robot

Fig. 1 Chebyshev linkage hand

system. In addition, as a result of these efforts, we have achieved automation of assembly operations at our own plants. In this paper, we present the elemental technologies related to our assembly robot system, and show some application examples in our production lines.

1 Issues of assembly automation using robots

If the basic operations are simple in nature, such as welding or painting, etc., robots often demonstrate abilities superior to those of humans. In many cases, however, the assembly process consists of multiple operations. In such cases, what would be easy for a human often is difficult for a robot, or involves excessive costs to realize.

A summary of the issues for assembly automation using robots can be divided broadly into the three areas listed below.

① Acquisition of dexterity
② Acquisition of flexibility
③ Acquisition of accuracy

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(2) Acquisition of flexibility—error absorption mechanism

In assembly operations, the robot often comes in contact with the products, or the hand presses against gripped parts. When this happens, even a slight error in assembly position can impose a heavy load on the robot. Therefore, in applying robots to assembly operations, various methods for controlling the pressing force have been adopted, such

② Touch (distance) sensor method

A touch sensor is built into the error absorption mechanism to detect the occurrence of displacement due to pressing.

Since the marker imaging method does not require a sensor on the robot side, we can build a more reliable system. The touch sensor method involves the placement of multiple sensors that enable the estimation of tilt.

This technology lets us determine whether parts have been successfully assembled or not. For example, as shown in Fig. 4(c), if a large displacement has been measured in the course of a parts insertion operation, we can conclude that parts have interfered with each other and the operation has failed. Using these detection results, we can respond with retries of the assembly, etc.

In addition, in assembly of gearwheels involving gear engagement, we can perform such advanced operations as searching for the gear engagement phase with the parts in a pressed state, and judging success by the release of error absorption mechanism pressing.

(3) Acquisition of accuracy—vision sensor technology

One effect expected of automation of assembly operations is implementation of uniform and accurate operations that humans have difficulty performing, to eliminate careless errors and maintain product quality. However, this issue cannot be resolved solely by the installation of robots; coordination with sensors is also essential.

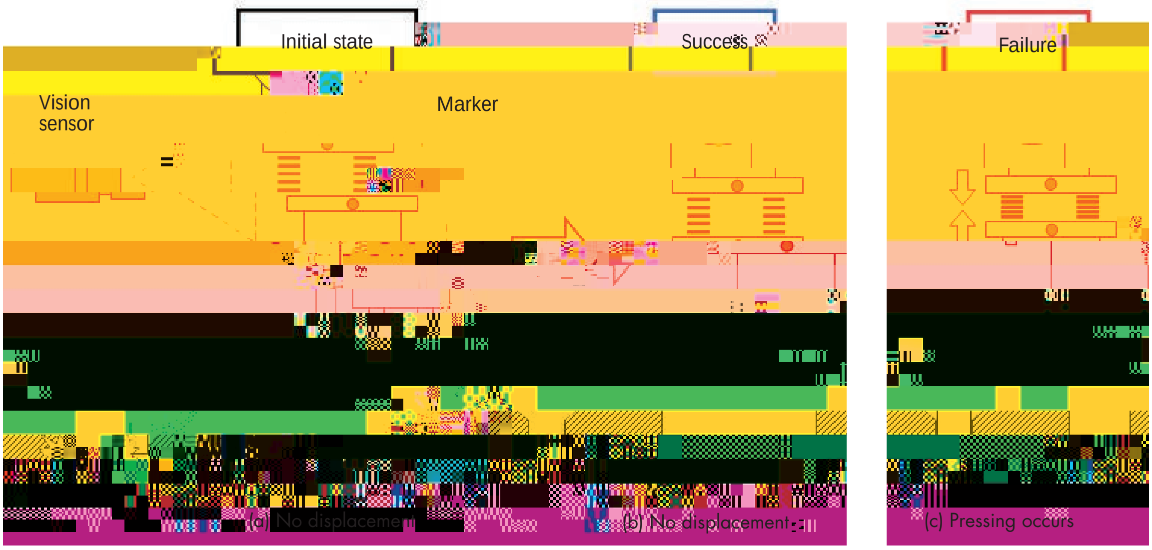
We have long been engaged in the development of vision sensors for robots and have applied them to many production sites. Here, we present an example of vision sensor technology applied to assembly robot systems.

(i) Position detection technology

To ensure performance of accurate assembly operations by robots, the position of the parts to be assembled must be determined to high precision. If the parts size or shape is fixed, then the simplest method is to install tools capable of mechanical positioning. However, with greater diversification of customer needs, the production site increasingly needs to produce diverse products. In such cases, provision of special tools for each part can lead to massive cost increases.

To address these issues, we applied a vision system to the assembly robot system for performing parts position recognition. These are installed on general-use pallets to perform visual recognition of the characteristics of supplied parts and measure their positions. Based on the measured position information, the robot can correct the parts assembly position.

This action achieves accurate assembly operations without the need for preparation of special tools for each product model, contributing to lower facilities costs.



(ii) Assembly error detection technology