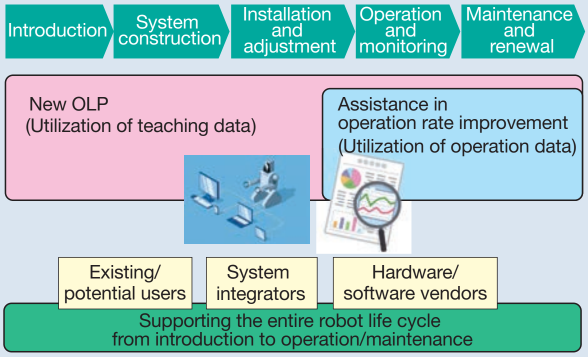
New Comprehensive Services That Cover the Life Cycle of Industrial Robots



Market demands for automation in various fields are emerging due to the shortage of workers derived from the declining birth rate and rapidly aging population. However, the implementation of automation in society cannot be realized as soon as is being expected. This is because experts in operating machinery such as robots cannot be allocated as required. Therefore, Kawasaki focuses on developing a service platform that comprehensively supports the various phases of the robot life cycle.

Introduction

As the shortage of workers becomes a social problem caused by the declining birth rate and rapidly aging population, there is a growing need to utilize robots as a solution to this problem.

1 Background

The scope of usage of industrial robots has been expanded from conventional areas of operation such as welding, coating and transportation to assembly and inspection. On top of that, they have been introduced in small and mid-sized firms—as opposed to just leading companies—and there has been an increasing number of situations where robot engineers' support is required. As a solution to such circumstances, services that support robots' utilization from examination of feasibility to maintenance are required [1].

2 Concept of services

The following describes challenges we face and services we propose for the examination of the feasibility of introducing robots and for robot operation.

(1) Service to support the examination of the feasibility of introducing robots

(i) Current situation and challenges

To automate production processes, many different things need to be examined not the least of which is the analysis of manual operations to figure out how to replace such work with robots, how to arrange peripheral equipment, and whether the operation can be completed in a reasonable amount of time, and these examinations are carried out by system integrators (SIs) in many cases. However, the number of companies that offer these services is small compared with the needs of automation these days, so it is difficult to accelerate the spread of automation with robots.

One of the tools that SIs use when examining the feasibility of using robots is Off-Line Programming (OLP). This is a tool to create a robot operation program in a virtual space using 3-dimensional data. It makes it possible to verify the robot layout and cycle time and programs can be uploaded for use in actual robots. However, OLP often cannot verify synchronization with peripheral equipment. In addition, it can only be used for the initial rough examination as various changes are made at the stage of fabrication of actual robots. It takes time to create a robot operation program and examine the motion path, and its performance varies depending on the person's skill level. Functions for sensing, force sense control and other skills need to be incorporated into OLP, especially when seeking to execute a complicated operation such as assembly with a robot, so it takes longer to design and create an operation program in such cases.

(ii) Overview

We will provide the following service for OLP to help examine the feasibility of the introduction of robots in an efficient manner:

- Function to synchronize with peripheral equipment by using and sharing data with software made by a third party.

- Library of operation programs for sensing, force sense control and other skills using arms and other existing peripheral equipment
- Function to automatically create an optimal motion path
- Environment where data is shared in different locations such as at an office and a site where an information system is introduced or between an SI and user

The service is provided on a cloud server on which contents are continuously added/improved and are always up-to-date. The cloud server is accessed by members of our marketing and engineering-related departments as well as SIs so that a variety of support will be provided in an efficient manner. When a lot of data is accumulated on the cloud, users can share know-how and the introduction of robots will become easier. It may also be possible to develop more useful new functions by analyzing the accumulated data. Furthermore, we are considering partial replacement of know-how on the introduction of robots with AI.

These functions will not be developed only by Kawasaki. We will provide a platform for Robot as a Service, in which functions developed by third parties can also be introduced as content as shown in **Fig. 1**, so that the platform will become a marketplace in which various stakeholders can participate.

(2) Service to support robot operation

(i) Current situation and challenges

As part of our service after the introduction of robots, we monitor the data of robots in operation and predict when failures might occur to prevent unexpected system stops.

Even if the robots do not fail, there are some cases in which robots' operational efficiency cannot be maintained due to the occurrence of operational conditions that are different from those covered in prior verifications, but it is just as big a problem for users as a failure. The lowering of robots' operational efficiency is caused by the timing of synchronization with peripheral equipment, variations in workpieces, incorrect supply of workpieces and various other factors, and it is not something that can be solved by the user alone in many cases. However, it would be too inefficient for an SI to conduct an analysis on-site every time a problem occurs, yet without a solution users will not be able to introduce or operate a robot system without any worries.

(ii) Overview

We will provide the service shown in **Fig. 2** to support the efficient operation of robots:

- Tool to acquire data from peripheral equipment as well as robots to visualize operating conditions
- Tool to analyze acquired data remotely to identify factors causing low operation rates and provide

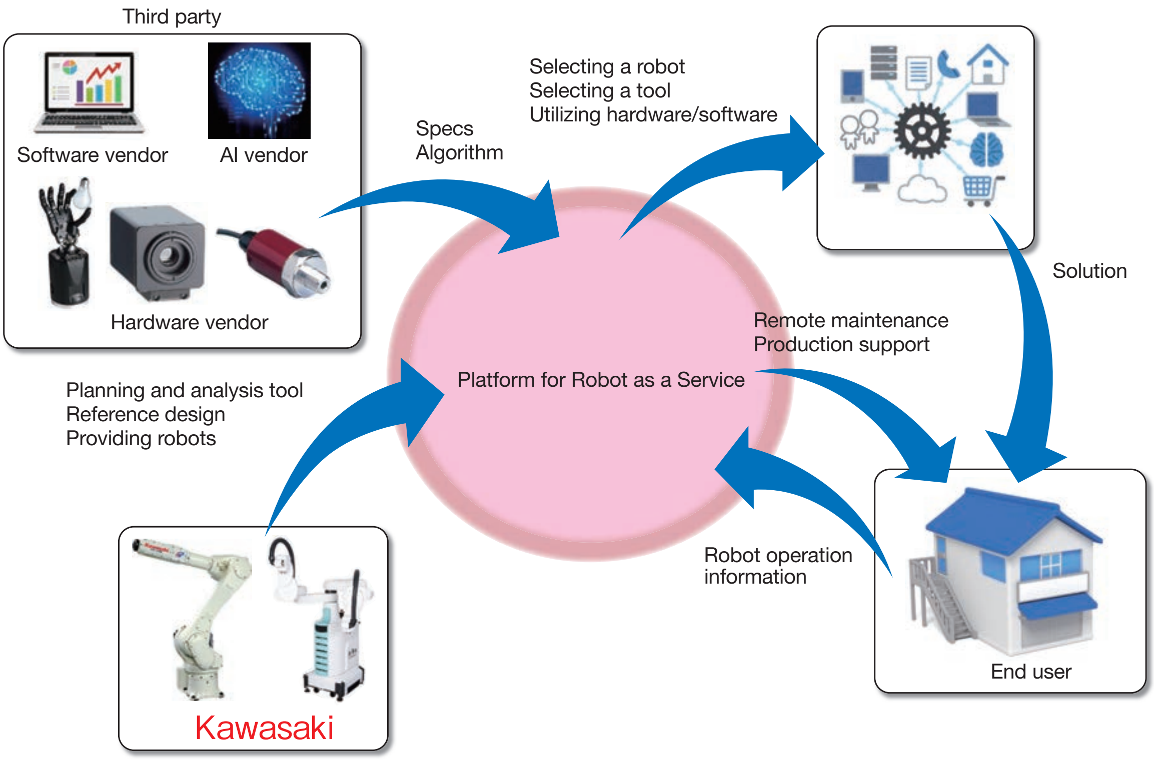


Fig. 1 Concept of the platform for Robot as a Service

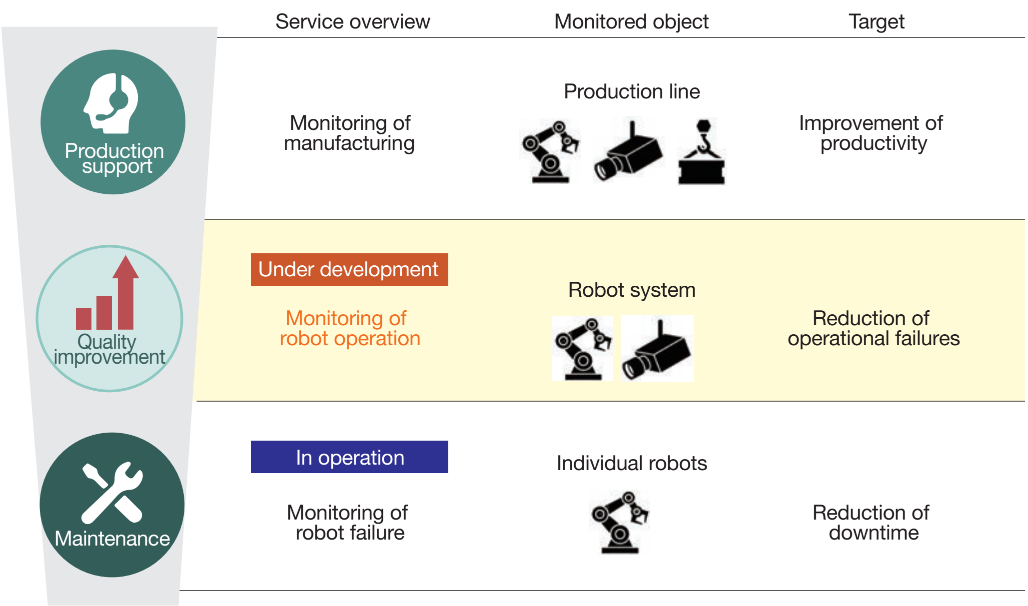


Fig. 2 Support layers for robot operation

information to improve operation

- Environment where operating conditions are identified remotely by sharing OLP data and data acquired on-site to introduce improvement programs remotely

The analysis of acquired data will be performed manually at first, then learned by AI and ultimately automated as a goal for the future. The acquired data will be synchronized with monitoring of operations throughout a factory, and various other functions will be added according to the user's wishes. Just like the aforementioned OLP, we will provide a platform for Robot as a Service, in which acquired data is accumulated, and functions developed by a third party can also be introduced as content as shown in **Fig. 1**, to create an environment where continuous progress can be made.

3 Technical challenges

We are facing the technical challenges described below when executing the services described in section 2.

① Ensuring information security

Data containing a lot of know-how that can be assessed and utilized by SIs and vendors will make it possible to accelerate the development of functions and expand the scope of robot usage. However, the platform requires a system to ensure security without giving up usability because the data may include confidential customer information and technical information.

② Synchronization of robots with a virtual environment

The robots in a production site must always be synchronized with the virtual environment in OLP so that OLP can be utilized for the examination of the feasibility of introducing robots and remote monitoring. Therefore, it is necessary to develop functions such as those for creating 3-dimensional data easily, for environmental sensing and for importing the information of peripheral equipment.

③ Improvement of OLP's operability

While OLP will be more and more useful as various functions are added, operation will become difficult due to the complicated functions. Therefore, operability must be improved in line with the improvement of functions.

④ Using both cloud and edge computing

The variety of data and functional content accumulated on a cloud server may generate new value. On the other hand, it is necessary to consider that server capacity affects service costs and that communication speed affects usability. Instead of storing all the content on a cloud server, data processing must also be performed on edge computers to create a balanced system configuration.

⑤ Data selection and analysis

In order to provide services that are really useful to users, it is necessary to select the data to be acquired and examine a data analysis method. In addition, information needs to be provided in an appropriate manner.

4 Activities

(1) OLP development

Functions that support teaching are required, including a function to perform high-speed and high-precision simulation for larger 3-dimensional environmental data and one to automatically create a program for the complicated shape of a workpiece to respond to the needs of automation in various kinds of fields.

Kawasaki has K-ROSET, a robot simulator that can simulate robot motion with high precision. K-ROSET has functions that are equivalent to those of robot controllers and it is used in prior verifications to check the motion and cycle time of a robot program. We also have KCONG, a teaching support tool that uses CAD geometry information. KCONG makes it possible to create a teaching point along a ridge line based on the shape of a workpiece. It also has a function to automatically create an operation program that covers the database of operating conditions [2].

By utilizing these types of software, Kawasaki is developing next-generation OLP which integrates K-ROSET and KCONG as shown in **Fig. 3**. In order to realize the concept described in section 2 based on the software, we will develop a new function using a cloud server and another function to solve the challenges of ① to ③ described in section 3.

We are also verifying the service using a cloud service in parallel with the development of the next-generation OLP software. Specifically, we are verifying whether the various services proposed in section 2 can actually be provided in collaboration with several SIs. This will lead to the early provision of services by identifying not only technical issues, but also operational challenges in data sharing such as the handling of intellectual properties.

(2) Development of a system for data acquisition and analysis

For the verification of solutions for the challenges in ④ and ⑤ of section 3 and for the small start of internal productivity improvement, Kawasaki is acquiring and analyzing operational data to improve the rate of operational success and visualizing the operational quality.

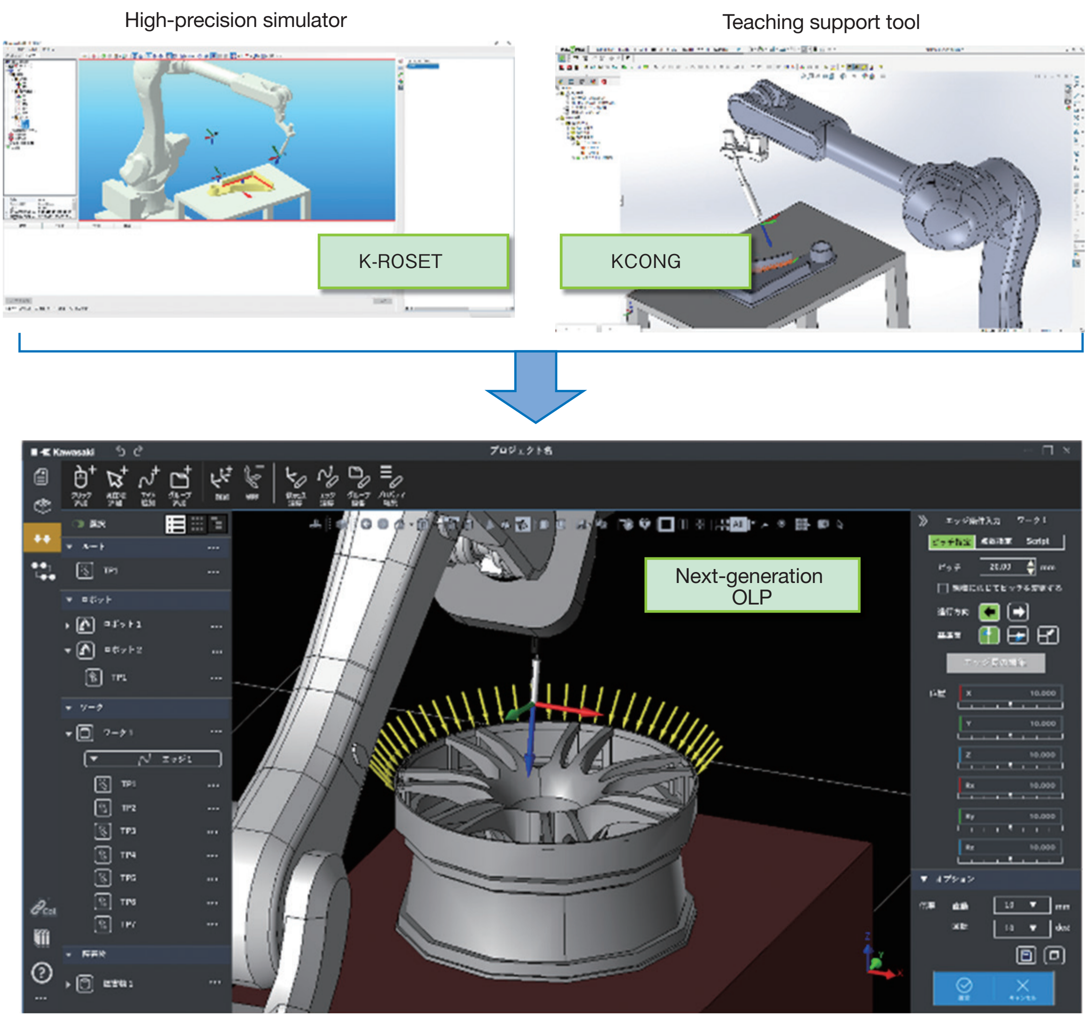


Fig. 3 Image of the next-generation OLP software under development

(i) Overview of the system

As shown in **Fig. 4**, the data acquisition and analysis system consists of edge computers which acquire data and perform primary processing on-site, the cloud which accumulates and analyzes data, and the data communication network which connects edge and cloud computing platforms.

In the edge computers, primary processing is performed for robot operation data, camera images and other peripheral equipment data such as the extraction of operational information and image processing to create data to be transferred to the cloud.

The data transferred to the cloud is stored in a chronological database which is accessed by an analysis application on the cloud to perform analysis of factors that caused operational failures and other processing. The analysis results and operational information are displayed on a mobile device such as a tablet as a dashboard as shown in **Fig. 5**. These sorts of information will enable production sites to take concrete steps to enhance robot operation for the maintenance and improvement of productivity.

(ii) Analysis of acquired data

The analysis application is the killer content of this system as the performance of data analysis has a significant impact on the robot user's productivity.

We are now focusing on the development of an analysis application to visualize the causes of robots' operational failures, which is directly related to the user's productivity, while the content will be increased one piece

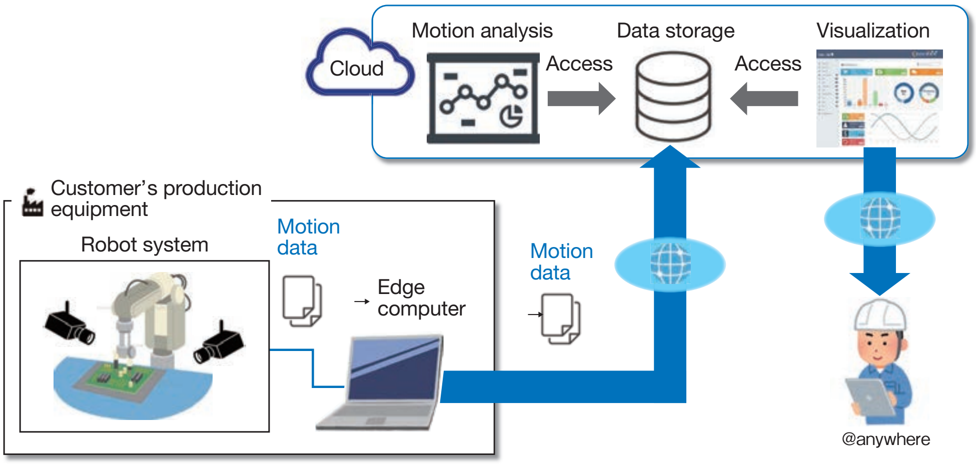


Fig. 4 System overview for data acquisition and analysis

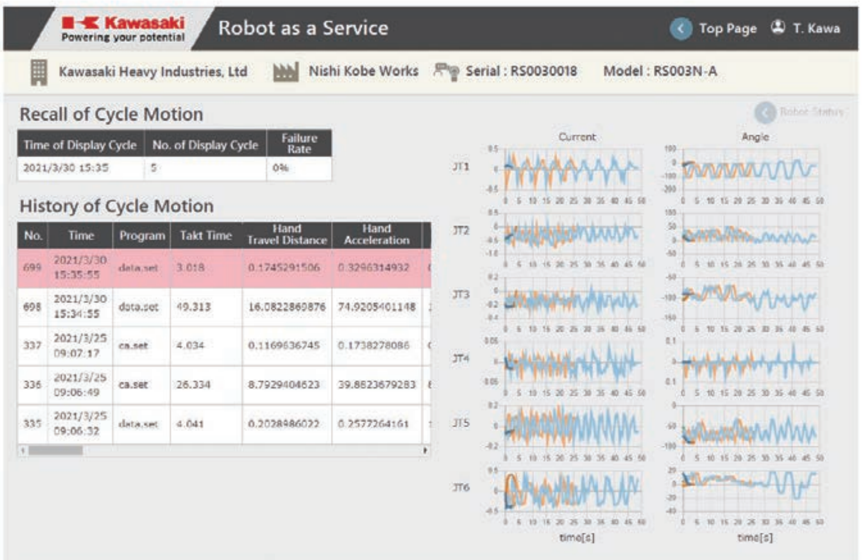


Fig. 5 Example of monitoring system

after another.

Failures in robot operation are often caused by a combination of various factors. This makes it difficult to identify the causes of robots' operational failures because individual monitoring of robots, tools and workpieces identifies no problems in many cases. Therefore, we will apply multimodal analysis [3, 4] in which several types of information are analyzed in order to judge abnormalities with high precision.

Kawasaki is now working on correlation analysis to extract combinations of changes in data that occur when a robot fails. The analysis results will enable us to identify data to be used in multimodal analysis for the development of an analysis application to identify factors causing operational failure.

Conclusion

Kawasaki is working on services to support the use of robots as a solution to the shortage of workers.

After providing such services, it is important to continuously improve functions by strengthening contact with users and collect more data. We will also analyze collected data to understand market needs, for technological development and the development of robots. Furthermore, OLP will be used as a tool to collaborate with other companies to accelerate open innovation.

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