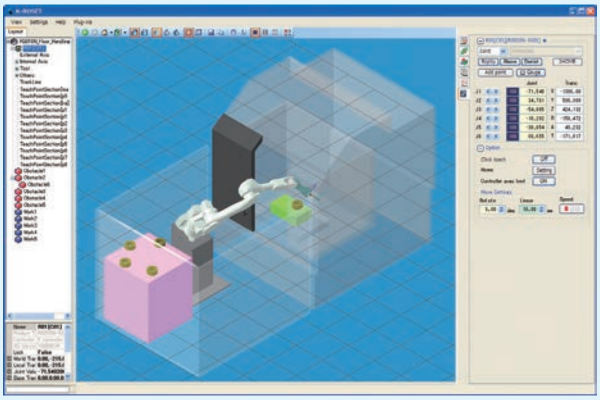
K-ROSET robot simulator for facilitating robot introduction into complex work environments



With the aims of improving the competitiveness of our robot systems and differentiating our robot products from those of our competitors, we are developing various applications based on robot simulators. This paper presents the new robot simulator K-ROSET and describes applications expanded on its system.

Preface

As the range of applications for robot systems has increased, various complicated issues have arisen, such as coordination between robots and their peripheral equipment and the installation of robots with multiple applications on the same line. Additionally, there is a demand for simple creation of advanced robot operation programs. In order to resolve these issues, the various companies that make robots are working to improve and add functionality to their own application examination simulators.

In 2011, we developed K-ROSET, a new robot application examination simulator. In addition to the basic functions that are demanded of a robot application examination simulator, K-ROSET provides an environment for developing and testing robot operation programs on a computer. K-ROSET's functions can also be expanded through the addition of the necessary applications. In this paper, we will provide an overview of K-ROSET and examples of how its functions can be expanded.

1 Overview of K-ROSET

In order to improve the efficiency of robot teaching, it is necessary to make use of offline tools such as robot simulators. We have developed the K-ROSET robot simulator and the KCONG automatic teaching data generator as offline tools to simplify the introduction of robots, and we provide our users with optimally-configured robot systems that make use of the tools in different ways according to the purpose and use.

K-ROSET is a tool that simulates the operations of

Table 1 Main functions of K-ROSET

· Interference checks	· Display of trajectories
· Setup location analysis	· Distance measurement
· Cycle time verification	· Timeline verification
· I/O simulation	· Simple shape modeling
· External axis support	· Virtual Teach Pendant
· Modeling of various types of tools	· Creation of animations
· Simultaneous verification of multiple robots	· CAD data importing

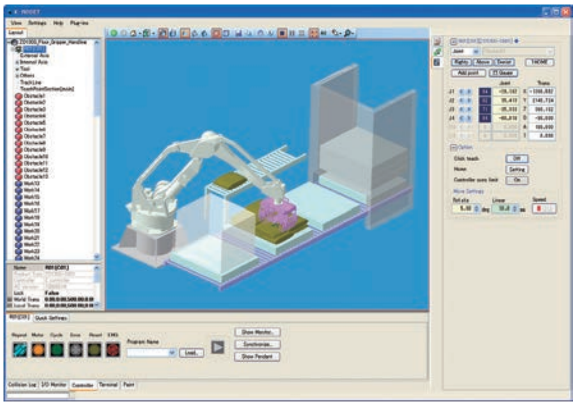
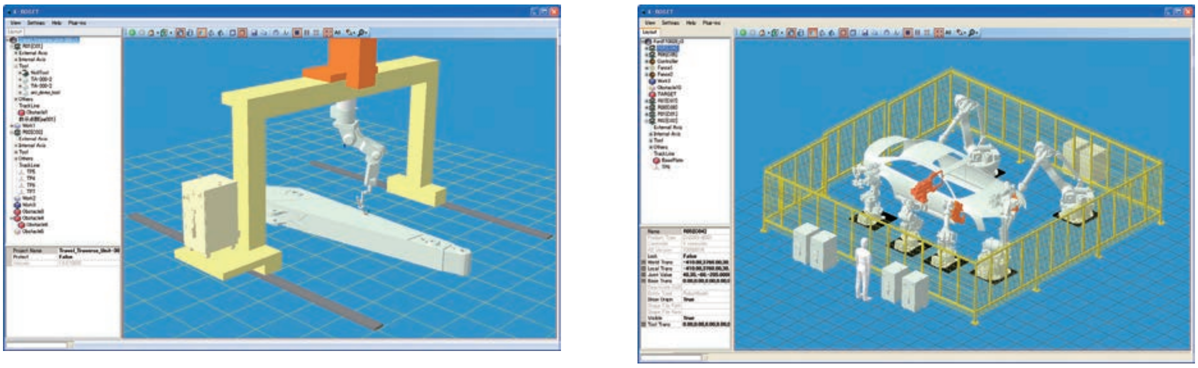


Fig. 1 Operation screen of K-ROSET



(a) Arc welding (b) Spot welding

Fig. 2 Simulation examples of applicable targets

actual robots on a computer. It enables operating robots using the same methods, and executing operation plans using the same logic, as with the actual robots. Furthermore, by adding necessary applications, it is possible to automate the actual work of robot teaching, eliminating teaching work based on experiences and trial and error that used to be performed by humans.

The main functions of K-ROSET are shown in Table 1, while its operation screen is shown in Fig. 1.

(1) Structure

With K-ROSET, we have improved operability by adopting a software structure that integrates 3D rendering software with high processing speed and low memory requirements, complete with an operating interface that is conveniently laid out around it. By placing the robots, workpieces, teaching points, etc. on the screen, the operator can intuitively generate an operation program for the robot and simulate an actual system on the computer.

(2) Applications

Actual robot systems can be used for a wide variety of tasks that include handling, arc welding and painting, and on K-ROSET, simulations can be performed separately by application (Fig. 2). It is also possible to simulate robot systems in which robots with different applications (such as arc welding and handling, or handling and sealing) are installed simultaneously (Fig. 3).

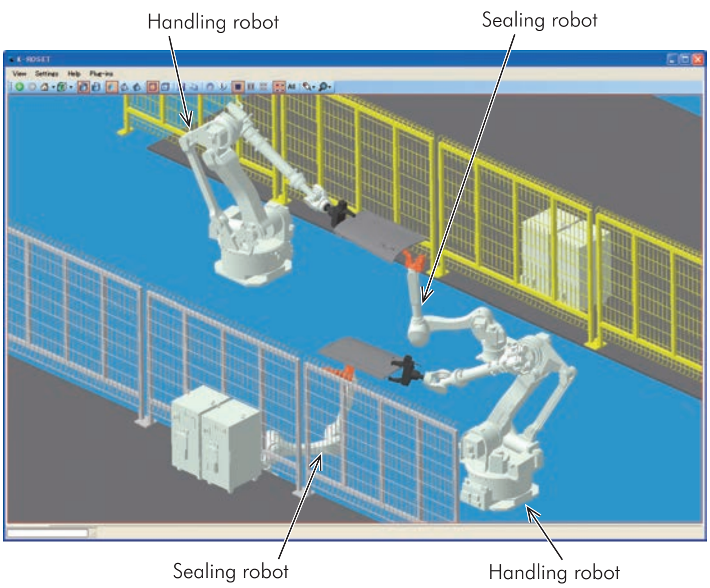


Fig. 3 Simulation example of multiple applications

2 Characteristics of K-ROSET

With complex robot systems that include multiple robots or things like external axes, conveyors and peripheral equipment, it is vital to be able to study the operation without using the actual robots and equipment. When doing so, making use of the following robot simulator functions can be expected to have the benefits shown in Table 2 during the various steps of introducing manufacturing equipment.

① Layout examination
② Creation and verification of robot operation programs
③ Cycle-time verification

The parts of K-ROSET that compute robot operations make use of the same operation software that is used in robot controllers. Additionally, because its simulation speed is several times faster than the operation speed of actual robots, it can carry out high-precision and high-speed computation of cycle time.

Making use of K-ROSET's functions eliminates the trouble of guiding the robot into a proper position through manual operation, making it possible to reduce teaching time. For example, it is possible to click on a workpiece on the screen to create a teaching point in that location and drag and drop that teaching point into the program area (the edit screen area) to create an operation instruction.

Table 2 Merits of robot simulators

Before Introduction	At the Time of Introduction	After Introduction
System proposal	Examination of applications	Automatic teaching
Layout examination	Verification of operation	Verification of improved

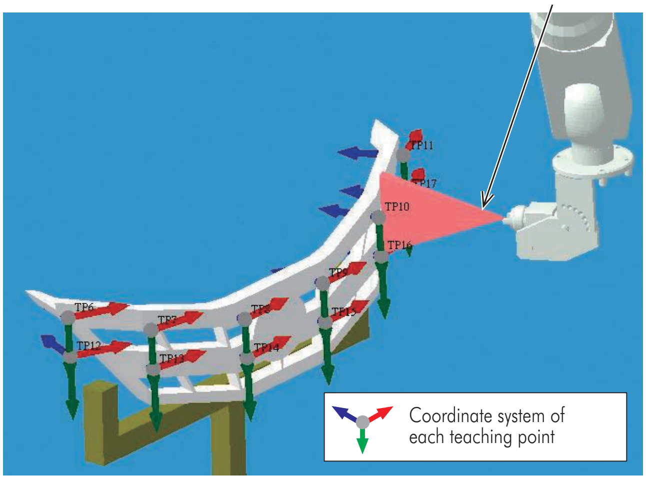


Fig. 4 Simulation example of teaching points creation

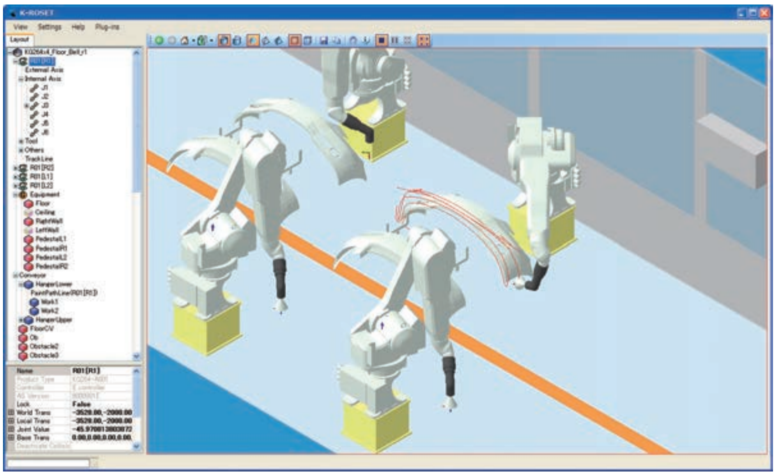


Fig. 5 Simulation example of real application

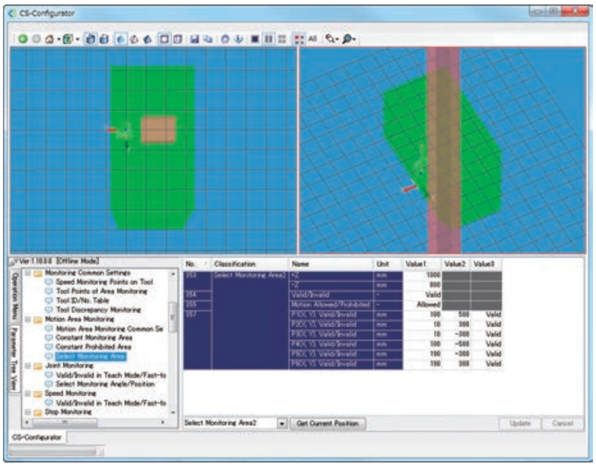


Fig. 6 Example of CS-Configurator setting screen

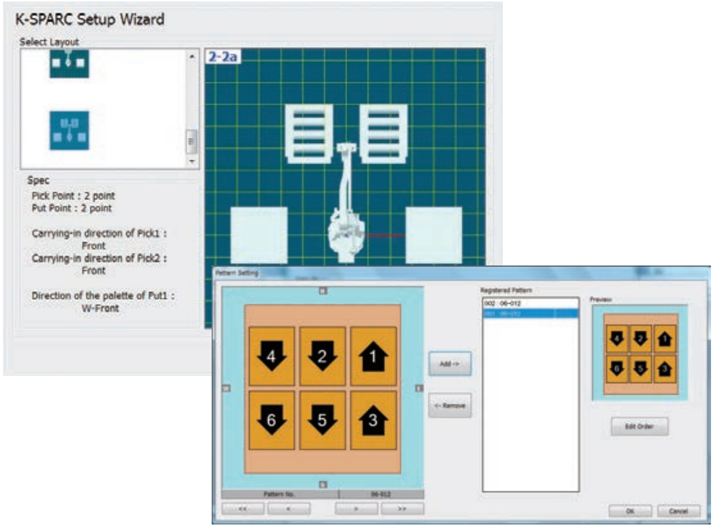


Fig. 7 Example of K-SPARC setting screen

Fig. 4 shows an example in which teaching points have been created for a workpiece, while an example of operation based on the teaching points created is shown in Fig. 5. The operation trajectory of the robot tool tip is shown in Fig. 5.

3 Examples of customization

With K-ROSET, users can create their own operation interfaces, expand functionality and otherwise customize the program (using plugins). In addition to using K-ROSET's main simulation function, it is possible to use new functions and custom functions along with K-ROSET.

Actual examples of additional applications that have been developed using customization functions are given below.

(i) CS-Configurator (Fig. 6)
Parameters for the safety monitoring unit can be set easily based on visual representation. For example, a 3D display enables intuitive configuration of the monitoring space.

(ii) K-SPARC (Fig. 7)
Palletization patterns are automatically generated by K-SPARC, and K-ROSET is used to arrange robots and equipment. Additionally, the operation program can be run to confirm the loading operation.

(iii) Interference prediction function (Fig. 8)
When changing programs after robot installation, connecting to this function online makes it possible to predict interference between robots, workpieces and surrounding equipment during operation and to easily check the locations of predicted interference using a 3D display, preventing interference before it occurs.

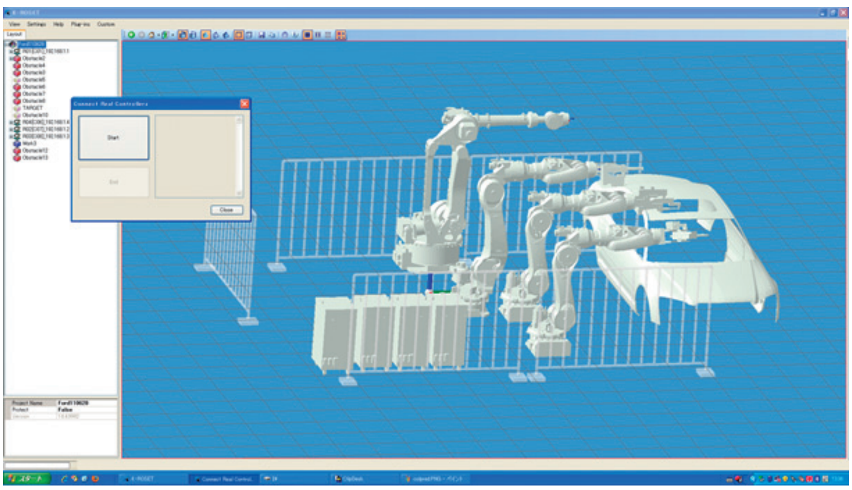


Fig. 8 Example of interference prediction function

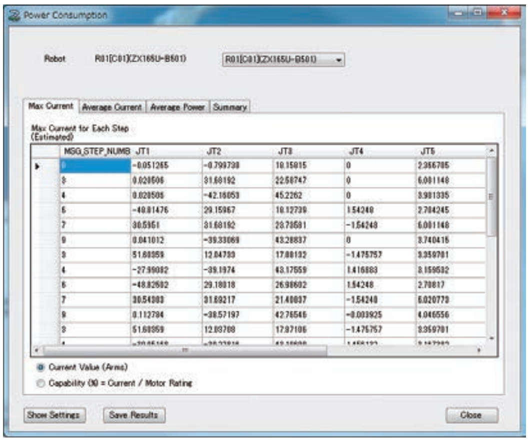


Fig. 9 Example of power consumption simulation

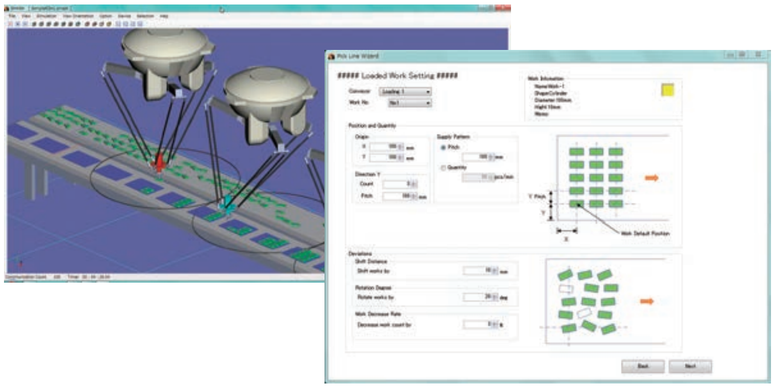


Fig. 10 Example of K-PET setting screen

(iv) Electrical consumption simulation function (Fig. 9)
This function can be used to run a robot operation program on K-ROSET, estimate the current and power used during operation, and display the results in tabular format.
(v) Picking robot simulation (K-PET)
In recent years, the use of robots in consumer products industries such as food, drugs and cosmetics has expanded rapidly, and it is particularly common to use them in combination with vision systems for the high-speed transfer of small-item workpieces. Quick verification of a robot's transfer ability is one of the keys to the expansion into these markets. Because of this, we are working to develop systems that are specialized for this kind of application and can carry out setup and simulation in a more simplified manner. K-PET, a specialized tool for the computer simulation of picKstar, a high-speed picking robot developed by Kawasaki, is shown in Fig. 10. K-PET features a menu that can be used to easily set up feed and discharge conveyors, feeding and discharge methods for the workpiece in question, etc. Additionally, it makes it easy to determine how multiple picKstar units will be arranged.

4 Linkage with other applications

(1) Linkage with vision systems

Linking K-ROSET with other applications makes it possible to carry out more advanced application verifications. Development is now underway for a simulation function that combines K-ROSET with K-VFinder, a 2D visual recognition system that is used with products such as picKstar. Doing so will make it possible to simultaneously carry out studies of vision system installation on a computer and operation verification of robots that are combined with vision systems.

An example of a linkage with a vision system is shown in Fig. 11. The workpiece information generated by K-ROSET on the left side of the screen is sent to K-VFinder on the right side, and a simulation is carried out as if the workpiece had been recognized with an actual camera.

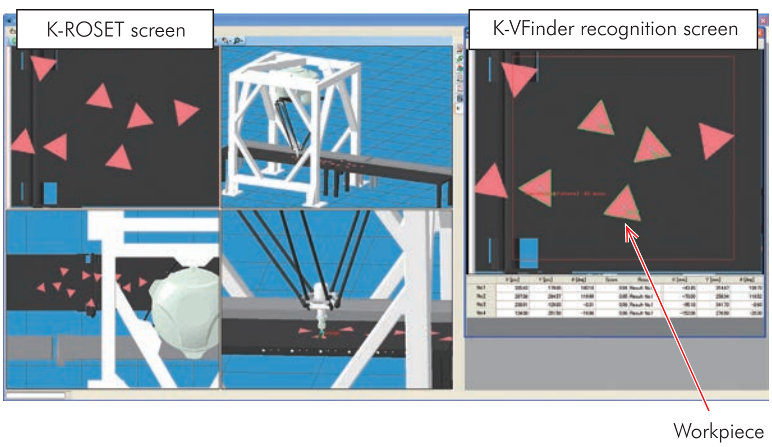


Fig. 11 Example of K-ROSET and K-VFinder

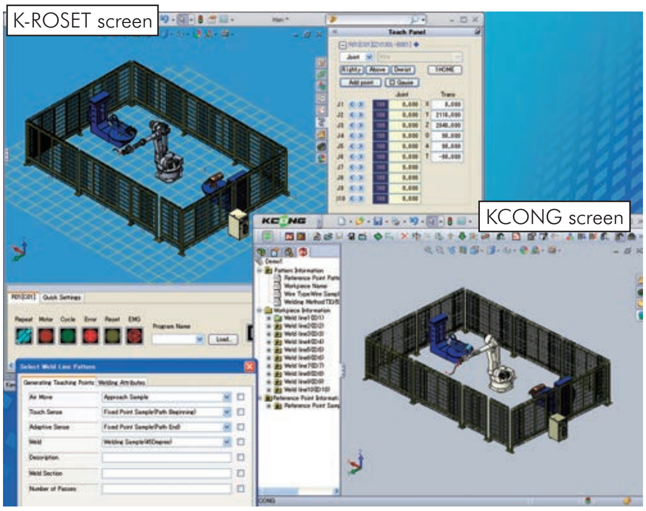


Fig. 12 Example of K-ROSET and KCONG

(2) Linkage with automatic teaching systems

The KCONG software for automatic teaching data generator comes with a built-in 3D CAD program, and K-ROSET uses the same 3D CAD program so that it can be linked with KCONG. We have thus enabled linking data between the two systems to merge the application study function (including peripheral equipment) of K-ROSET with KCONG's function for automatically generating teaching data based on 3D workpiece data.

Figure 12 shows this linkage. KCONG automatically generates teaching points based on the data for the system layout created using K-ROSET. Additionally, the data created is given to K-ROSET for operation verification.

Concluding remarks

We do not simply develop tools for robot application study and simulation. We are also working to make use of robot simulation technology as a tool to differentiate our robot systems.

We intend to continue to differentiate ourselves from other companies through the development of offline study systems and a range of other applications, in order to provide our customers with more desirable and effective robot systems.

Shogo Hasegawa
FA System Department,
FA and Clean Group,
Robot Division,
Precision Machinery Company

Masayuki Watanabe
FA System Department,
FA and Clean Group,
Robot Division,
Precision Machinery Company

Takayuki Yoshimura
FA System Department,
FA and Clean Group,
Robot Division,
Precision Machinery Company

Hiroki Kinoshita
Control System Department,
System Technology Development Center,
Corporate Technology Division

Professional Engineer (Information Engineering)
Fumihiro Honda
New Energy and Industrial Technology
Development Organization

Hironobu Urabe
IT System Department,
System Development Division,
Kawasaki Technology Co., Ltd.