Collaborative Robot "MELFA ASSISTA"

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1. Introduction

At many manufacturing sites including automobile and electric/electronic part production sites, the demand for automating production lines using robots has been increasing year by year due to labor shortages and rising labor costs. However, mid-ranking manufacturers which do not have enough robot engineers have been unable to introduce many robots, hindering system design and start-up.

In recent years, collaborative robots that can be easily introduced into existing systems without safety fences and that work with humans have become standardized, allowing any workers, even those who are not robot engineers, to easily perform start-up. Collaborative robots are expected to be actively used in various applications and fields of business.

To satisfy such market needs, Mitsubishi Electric Corporation has developed a collaborative robot, MELFA ASSISTA, to allow a production area to be shared between humans and robots without safety fences, enable humans to be replaced easily with robots, and simplify system design and start-up. This paper describes the main characteristics of MELFA ASSISTA.

2. Characteristics of MELFA ASSISTA

2.1 Safety measures to allow MELFA ASSISTA to work together with humans

MELFA ASSISTA is a vertical 6-axis collaborative robot that can work with humans in the same area without a safety fence and that can carry 5-kg objects. It is highly safe thanks to the arm design and conformance to functional safety standards as described below.

2.1.1 Arm design

Without safety fences, robots may come into contact with humans during operation. Accordingly, MELFA ASSISTA is designed with a rounded shape to reduce collision forces in case of collision with humans. In addition, the joints of the robot are designed with spaces to prevent a person's fingers and hands from becoming caught upon touching the robot arm.

To allow humans and robots to work together in the same area, it is also important for humans to understand the status of the robots. An LED light on top of the robot arm shows the operation status to nearby workers, so humans can work with the robot without anxiety. Figure 1 shows the arm, which is designed to ensure safety.

2.1.2 Functional safety conforming to ISO/TS 15066

MELFA ASSISTA conforms to international standards ISO 10218-1 and ISO/TS (Technical Specification) 15066 and has been certified by an international third-party certification authority for functional safety standards. An example of one functional safety measure is the torque monitoring function (safe torque range (STR)), which detects a collision with the robot arm during start-up and automatic operations and stops it. The safety monitoring function eliminates the need for safety fences and enables manual human operations to be replaced easily by robots, while requiring only the same area (Fig. 2).

2.2 Easier manipulation

When introducing a robot, teaching operation is required, in which a teaching box is manipulated to teach the robot the positions to move to. MELFA ASSISTA has operation buttons on the arm as well as a direct teaching function, thus eliminating the conventional need for a teaching box to manipulate robots. The buttons also make it possible even for inexperienced robot operators to perform teaching quickly.

Fig. 1 Arm design for safety

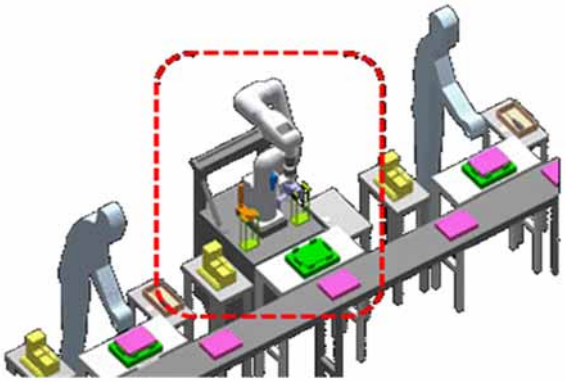

Fig. 2 Elimination of safety fence by functional safety

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2.2.1 Operation buttons on the arm

MELFA ASSISTA has operation buttons on the robot arm. These buttons can be used to start and stop program operation, eliminating the need for a teaching box and other external control devices. In addition, when creating a robot program, the buttons can be used for teaching, hand opening/closing, hand alignment (the arm end of a robot is made vertical or horizontal), and direct teaching. This allows a robot program to be created with fewer steps.

2.2.2 Direct teaching function

The direct teaching function allows an operator to directly push and pull a robot arm to manipulate it and teach behavior. This function is essential to enable collaborative robots to be introduced easily without using a teaching box. MELFA ASSISTA is the first to employ this direct teaching function (Fig. 3). Collaborative robots of other manufacturers typically use torque sensor information to realize a direct teaching function. However, MELFA ASSISTA uses only servo control, not torque sensors, to realize this function. Therefore, no torque sensor needs to be installed in arms, and so wiring and piping can be routed inside arms as described in 2.4.1, and robots can be introduced more easily. The characteristics of the direct teaching function are described below.

(1) Intuitive manipulation

Conventionally, a teaching box or other external control device is required to manipulate a robot. The MELFA ASSISTA robot, thanks to its direct teaching function, can be intuitively manipulated to a desired posture without using an external control device. This reduces the time required for teaching by half or less compared to existing models. In addition, the robot can be easily manipulated without connecting an external control device in various cases, such as when the arm end is directed upward to install a hand or when a robot arm is temporarily removed for maintenance of peripheral equipment.

(2) Three modes of operation

Vertical 6-axis robots offer great flexibility, and so to set them to a desired posture, it used to be necessary to operate an external control device while paying attention to the coordinate system. The direct teaching function on MELFA ASSISTA has three modes of operation as described below; operators can easily set the robot to a desired posture by switching the mode based on the purpose without considering the coordinate system (Fig. 4).

(i) Flexible joint mode
Each axis can be moved to any angle.

(ii) Translation mode
The arm end can be moved while maintaining the same orientation, and thus the hand can be moved in a constant posture.

(iii) Rotation mode
The arm end can be rotated and thereby the arm posture can be changed without moving the hand position.

(3) Safety

To prevent a worker from accidentally starting program operation from the outside when another worker is performing direct teaching, the operation authority can be held using the operation buttons on the arm. Thus, MELFA ASSISTA has a function that allows operators to perform direct teaching safely.

2.3 Easier programming

With conventional industrial robots, to program a target behavior, technical knowledge of robots was required. Meanwhile, MELFA ASSISTA is intended for new users who have no such technical knowledge. Therefore, to allow anyone to use our robots easily, we have developed robot engineering software, RT VisualBox, for MELFA ASSISTA. The software performs robot behavior, such as look, take, and carry, through intuitive screen operations using visual programming, interactive initial setting, and vision setting, eliminating the need for technical knowledge of robots.

Fig. 3 Direct teaching

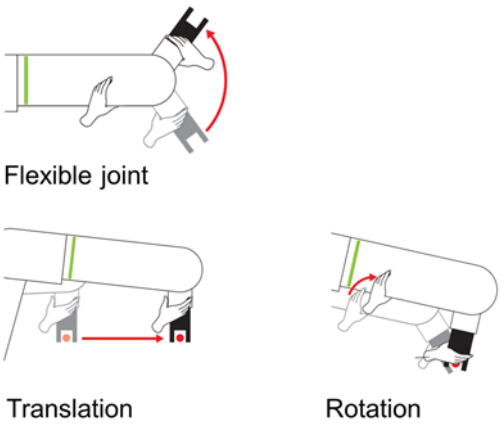

Fig. 4 Three modes of operation

2.3.1 Visual programming

A special programming language, MELFA BASIC, is used to program and operate our industrial robot MELFA FR Series.(1) This requires an understanding of the language specifications and special commands. To help users perform programming without acquiring technical knowledge, RT VisualBox provides command blocks for special commands. Programming involves two steps: selecting a block for target behavior from the block group, and placing it by drag-and-drop. These steps are repeated to create a program. In addition, a detailed setting screen is provided for each command block and a command can be specified in detail on this screen. Because the MELFA ASSISTA is for users who have not used robots before, only 10 command blocks for basic operation commands, such as move, hand open/close, signal output, and divergence, are provided, thus simplifying operation programming. Figure 5 shows a programming screen.

Fig. 5 Programming screen

2.3.2 Interactive easy setting

To allow MELFA ASSISTA to work in the environment (e.g., installation orientation and installed hand) of each user, it is necessary to set parameters appropriately for the environment, and so a scheme is provided to assist such setting. When RT VisualBox is connected to MELFA ASSISTA for the first time, an interactive initialization screen is displayed; entering and setting values according to instructions completes the necessary setting (Fig. 6). For example, when a hand installed by the user is selected on the hand selection screen, the parameters for the hand specification are set automatically. This makes it easier to specify the various settings based on which the robot behaves.

In addition, work recognition and holding operation using a vision sensor can be made only by performing setting according to instructions displayed on the vision setting screen (Fig. 7). Conventionally, engineering software dedicated to vision sensors needed to be used for setting and programming, making it necessary to use and switch two types of software (robot engineering software and vision sensor engineering software) to make adjustments. When RT VisualBox is combined with our vision sensor MELSENSOR, RT VisualBox alone is enough for vision sensor recognition setting/adjustment and robot operation programming using the vision. This reduces the work hours for start-up.

For complicated programming and detailed setting, the existing robot engineering software RT ToolBox3 for the MELFA FR Series can also be used.

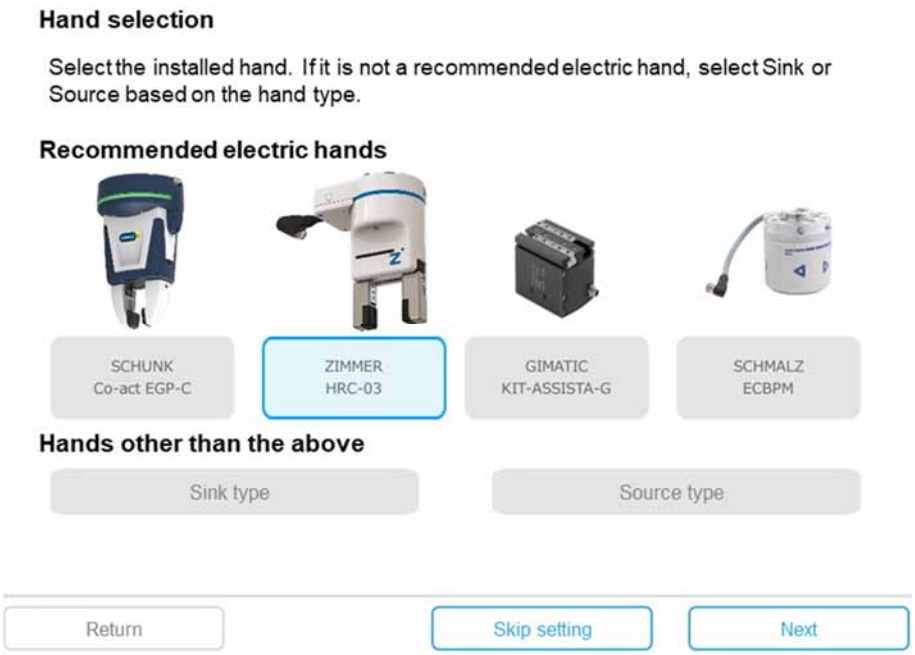

Fig. 6 Initialization screen

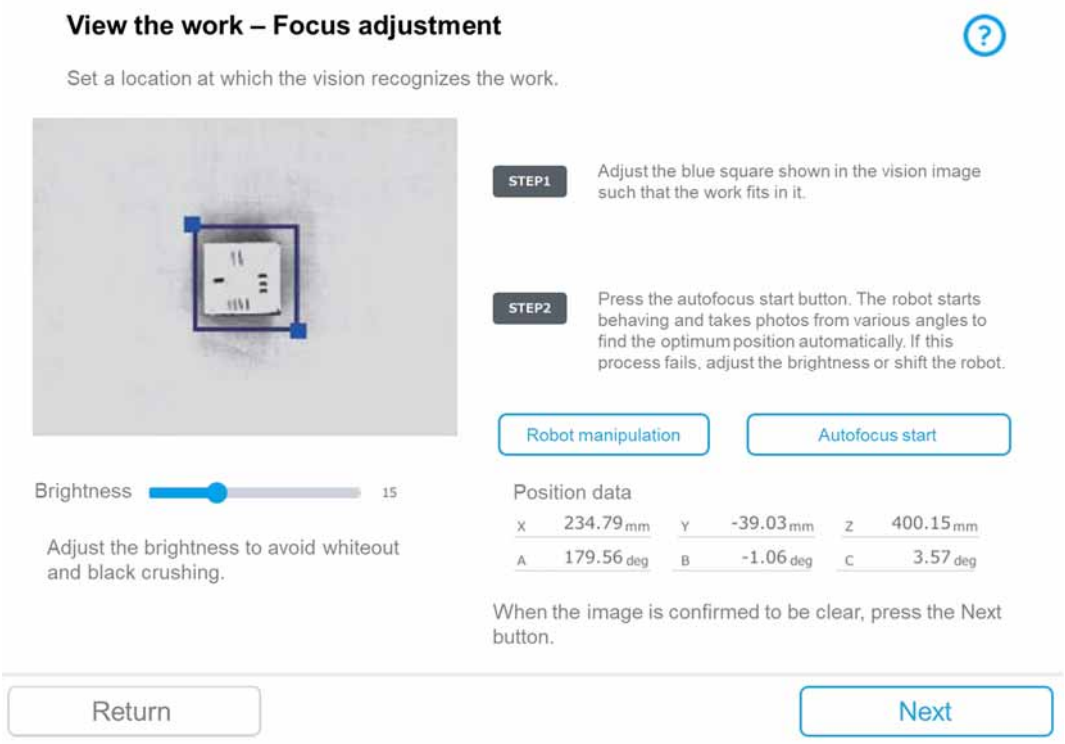

Fig. 7 Vision setting screen

2.4 Easier introduction

Because a robot needs to be installed as part of a system, it must be easy to start up not only the robot but also the system. The mechanism and scheme described below are provided to make it easy to introduce MELFA ASSISTA.

2.4.1 Wiring and piping in arms

To have robots perform various tasks, an electric hand, air hand, and vision sensor need to be attached to a robot depending on the purpose. MELFA ASSISTA contains the wires and pipes required to control them in the robot arm, which makes it easy to connect a hand and sensor to the robot.

2.4.2 Cooperation with partners

When MELFA ASSISTA was released, a partner community exclusive to collaborative robots was set up for MELFA robots. We will link our robots to peripheral devices (e.g., hand and camera) that partner companies develop and will develop products that satisfy user needs to further improve the usability.

3. Conclusion

This paper described the characteristics of our collaborative robot, MELFA ASSISTA, developed this time. We will add and improve the functions to allow collaborative robots to penetrate the market further in the future.

References

(1) Masakazu M.: Industrial Robots “MELFA FR Series,” Mitsubishi Denki Giho, 91, No. 4, 217–220 (2017)