

Development of RocoMo-V (AGV with a Collaborative Robot)

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Abstract

We developed RocoMo-V^{*1} which is an Automatic Guided Vehicle (AGV) with a small collaborative robot manufactured by FANUC CORPORATION. The collaborative robot can work with people in the same work space. Just one unit, this AGV can travel and perform material handling work. RocoMo-V can move forward, backward, sideways, slantwise, spin turn, and can be operated flexibly even in places with narrow passage widths. In addition, by using the laser range finder mounted on the AGV to generate a map of the surroundings and setting the travel route on the map in advance, guideless travel that does not require a guidepath with magnetic tape or others has been realized. This eliminates the need for guidepath construction even at sites where the factory layout changes frequently, and allows the AGV's travel route to be changed.

1 Preface

In recent years, the introduction of industrial robots has been considered at various production sites, but many issues have been raised in studying the introduction of robots. For example, the waiting time for an order is long, the operating rate of the robot does not increase, and labor saving is not achieved. We, therefore, developed RocoMo-V - an Automatic Guided Vehicle (AGV) with a collaborative robot. This robot can work in harmony with worker. RocoMo-V can improve the operating rate of robots by carrying out multiple process operations while moving between multiple processes. In addition, RocoMo-V can be used to transport works between unmanned processes. This results in labor saving. This paper introduces the features of the newly developed RocoMo-V.

2 Specifications

Fig. 1 shows the external appearance of RocoMo-V. **Fig. 2** shows the outline drawing. **Table 1** shows the specifications. A hand attached to the wrist of the collaborative robot transfers the object to be transported from the ground equipment onto the platform of an AGV. The AGV transports it to the next process.

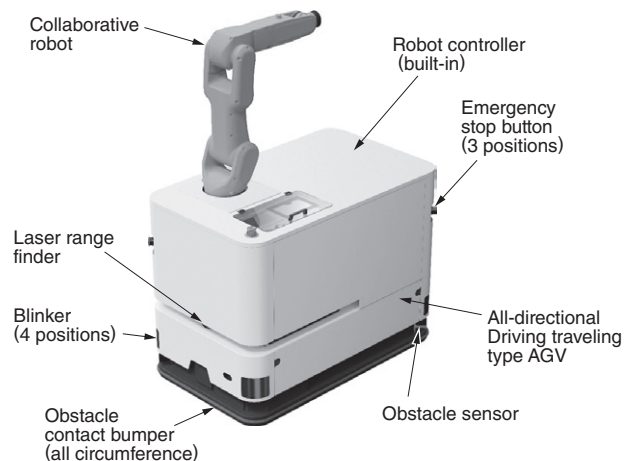


Fig. 1 RocoMo-V

A basic model of RocoMo-V is shown.

3 Features

The features of RocoMo-V are as follows.

3.1 All-Directional Driving

RocoMo-V can move forward, backward, sideways, slantwise, and spin turn. **Fig. 3** shows an example of forward, backward, and sideways. **Fig. 4** shows an example of slantwise and spin turn. By switching these operations at any time, all-directional driving can be realized.

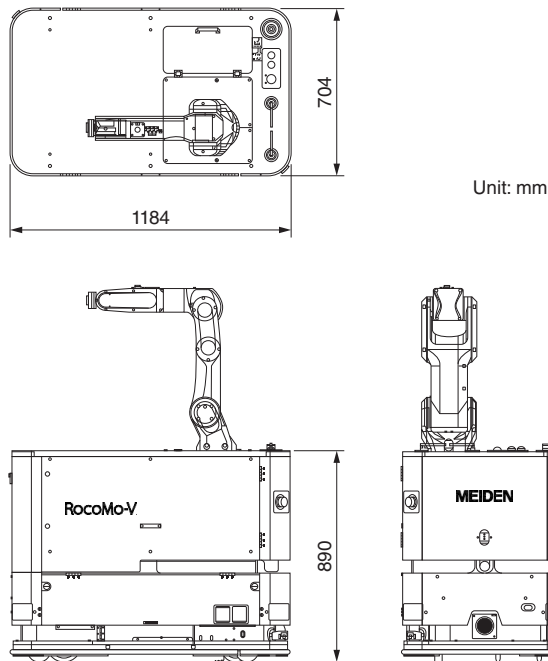


Fig. 2 Outline Drawing

Dimensions of the body are W704 × H890 × L1184 mm. For automatic transfer operation, a collaborative robot transfers the object to be transported on the platform and AGV conducts the automatic transport.

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Table 1 Specifications of RocoMo-V

A list of RocoMo-V's specifications is shown.

AGV	Guidance system	Multi-guidance system (magnet guidance system, laser distance measurement, and SLAM using laser)
	Driving and steering system	Wheel speed differential steering system
	Traveling direction	All-directional driving (forward, backward, sideways, slantwise, and spin turn) ※Slantwise is limited to magnet guidance and laser distance measurement case.
	Rated capacity	64 kg (Loading object 50 kg, robot wrist carrying mass capacity 14 kg)
	Maximum speed	Forwarding and backward: 60 m/min., Sideways: 30 m/min.
	Stopping accuracy	±10 mm (magnet guidance, laser guidance distance measurement) ±50 mm (Self-navigation)
	Gradability	2% (Continuous 5 m)
	Charging system	Automatic battery charge
Robot	Collaborative robot	CR-14iA/L by FANUC CORPORATION
	Control unit	R-30iB Mate Plus by FANUC CORPORATION

3.2 Guidance System

RocoMo-V enables guideless driving without the need for physical landmarks. For guideless

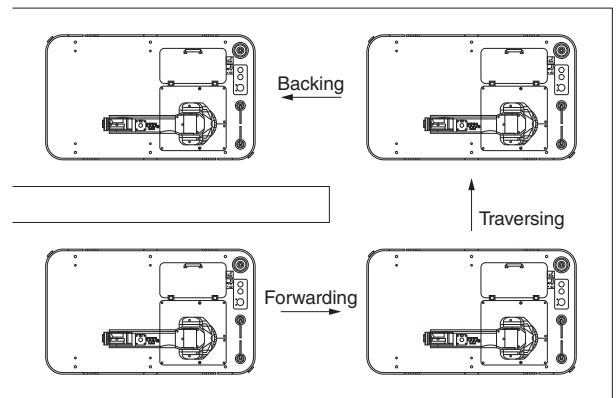


Fig. 3 Forward, Backward, and Sideways

In addition to basic bidirectional traveling (forward and backward), sideways is possible. Flexible movements are realized.

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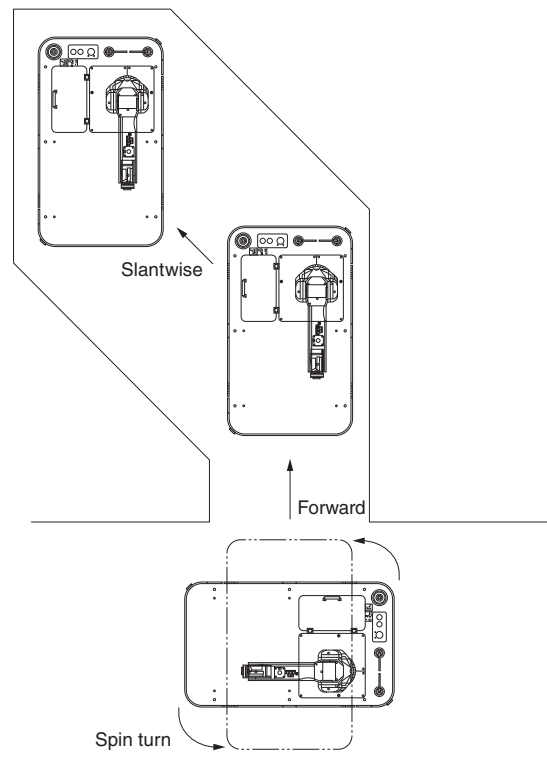


Fig. 4 Slantwise and Spin Turn

Even in a passage where it is difficult to drive on curves, the AGV can turn on the spot with a spin turn and change direction. Even in a special dead end, AGV can enter diagonally without changing its posture.

driving, an autonomous driving system using Simultaneous Localization And Mapping (SLAM) technology is adopted. The AGV's self-position is estimated from the map and laser range finder information, and the guideless driving is performed. In addition to the SLAM using laser, it also supports the magnet guidance and the laser distance measurement that measures the distance and angle



Fig. 5 Automatic Battery Charge Control Unit

The external appearance of the automatic battery charge control unit is shown. It is equipped with an interlock to prevent charging error and malfunction. It supplies power to RocoMo-V.

between the reflector and the reflector installed on the ground.

3.3 Collaborative Robot

RocoMo-V is equipped with the collaborative robot, the CR-14iA/L manufactured by FANUC CORPORATION. In addition, since it stops safely even if it comes into contact with a moving person or object, this robot can work in harmony with a worker and does not require an isolated safety fence.

3.4 Stability

Our conventional all-directional driving AGVs often use suspension to obtain stable driving performance. However, there is a problem that shaking occurs when the collaborative robot operates, and the pose accuracy during robot operation decreases. We, therefore, reviewed how to keep four wheels on the ground and adopted a mechanism to suppress the shaking, and stable cooperation of the robot was realized.

3.5 Automatic Battery Charge Function

For RocoMo-V, there is an automatic battery charge unit installed on the ground side to automatically charge the battery. Fig. 5 shows the external appearance of the automatic battery charge control unit. Fig. 6 shows the external appearance of the



Fig. 6 Automatic Battery Charge Terminal

The external appearance of the automatic battery charge terminal is shown. When RocoMo-V stops at the charging location, it connects automatically.

automatic battery charge terminal. For charging, RocoMo-V stops at the charging location, and after RocoMo-V's charging terminal and the terminal of the automatic battery charge unit come in contact, the charging starts. This eliminates the need for manual battery replacement work and enables continuous operation for 24 hours.

4 Postscript

By developing RocoMo-V, we have realized a new AGV system like never before. We will continue to respond to customer requests by further improving the functions and performance of RocoMo-V and improving the user interface to provide an excellent AGV system.

We would like to express our deep gratitude to all the people involved in this project at FANUC CORPORATION for their great cooperation in the development of RocoMo-V.

· All product and company names mentioned in this paper are the trademarks and/or service marks of their respective owners.

(Note)

※1. RocoMo-V: Robot Collaborating Mobile Vehicle