The Fourteenth International Symposium on Artificial Life and Robotics 2009 (AROB 14th '09),
B-Con Plaza, Beppu, Oita, Japan, February 5 - 7, 2009

# Man-machine Interface for Modular Robot System

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***Abstract***: A modular robot is composed of multiple modules, each comprising a sensor, an actuator, and a control system. Each module accumulates information about its own sensor, actuator, and connection to other modules and communication information between adjoining modules. The user obtains this information via an interface and can thus recognize the state of the robot and issue commands. However, when the number of modules becomes large, the amount of information sent from the modules becomes too much for the user to deal with effectively. Naturally, it also becomes more difficult for the user to issue commands to the modular robot as the number of modules increases. In this study, we developed an interface to present, in a simple manner, information aggregated in a certain module from other modules, and we examined its effectiveness in a modular robot composed of these modules.

***Keywords***: modular robot, interface, CDMA

## I. INTRODUCTION

A modular robot is composed of multiple modules, each comprising a sensor, an actuator, and a control system. These modules are the fundamental compositional units of the robot body. Each module uses its sensor to collect information about the environment and accumulates that information. To this information it adds information that the module accumulates about itself, such as the state of the actuator and the connections between modules. Communication information between adjoining modules is also accumulated. By obtaining this information via an interface, a user can recognize the state of the robot and can issue commands. However, if the number of modules is increased to several thousand or more, the amount of information sent to the user from the module becomes too much for the user to deal with effectively. Naturally, it also becomes more difficult for the user to issue commands to the modular robot as the number of modules increases.

A multi-arm module used in this study possesses eight arms, that is, four movable arms and four attachable arms, and can be attached to and detached from other modules. A movable arm and an attachable arm are arranged on each diagonal of the generally cube-shaped module. Fig. 1 shows a modular robot constructed using these modules.

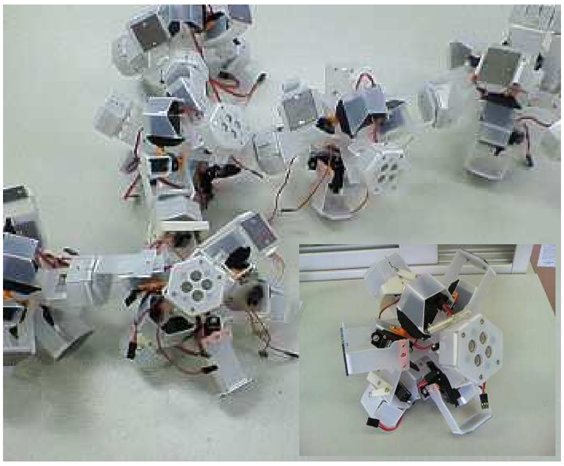


Fig. 1. Modular robot.

In this study, we developed an interface for presenting to the user, in a simple manner, the information aggregated in a certain module from other modules, and we examined its effectiveness in a modular robot composed of these modules. This interface is composed of a communication system, a positional search system that searches for arms of the adjacent module, and a system that aggregates and presents information about the modular robot.

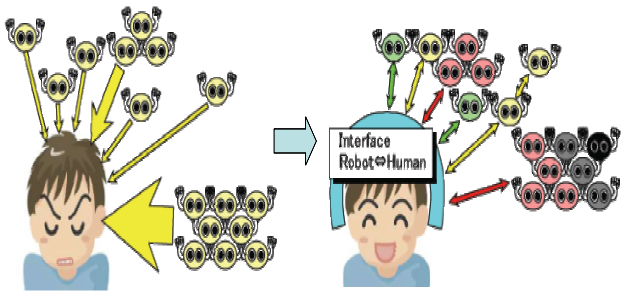



Fig. 2. Man-machine interface.

## II. Man-machine Interface

### 1. Communication system

The communication between modules was assumed to be short-range local communication via infrared light, and the communication distance was assumed to be the same as the module size, about 10 to 15 cm. Code division multiple access (CDMA) was adopted as the communication method so that there were no interruptions even when sending and receiving information between two or more modules simultaneously.

A communication device, either a transmitter or receiver, was installed at the end of each arm, as shown in Fig. 3. The positional search system and the communication system for the arm were implemented with a single device by utilizing the directivity of the communication element (infrared receiver IC).

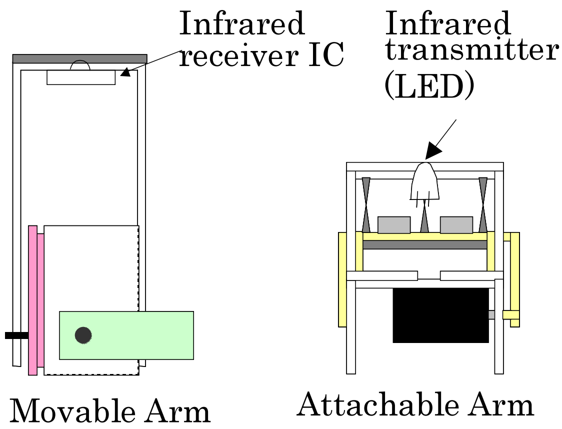



Fig. 3. Communication system.

### 2. System for aggregating and presenting information

The system that collects and presents information was designed based on a cubic model of each module, where the vertexes of the cube represent the tips of the arms, as shown in Fig. 4. The arm on each corner is of a different kind from the structure of an actual module. A unique ID was assigned to each module, and an identifying number was assigned to each arm of the module. When communicating between modules, the module ID and the arm number used for sending and receiving were transmitted as information. The current shape of the modular robot can be determined by accumulating information about the connections between modules.

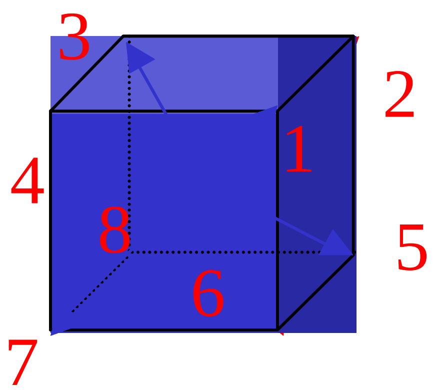



Fig. 4. Module model.

The format of the transmission signal showing the connection between modules was as follows: [Transmission-side module number (Tn), reception-side module number (Rn), reception-side arm number (An)]. Each part was modulated by using a spread-code sequence and transmitted. For the module located at the end of the robot, when its own information was sent, '0' was substituted for the part containing the reception-side module number. At the reception-side module, the module number and arm number were added to the respective parts and transmitted to the next module. Fig. 5 illustrates this.

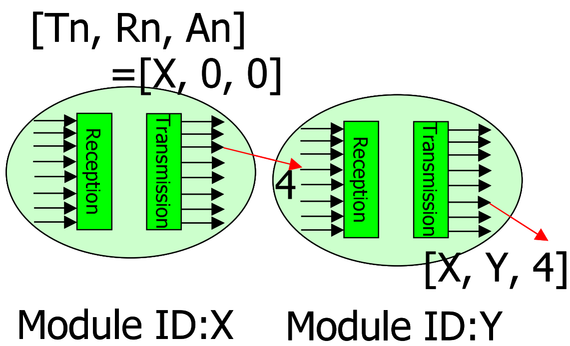



Fig. 5 Transmission format.

Two peripheral interface controllers (PICs) were used, one for receiving and one for transmitting, and pins on the PICs corresponded to module arms. Only information about the connection was transmitted in the transmission part. The acquired data in the reception part was sent to a demodulator in a personal computer (PC), which demodulated the format.

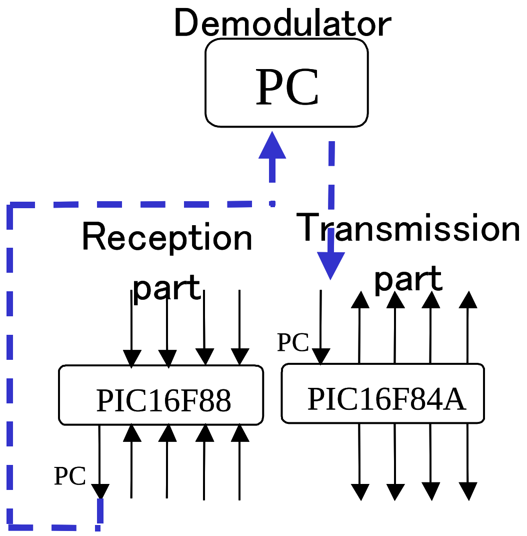



Fig. 6 System configuration.

The communication between modules was performed as shown in Fig. 7, and information was aggregated in the upper right module. This module communicated with the PC, and the PC demodulated the obtained information to determine the configuration of the robot and display it in 3D.

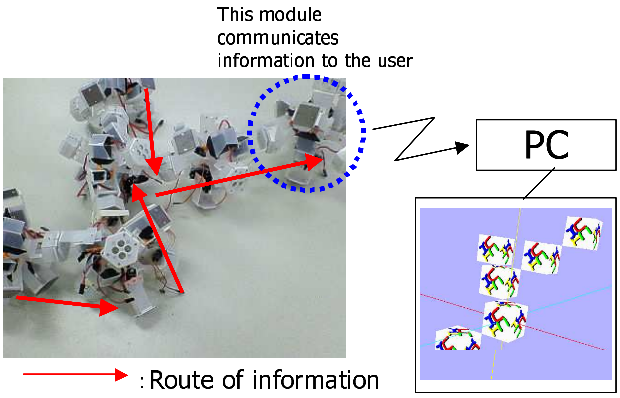
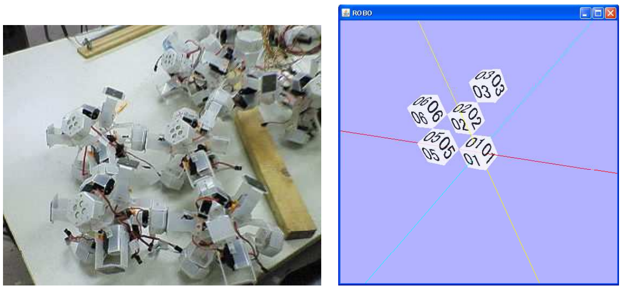



Fig. 7 Reproduction of modular configuration.

When the modules were connected as shown in Fig. 8(a), the result of reproducing the configuration of the modular robot based on information about the connections between modules is shown in Fig. 8(b).



(a) (b)

Fig. 8 Modular configuration (a) and 3D view of reconstructed configuration (b).

## III. CONCLUSION

In this study, we constructed a system that aggregates information about the connections between modules of a modular robot, and presents the information to a user in a simple manner. Future work will include investigation of a complementary system for transmitting information (commands) from the user to the modular robot and development of a method for presenting information in a multimodal manner.

## Acknowledgements

This work was supported in part by Grant-in-Aid from the Hayao Nakayama Foundation for Science & Technology and Culture, Japan. This support is gratefully acknowledged.

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