Automatic Connection System for Modular Robots

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Abstract

We have developed a connection system that automatically connects modular robots to each other. Alignment by magnetic flux density (MFD) was used for automatic connection. High connection performance was achieved by using connection mechanism.

1 Introduction

All of today's widely used robots have been developed and designed for a variety of purposes and environments. As a result, it is difficult for robots to operate in environments other than those defined for their intended use. To solve this problem, we are developing robots whose functions can be changed by reconfiguring modules according to the required tasks[1]. However, most of the present modular robot must reconfigure by the operator to change its shape[2]. We believe that automatic recombination of modules is effective in increasing scalability in an unattended environment. The purpose of this study is to develop a modular robot equipped with a mechanism that enables automatic connection with other robots, and to use it to perform automatic connection in the unattended environments. In this paper, we propose an automatic connection system and evaluated it.

2 Robots Configuration

The robots that perform automatic connections require a localization, a locomotion mechanism, a connection mechanism, coarse and fine alignment system and a communication system between module robots. Figure 1 shows a schematic diagram of a developed modular robot. The proposed automatic connection system is attached to the Turtlebot3 (ROBOTIS) which is used as the locomotion mechanism for the modular robot. The middleware ROS (Robot Operating System) is used to facilitate self-position estimation and communication between robots. Figure 2 shows a schematic diagram of the configuration of the connector. The connector comprises a rotating disk to connect the other robot, three set of magnet and Hall IC as the alignment sensor, transceiver element (IR LED and phototransistor) to identify the robot and recognize robot information. The robots can automatically connect in any environment by recognizing each other's location and moving on their own.

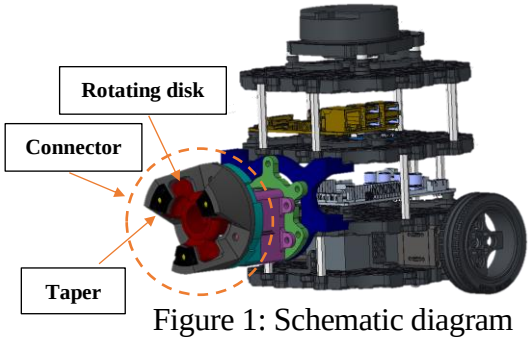


Figure 1: Schematic diagram of the modular robot

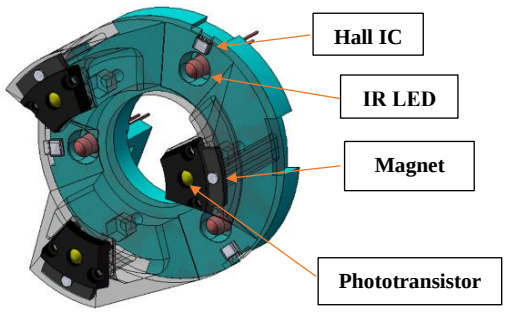
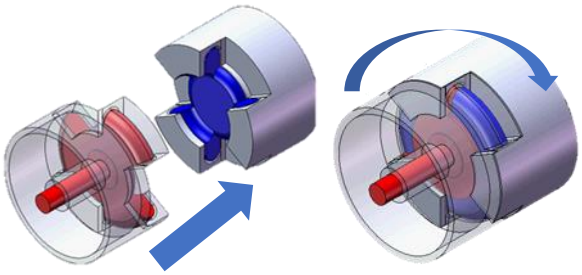


Figure 2: Schematic diagram of the connector



(a) Stand-by state (b) Connected state

Figure 3: Connection mechanism

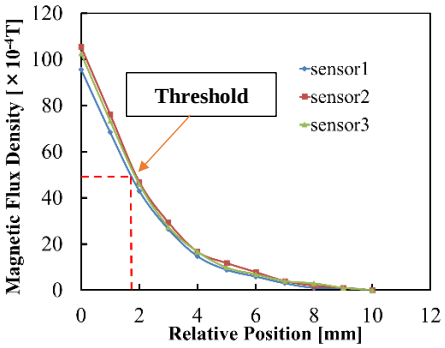


Figure 4: Relation between relative position and magnetic flux density

Automatic connection is performed by the following procedure. First, the robots face each other based on their positions obtained by localization, and then position themselves mechanically by following each other's tapers as shown in Figure 3(a). The structure is designed to allow smooth connection even if there is some misalignment during connection. Finally, after confirming the connection position of the robot with a positioning sensor, the connection is made by mutually rotating the central rotating disk according to the identification information provided by the transceiver element as shown in Figure 3(b). This allows the robot to connect based solely on its own judgment. This system uses no energy when connecting, making it ideal for modular robots.

3 Results and Discussion

A key part of the connection system is confirmation of the final connection position of the robot. Therefore, in order to estimate the position with 1mm accuracy without contact, we designed a relative position sensing system using changes in magnetic flux density (MFD).

The MFD of three magnets mounted on one connector is measured by three Hall ICs mounted on the other connector. The relative position can be estimated from the MFD. The relationship between the relative position and the MFD is shown in Figure 4. Based on the connector shape, we decided that the allowable relative position for connection is 1.5mm.The MFD threshold for the connection position of 1.5 mm was determined to be 50×10^{-4}T.

This system allows up to 10 mm of left/right misalignment and 15° of angular misalignment.

4 Conclusion

We developed the automatic connection system for modular robots. The MFD was used as the alignment sensor with magnets and Hall ICs. The relationship between the relative position and the MFD was identified, and the threshold value was set to determine contact.

Acknowledgements

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References

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[2] H Kurokawa, K Tomita, A Kamimura, S Kokaji, The International Journal of Robotics Research, Vol.27, No.3-4, pp.373-386, 2008.