A Novel Design for the Self-reconfigurable Robot Module and Connection Mechanism

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Abstract. Many researchers have paid more and more attention to the lattice self-reconfigurable modular robot for its excellent flexibility in connection and separation movements of modules. The paper proposes a novel design of self-reconfigurable robot module (M-Lattice) with the overall description. Moreover, the key features of module’s genderless pin-slot-based connection mechanism are introduced. Finally, the connection mechanism is proved to be feasible for the tasks of module’s self-reconfiguration by the experiments.

Keywords: Self-reconfigurable robot, Modular, Connection mechanism.

1 Introduction

As a front area of research, self-reconfigurable modular robot has got more and more attention all over the world recently with the advantages of the reconfigurable robot and the mobile robot, the modular robot is a typical autonomous mechanical unit which has abilities of independent movement, computation and communication[1-2]. A large number of modules with the same functions constitute a self-reconfigurable modular robot system. The most prominent feature of the system is the ability to change its shape without outside help through the module separation between the active connections or to change the system topology in order to adapt to the complex non-structural work environment. This target-based self-reconfigurable ability is given to self-reconfigurable modular robot with the flexibility that a fixed structure robot can not be achieved. That makes it effective in an unknown environment, such as disaster search operations, space or ocean explorations and other areas [3-4].

For the design of self-reconfigurable robot module, connection mechanism is a particularly important part for a flexible and reliable connection mechanism has laid the foundation for the self-reconfigurable movements among modules [5]. Up to now, many researchers have built several prototypes. The adopted connection mechanism can generally fall into such types as mechanistic and electromagnetic. A typical case of mechanical interface is Superbot modules designed by Wei-Min Shen etc. from USC (University of Southern California), which use a multi-jaw structure to accomplish connection and separation of modules by imitating human hands [6]. M-TRAN II, designed by Yoshida etc of AIST (Advanced Industrial Science and Technology) applies an electromagnetic interface [7]. The magnet on its plane is used...
for connection and a shape memory alloy (SMA) provides the driving force to separate when it gets heat.

The domestic research in this field is also making a continuous progress. HitMSR robot modules (Jie Zhao, et al, Robotics Institute of Harbin Institute of Technology) uses an electromagnetic interface[8], and the M-Cubes (Yanqiong Fei, et al, Research Institute of Robotics, Shanghai Jiaotong University) adopts a mechanical interface with a pin-hole-based design [9].

Compared to electromagnetic interface, mechanistic one is a more reasonable for the self-reconfigurable module owing to its remarkable advantages of being more efficient, reliable and energy-saving. On the other hand, it requires more parts with a higher machining accuracy. And too many moving parts will increase the cost and make it too complicated. In order to improve these problems, a novel mechanistic connection mechanism applied to a three-dimensional self-reconfigurable robot module M-Lattice is proposed in this paper.

2 Design of the M-Lattice Module

2.1 Overall Design

The topology of the M-Lattice module is lattice structure just as shown in Fig.1. Thus the self-reconfigurable system constituted by the modules looks like a mesh. Each node in the mesh represents a robot module and the changes of nodes’ positions mean the system structure transformations. This kind of lattice structure brings great convenience to realize the self-reconfigurable movements because a module in the mesh can move from one node to the others neighboring [10-11]. As illustrated in Fig.1, the robot module designed to be a center-symmetric three-arm structure, consists of a triangular central frame and three identically constructed mechanical arms which are installed on the three side walls of the center frame. Each mechanical arm contains two joints and one connection mechanism. The connection, separation and other movements of modules are completed by three degrees of freedom arms. Therefore, the connection mechanism at the end of the arm is essential to the stability

![Fig. 1. A novel lattice self-reconfigurable robot module](image-url)