A Modular Robotic System with Self-Reconfiguration Strategies Demonstrating Autonomous Module-to-Module Alignment and Docking

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Abstract: A modular reconfigurable robotic system is formed by a group of autonomous kinematic machines with variable morphology. Other than traditional fixed structure robots, modular and reconfigurable robots can rearrange their shapes by changing the connectivity of the parts or form a new structure with other robotic modules via various docking mechanisms to provide diverse functionalities, achieve complex tasks, and adapt to new environments.

This work describes a modular robotic system with self-reconfiguration strategies. The proposed robotic system is developed to combine the advantages of a group of small robots and rigid-structured large robots. Researchers generally agree that a group of mobile robots have several advantages over single-robot systems in some cases. The basic idea is that multi-robot systems can perform tasks simultaneously and achieve higher efficiency than a single robot or accomplish tasks not executable by a single one. Besides, these small robots have the ability to navigate through compact spaces. However, large robots do not have some characteristics, such as adaptation to uneven ground and manipulation capabilities. In this research, we present the development of modular and reconfigurable robots capable of docking with each other to bridge the gap between small and large robot functionalities to better respond to challenges associated with complex tasks and environments.

Each module in the proposed robotic system is capable of navigation and interaction with the environment individually. A non-back drivable active docking mechanism with two Degrees of Freedom (DOF) was designed to fit into either pulley of the track units of the robotic modules. The quantity and location of the docking mechanisms are customizable and selectable to satisfy various mission requirements and adapt to different environments. In addition, a Lyapunov function-based precision controller will be presented to demonstrate the autonomous docking process of the robot modules for assembling autonomously into other configurations to perform complex tasks.

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