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MODULAR SELF-RECONFIGURABLE SPACECRAFT BASED ON SMART BRICKS

Abstract

Presently, most spacecraft are monolithic systems, which are optimized for some particular tasks. Functions of these spacecraft are usually unchangeable in space, so it is difficult for the spacecraft to adequately respond to unexpected situations and various missions. To overcome drawbacks of the monolithic spacecraft architecture, modular spacecraft architecture is explored in recent years, which is demonstrated as a promising way to provide space systems with more flexibility, adaptability, and responsiveness. This paper introduces a new spacecraft architecture, named as modular self-reconfigurable spacecraft architecture. The purpose is to explore an innovative way for space system construction and operation. In the new architecture, a spacecraft is composed of a set of nano smart bricks with standardized hardware and software interfaces. The smart bricks are manufactured and stored separately before deployment. They can be quickly assembled together when launch. Once in orbit, all the smart bricks become reusable space resources, which can be flexibly combined together as basic building blocks to form a reconfigurable spacecraft. Smart bricks are connected with each other through electro-magnetic locking interface. Communication and power transfer between smart bricks are realized in a wireless way, which greatly simplifies interfaces between each other. With program controlled electro-magnetic interfaces and angular momentum exchange devices, the smart bricks can change their structural combining form autonomously according to various task requirements, without the assistance of other servicing spacecraft. To realize the new architecture, there are some enabling technologies. In this paper, technical problems including integrated framework of smart bricks, program controlled electro-magnetic interface, topology reconstruction algorithm, plug and play mechanism, self-organized networking and cooperative attitude control methods of the aggregated satellite are discussed. To verify the proposed architecture, an experimental prototype with four nano smart bricks was developed, and the testing system based on air bearing table was established. The enabling technologies were measured through simulation and test. All experimental results are in good agreement with the requirements.