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PROPELLANTLESS CLOSE RANGE RENDEZVOUS AND DOCKING USING A SINGLE ELECTROMAGNETIC DEVISE FOR SMALL SPACECRAFT

Abstract

This study proposes a new magnetic docking system for small spacecraft and designs the control method. Small spacecraft can achieve multiple spacecraft missions at lower cost and in shorter development period compared with conventional spacecraft, and the number of the missions that can be achieved is increase with spacecraft docking systems. Thus, spacecraft can perform a variety of missions effectively when using small spacecraft docking systems. The conventional spacecraft docking methods have utilized arms and docking mechanisms which are very heavy and complicated. These systems upsize the spacecraft, and it leads increasing of the cost and lengthening of the development period. Furthermore, the conventional docking systems are only for docking and grasping, cannot utilize as position controlling actuator for rendezvous and separation. Thus, conventional docking systems are not suitable for small spacecraft considering the strict restriction of its size, weight, and power consumption. Hence, a new docking system for small spacecraft needs to be developed. This study proposes a new docking system using electromagnetic force. In this system, the target spacecraft has a coil, and the chaser spacecraft has a permanent magnet. Then, the electromagnetic force moves and rotates the chaser, and docks them. After the docking operation, the magnetic force between the permanent magnet and the core of the coil grasps the spacecraft without electric power. Moreover, this system can separate the spacecraft and change the relative orbit of the spacecraft by controlling the repulsion force between the coil and the permanent magnet. Therefore, the proposed docking system can perform close range rendezvous, docking, grasping, and separation only using the coil and the permanent magnet. In this study, we investigate the docking control method of the proposed docking system. In general, electromagnetic force has strong distance dependence and modeling error. Hence, this study chooses sliding mode control and develops the control method since it can deal with strong non-linearity and modeling error. Furthermore, using the designed method, this study verifies that the proposed method can dock two small spacecraft with practical devices for that.