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VISUAL GUIDANCE AND NAVIGATION SYSTEM FOR SPACE DEBRIS MITIGATION AND DEMONSTRATION DURING ADRAS-1 MISSION

Abstract

With the increased use of motorization and the diverse approaches to space utilization, space debris is becoming a serious problem. It has been suggested that the number of space debris items increases via mutual interactions; therefore this debris must be removed from the Earth's orbit. In order to realize space debris mitigation, the ability to access the target debris reliably and efficiently is indispensable. However, an item of target debris is referred to as an "uncooperative target," which has neither control over nor awareness of its trajectory or position. Thus, a highly advanced autonomous visual-guidance navigation system that can autonomously identify target debris and direct rendezvous maneuvers with that debris is essential. However, such a space-debris mitigation system must be low cost, because of its subsidiary nature. In other words, a very difficult problem must be solved at very low cost. We have developed a highly autonomous camera system by combining autonomous control software technology and commercial off-the-shelf (COTS) devices. Using a high-resolution COTS imager and a field-programmable gate-array (FPGA) system, high-resolution imaging and very fast image processing have been achieved at very low cost. In addition to the hardware improvement, through utilization of a free-software scheme, we have improved software performance and the reliability of software resource sharing between university satellite development communities. Further, we have successfully utilized the intelligent camera system in various missions, for satellites such as Interplanetary Kite-craft Accelerated by Radiation of the Sun (IKAROS), Hayabusa-2, and Hodoyoshi. Now, we plan to utilize the intelligent camera system for visual guidance and navigation in space-debris-mitigation procedures, by combining this system with orbit-estimation and autonomous rendezvous and homing control technology. We plan to demonstrate the performance of the developed system during the ADRAS-1 space-debris-mitigation demonstration mission proposed by ASTROSCALE. During that mission, the capabilities of various kinds of technology required for space debris mitigation will be fully demonstrated using small satellites. The BOY debris de-orbiter will be attached to the target by the chaser satellite, known as MOTHER, and will perform a de-orbiting demonstration. Our camera system will be utilized to monitor the overall process, and also for the rendezvous control process. In this paper, we provide an overview of the visual guidance and navigation

system for space debris mitigation and discuss its performance. An overview of the ADRAS-1 space-debris-mitigation demonstration mission is also given.