19th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations - 19th IAA SYMPOSIUM ON SPACE DEBRIS (IP)

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GROUND TEST OF VISUAL SERVOING FOR HIGH SPEED TUMBLING SPACE DEBRIS CAPTURE AND LESSONS LEARNED

Abstract

Space operation technologies, such as the capture and disposal, of space debris, the service of satellites, and the robotic assembly and maintenance of large space structures, will be essential for space activities in the near future. A common, but most difficult exploitation is using manipulators capturing a 'dysfunction satellite' or space debris on orbit. The visual system is often used to guide the manipulator based on image sequences. This task will be more challenging if the target is tumbling at a high speed, because the common hand eye cameras navigate through identifying the capture point and its surrounding images. If the target rolls at a high speed, this navigation method will no longer be effective. It is very necessary to study the restriction of the successful operation for rotational or tumbling targets under the constraints of space lighting conditions and on-board computing capability. A ground test platform is established, which includes a pair of robotic arms and a target object mockup mounted on a turntable. A stereo camera is fixed with the pedestal of the manipulators as the navigation system to provide the position, velocity, attitude, and rotation velocity of the target to the robot controller in real-time. OpenCV and Python are adopted to process images and realize the control algorithms. This paper first presents the fundamental methods for pose measurement and states estimation of rotational space targets, then introduces problems encountered in the ground tests and the solutions. Finally, Testing cases with various rotation velocities and initial attitudes are performed based on the Monte Carlo method to verify the validation and flexibility of the proposed algorithms. The performance and constraints are analyzed and compared between different methods adopted for pose measurement, including feature matching with Surf, Optical flow tracking, Geometry matching as well as CNN.

Key Words: Space Robot, Debris Capture, visual servoing