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Author: Mr. Taisei Nishishita
Japan Aerospace Exploration Agency (JAXA), Japan, nishishita.taisei@jaxa.jp

Dr. Daichi Hirano
Japan Aerospace Exploration Agency (JAXA), Japan, hirano.daichi@jaxa.jp
Dr. Shinji Mitani
Japan Aerospace Exploration Agency (JAXA), Japan, mitani.shinji@jaxa.jp
Mr. Seiko Piotr Yamaguchi
Japan Aerospace Exploration Agency (JAXA), Japan, yamaguchi.seiko@jaxa.jp

DYNAMIC MOTION PLANNING OF FPV CAMERA FREE-FLYERS FOR AUTONOMOUS CREW TRACKING AND COLLISION AVOIDANCE

Abstract

JAXA is currently working to reduce the finite time resource of crew members on the International Space Station (ISS) by introducing robotics technology. As part of this activity, we are developing a free-flying robot, Internal Ball Camera (Int-Ball) to conduct photography tasks instead of crews. Int-Ball has various functions to move to the target point by the teleoperation from the ground operator and to take images autonomously. The final goal of this project is to have the robot completely replace the photography tasks previously performed by crews and to reduce their resource by nearly 10%.

The first Int-Ball was launched in 2017 to verify component technologies such as wireless communication and hovering. Based on the lessons learned of the test, the next generation Int-Ball2 with further updates is under development. In the ISS demonstration test with Int-Ball2, we plan to conduct a demonstration of a series of shooting tasks without any support from crews, such as autonomously moving to the shooting point, completing the shooting task, and returning to the docking port and recharging.

The main operation scenario is to take images from a fixed point, but other advanced scenarios such as dynamic First-Person View (FPV) shooting, in which the robot follows the target object, are also expected. Furthermore, it is essential to have an emergency maneuver function to avoid collision with the approaching crew or other floating objects for continuously accomplish the mission.

In this work, we show how Int-Ball2 can realize advanced mobility functions as in the previous example, which are necessary to "completely" replace the crew's photography task. Specifically, this paper describes the target and obstacles detection method, and the 6-DOF motion planning algorithm such that the main camera's field of view is always directed toward the target object and the robot moves along the target trajectory while capturing video. In addition, we describe a method for dynamically computing an optimal path such that even if an obstacle approaches on the path, the subject is not hidden by the obstacle and a collision is avoided. Furthermore, this research presents the control law using new cost function that avoids the risk of collision and minimizes the damage when collision is unavoidable. Finally, we show the results that demonstrate the validity of the proposed system architecture for long-term operation.