18th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Post Mission Disposal and Space Debris Removal (2) (6)

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# CAPTURE AND STABILIZATION STRATEGY FOR LARGE TUMBLING GEO DEBRIS REMOVAL USING SPACE ROBOTIC MANIPULATOR SYSTEM

**Abstract**

With the fast growing space activities of human beings, more and more spacecraft have been being launched into Earth orbits, and space debris issue is becoming increasingly urgent in the wide world. Different from the LEO protected region, most space debris objects in the GEO protected region are defunct satellites and rocket bodies, which are usually larger in size ($>$ 10 m) and weightier in mass ($>$ 1000 kg). They will pose disastrous hazards to other functioning spacecraft if left drifting in the GEO protected region. Moreover, these large GEO debris objects are usually rotating or tumbling because of initial motion and energy dissipation, which brings more challenges to the capture and removal mission. The safety approach and detumbling in pre-capture, the target tracking and impact reducing at capture instant, the angular momentum transfer and attitude stabilization in post-capture are all more difficult than those of small space debris.

Space robotic manipulator technology is expected to play an important role for active debris removal. This paper summarizes our recent results on the capture and stabilization strategy of large tumbling GEO debris using a space robotic manipulator system. The dynamic models of large space debris and robotic manipulator system are established to describe all the critical characteristics such as relative motion, nonlinear joints and rigid-flexible coupling multibody system. Two safety corridor flying strategies are designed and compared to allow the space robot to approach large tumbling space debris in limited time and without any collision. An optimal contact detumbling control method is proposed for reducing the three-axis angular velocities of large space debris and damping the nutation at the same time. The trajectory planning and the cooperative control for spatial proximal capturing operation are presented aiming to synchronously track the anchor point motion and reduce the capturing impact. The angular momentum transfer and the vibration suppression after capturing are researched using the particle swarm algorithm and the singular perturbation theory so as to stabilize the tumbling attitude of large space debris. Based on the above key technologies, a numerical simulation system is developed in order to verify the capture and stabilization strategy of large tumbling GEO debris. These research results provide a preliminary technical exploration for on-orbit experiment and engineering application.