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SATELLITE STABILIZATION WITH LASER UNDER INPUT DIRECTIONAL CONSTRAINTS

Abstract

The number of space debris in near-Earth orbit is steadily increasing, and it has caused severe problems to operational satellites. Mitigating the increase rate of space debris is common consent. To this end, Active Debris Removal (ADR) is one of the key approaches for sustainable space environment. Many ADR methods using robotic arms or electrodynamic tethers have been proposed, and they require contact operations. On the other hand, the ADR using a laser is also a promising technology for its advantage in contactless operations. Thus, the removal satellite has a smaller risk of functional loss by accidental collision. In the mission, the removal satellite irradiates target debris with the laser, and the thrust force is generated in the opposite direction of traveling, causing target deceleration. For an effective de-orbit, the thrust force must be generated in a desired direction, and the rotational motion of the target should be stabilized in advance. In this context, this paper derives a control law for detumbling the target debris with the laser. The control torques are generated by the thrust forces of the laser changing the irradiation direction. The difficulty stems from a constraint on the thrust force directions because the removal satellite is always leading the target, and the thrust force is only generated in the opposite direction of traveling. As a result, the directional constraint on the thrust force leads to the directional constraint on the control torques. This means that the desired torque cannot be generated depending on the target's attitude. This paper uses a target-centered NTW frame. The laser is assumed to land on the plane perpendicular to the T-axis and has a positive offset from the origin. To generate attitude control torques, the thrust force direction should be tilted from the normal vector of the plane. The control torque directions are limited to in-plane, and the angular momentum perpendicular to the plane, i.e., the direction along T-axis, is uncontrollable. Thus, the proposed method consists of two steps. First, the angular momentum except for the uncontrollable direction is stabilized, resulting in a single spin motion. Since the angular momentum is conserved in inertial frame, it apparently rotates in the NTW frame. That is, the remained angular momentum will be in the controllable directions. Second, single spin motion can be attenuated in a similar way to the first step. Numerical simulation results verify the effectiveness of the proposed control method.