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# RECURSIVE ADAPTIVE CONTROL FOR SPACE ROBOT: SPACECRAFT MOUNTED MANIPULATORS

**Abstract**

Since the first manmade satellite Sputnik 1 in 1957, more than 4000 space missions have been launched. It results in millions pieces of debris including inactive satellites, fragments of broken up spacecraft and equipment lost by astronauts. The space debris is a great danger to all space vehicles. The rapid increase of space debris may even cause Kessler syndrome, which must be prevented from happening. To this end, the on-orbital service may be our only chance. The experimental spacecrafts, such as Engineering Test Satellite No. 7 (ETS-VII) and Orbital Express, reveals that the spacecraft mounted manipulators can provide such on-orbital services. These experimental satellites are essentially space robots. In this paper, space robot refers to spacecraft mounted manipulators.

In this paper we consider a typical on-orbital service scene: the service space robot maneuverings around the service target, while its manipulators provide corresponding service. Control of the space robots plays a key role in on-orbital. Hence, this paper focuses on the control technique of spacecraft mounted with manipulators. According to the base control strategies, a space robot can be operated in four modes: 1) free-flying mode; 2) attitude-controlled mode; 3) free-floating mode. This paper studies the free-flying mode, because it has the best mobility and is the only feasible choice in many complicated orbital service.

Due to the complexity of the orbital service, the spacecraft may mount more than one manipulators to improve its on-orbital service ability. This paper aims to provide a control framework for these space robots. By directed path approach and spatial vector tool, recursive Newton-Euler dynamics of the space robot is derived. It is assumed that the exact knowledge of the inertia parameters is not available. To deal with this issue, an adaptive recursive adaptive controller is proposed in this paper. Moreover the contact between the end-effectors of the space manipulators and the service object is also taken into account. Finally, some numerical simulations are provide to demonstrate the effectiveness of the proposed controller in this paper.