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AUTONOMOUS CONTROL FOR FLEXIBLE JOINT SPACE ROBOTIC MANIPULATORS

Abstract

Since the last few decades, there has been a paradigm shift towards the greater utilization of large robotic manipulators in space applications. As an example, with the recent addition of Dextre (a two-arm robot) to Canadarm2, fine manipulation tasks that until then were performed by astronauts during spacewalks are now carried out by this highly advanced robotic system. However, the control of such robotic arms is not fully autonomous and assistance from astronauts or ground operators is still required to accurately position the endpoint of the manipulator. Therefore, if the control of such robotic manipulators could be fully autonomous, the astronauts would have more time to perform useful scientific experiments aboard the space laboratory.

The use of large space robots, which are required to autonomously and accurately perform manipulation tasks within an acceptable execution time, involves several operational challenges. Those challenges are mostly related to the structural flexibility of the links mostly caused by the elastic vibrations of the joints coupled with their large rotations and nonlinear dynamics. However, the great majority of control algorithms proposed in the literature so far addressing the problem of autonomous control of robotic space manipulators do not consider the joint flexibility, which may indeed lead to inadequate operational performance.

Within this context, this study shows how fully autonomous control algorithms for a two-link robotic space manipulator can be developed taking into account the flexibility of the joints. First, in order to take into account several conflicting goals (such as high endpoint accuracy, power consumption, execution time, vibration damping, increased autonomy), an optimal control system is proposed. Then, an adaptive control algorithm is also proposed in order to cope with the numerous uncertainties affecting the flexible space robot (such as the joint stiffness coefficient).

In summary, this paper presents novel ways of designing flexible joint control algorithms for robotic space manipulators, thus providing solutions to common problems facing the space industry.