ASTRODYNAMICS SYMPOSIUM (C1)
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DYNAMIC MODELLING AND CONTROL OF FLEXIBLE ROBOTIC SPACE MANIPULATORS WITH TELESCOPING BOOMS

Abstract

Historically, Remote Manipulator Systems (RMS), such as the Canadarm 1 and 2, and the Japanese Experiment Module's RMS, have been robotic arms which have followed the same design paradigm, based on rotary joints, giving them little ability to fold into a compact form. In the future, there is an interest to have smaller packing envelopes when RMS are used for onboard servicing of satellites and space stations, to reduce costs associated with the launch of these robots. In addition, space-bound manipulators are designed to be light-weight in order to minimize the mass of the payload. As such, the manipulators tend to be structurally flexible. To obtain a light-weight and highly performant RMS with a small packing envelope, such as the Next Generation Large Canadarm (NGLC), the design of flexible telescoping manipulators must be considered. This type of robotic arm must also include a robust control system that mitigates resulting vibrations so that the arm is able to complete precision work.

There has been much investigation done in the dynamics and control of rigid and flexible link manipulators, but there has been little development in the dynamics and control of telescoping, flexible manipulators. Current literature describes two methods for analyzing single fixed-free and slider-free telescoping beams. The first method considers the overlapping segment of the distal and proximal sections of a telescoping arm to have the same shape profile. The second, more complex method, assumes that there is some clearance between the two sections. In this paper, the difference between these two modelling methods is investigated to see if the first and simpler method accurately captures the dynamics of the two-link system as compared to the more complicated second method. The equations of motion of a two-link flexible manipulator with rotary joints and telescoping booms are derived using these two methods in conjunction with Hamilton's principle. This four degree of freedom system is similar to the proposed NGLC design. The resulting dynamics are discretized using the Rayleigh-Ritz method, and then robust control design is considered. Specifically, a passivity-based control (PBC) scheme is used to control the two-link manipulator models developed. PBC is a well known control architecture that is robust to structural mass and stiffness uncertainty, and has previously been used for the control of traditional flexible link, rotary joint manipulators.