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VISION BASED AUTONOMOUS CONTROL OF SPACE ROBOTIC MANIPULATORS

Abstract

Robotic manipulators have been widely used in space for docking, assembling, repairing and other on-orbit servicing (OOS) operations. So far, robotic manipulators have been successfully performed in space mainly with four fields: International Space Station (ISS), Mars Exploration Rovers (MER), Orbital Docking System (ODS) and Pure Experimental System (PES). However, most of current applications employ human-in-the-loop control, which lay the majority of the decision-making and guidance into human hands. Manual control from ground base suffers from long time delay, sending human operators into space to conduct the missions may induce higher cost and even the possibility of life loss. Autonomous control of robotic manipulators is a complex system strategy. Since most of the operations require capturing a noncooperative target (nCT), this paper is focused on autonomous control of robotic manipulators for capturing nCT. Problem encountered in autonomous capturing is the pose and motion estimation of the target. Photogrammetry is a technology to extracting 6 degree of freedom (DOF) pose information from 2D image. However, it highly relies on the accuracy of the vision feedback system. If an uncalibrated camera is adopted, the pose estimates will be largely affected by the poor accuracy of the camera. Even more, photogrammetry is a memoryless process, which means it has no effort on motion estimate. In order to also obtain motion estimate, filtering technologies are usually preferred. Extended Kalman Filter (EKF) is a popular filtering algorithm to estimate unknown variables based on a set of noisy measurements observed over time. Although the initial condition doesn't change the convergent tendency of the algorithm, it does affect the performance of EKF, especially when we dealing with nCT that the initial conditions are unknown. In this paper we proposed a new methodology that combines both photogrammetry and EKF to obtain pose and motion estimates of the nCT based on vision feedback. Photogrammetry is adopted to estimate an initial condition. Then EKF will take over the estimation and continue to estimate the pose and motion of the nCT in real time. Once we obtained the pose and motion estimation, an impedance controller is designed to drive the robotic manipulator approaching and capturing the target autonomously. Numerical simulations have been done to validate the effectiveness of newly proposed methodology for robotic manipulators to autonomously capture the nCT based on visual feedback.