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COLLISION DETECTION AND ISOLATION FOR FREE-FOATING SPACE ROBOTS

Abstract

In the last 30 years, many efforts have been made to develop robots capable of supporting and increasing space activities.

However, on-orbit robotics, and in general space robotics, is still a novel field of research. In the future, autonomous satellites equipped with robotic arms should be able to support astronauts during routine and maintenance work, capture tumbling objects, repair or refuel spacecrafts, relocate them and assembly structures.

In these contexts, accidental contacts may occur and be extremely dangerous, leading to mission failure. To avoid such consequences, intelligent robots should be designed implementing algorithms to mitigate the effects of possible incidental collision.

Collision handling task can be divided into four phases: detection, isolation, identification and reaction.

The goal of the first phase is to detect if a collision occurs or not. After the collision detection, in the isolation phase, the point at which the contact occured is localized. Afterwards, the external force/torque is tried to be estimated. Finally, the robot is controlled in order to react properly.

In particular, this paper presents some techniques to face detection and isolation phases considering a free-floating space robot.

In the free-floationg mode, no external forces/torques act on the system and therefore the linear momentum and angular momentum are preserved. When a contact occurs, the momenta lose their stationarity, and thus these quantities are good candidates to be used as monitoring signals to detect a collision.

The easiest approach would be to define a threshold and when the signal crosses this limit a contact is detected. However, defining a threshold in advance is not an easy task and, moreover, this strategy is particularly affected by false positive alarms, especially if the signals are noisy. Hence, more sophisticated techniques are preferable.

In this work hierarchical sequential analysis techniques are considered and applied to the problem. They exploit a first subsequence of the datastream to learn statistical features of the stationary phenomenon, then they check their evolution in time and, if a change in the system occurs, raise an alarm. Moreover, they are endowed with a second layer which verifies the reliability of the detection, decreasing false positive alarms.

Afterwards, since external torques and forces directly affect the momenta, the variation of these quantities is exploited to quantify the external disturbances, especially in orientation and point of application. Indeed, these information can be useful for the manipulator's reaction and to monitor the health status of the system.