TECHNISCHE UNIVERSITÄT MÜNCHEN
Human-centered Assistive Robotics
UNIV.-PROF. DR.-ING. DONGHEUI LEE

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M A S T E R ' S T H E S I S
for
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Fault Detection and Isolation for On-Orbit Servicing Spacecraft Using Observer-Based Methods

Problem description:

As the amount of inactive satellites and space debris posing a threat to on-orbit resources continues increasing [2], on-orbit servicing is receiving increasing interest by ESA and other space agencies. Robotic spacecraft are currently in the focus of research, as they can be used both for active life extension of non-functional satellites by repair or refueling, as well as for active debris removal. Such robotic spacecraft constitute a highly complex mechatronic system that is utilized in close proximity to the target spacecraft going to be captured, serviced or de-orbited. Due to the free-floating dynamics in this zero-g environment, collisions have to be avoided at all cost. In contrast to robotic systems on ground, there is no emergency button in space. Although there can be human supervision from ground, the system needs to be able to autonomously execute the current task at hand. In this context, failure detection, isolation and recovery (FDIR) plays an important role for keeping the system operational in case unexpected or even previously unknown errors occur. The traditional approach to FDIR for spacecraft foresees very simple, yet robust methods like lookup tables. These methods usually do not employ fault-specific recovery strategies. Instead they transition the system to a fail safe mode, with the subsequent need for an operator to resolve the situation from ground. For robotic on-orbit servicing (OOS) tasks, however, new methods have to be found in order to keep the system running and thus, avoid potential collisions. It is vital to autonomously detect and correctly identify any failure happening in the system in time, in order to execute an appropriate recovery strategy. This thesis will focus on FDIR of robotic manipulators employed on servicing spacecrafts. Model-based fault detection methods nowadays used in industry will be researched [1, 3, 4] and adapted for free-floating orbiting systems. These methods will be employed to detect non-nominal values in sensors and actuators and autonomously identify faults in the system.

Tasks:

- Literature review to become accustomed with the use case projects: e.deorbit and DEOS.
- Literature review of existing model-based FDIR methods for terrestrial manipulators.
- Implementation of controlled free-floating manipulator system.
- Implementation of fault-injection interfaces.
- Development and implementation of model-based fault-detection methods adapted to free-floating systems.
- In-simulation Testing and Validation of the developed methods.
- Optional: Implementation and testing of fault-detection methods on hardware simulator OOS-Sim.

Bibliography:

[1] Alessandro De Luca, Alin Albu-Schaffer, Sami Haddadin, and Gerd Hirzinger. Collision detection and safe reaction with the dlr-iii lightweight manipulator arm. In *Intelligent Robots and Systems, 2006 IEEE/RSJ International Conference on*, pages 1623–1630. IEEE, 2006.

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[3] Michael L McIntyre, Warren E Dixon, Darren M Dawson, and Ian D Walker. Fault identification for robot manipulators. *IEEE Transactions on Robotics*, 21(5):1028–1034, 2005.

[4] Ola Pettersson. Execution monitoring in robotics: A survey. *Robotics and Autonomous Systems*, 53(2):73–88, 2005.

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