SPACE SYSTEMS SYMPOSIUM (D1)
Space Systems Architectures (4)

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A DDS BASED REAL-TIME DISTRIBUTED SIMULATION ARCHITECTURE FOR SPACE ROBOTIC TELE-OPERATION

Abstract

Increasing costs and complexity of satellite mission motivate the idea of extending the operational lifetime or improving functionalities/performance of a satellite in orbit by satellite maintenance, on-orbit refueling and assembly etc. To enable such on-orbit servicing missions and meet the demanding requirements in harsh space environment, the application of space robot has been received significant attention. Since the high risk associated with space missions, human participated tele-operation will greatly enhance the reliability and redundancy of space robot system.

This paper presents a new real-time distributed simulation architecture based on Data Distribution Service (DDS) for space robotic tele-operation tasks. Conventional Service-Oriented Architecture (SOA) middleware platforms have the limitation of lacking support for data-centric QoS (Quality of Service) mechanisms. DDS, which is a data centric publish-subscribe middleware with low latency and QoS capabilities, provides a much better choice fit for the real-time requirements.

The objective of this paper is to make the simulation architecture open for collaborative tele-operation research and provide the operator an intuitive view of space robotic tele-operation in a wide set of scenarios. The main scope is the real-time distributed simulation system (RacoonSim) design based on the real world model as part of Real Time Attitude Control and On-Orbit Navigation Laboratory (RACOON Lab) which is designed and built in TU Munich's Institute of Astronautics (LRT). The mission profile and background of space robotic tele-operation are firstly recalled. Within this context, a closer look into RACOON system overall design and system simulation environment are described. Secondly, the detailed characters of DDS, including DDS specification and its core idea of data distribution, are exhibited. Thirdly, RacoonSim system, which comprises multi-body dynamics, path & trajectory planning and control subsystems of space manipulators, is introduced. Additionally, a friendly Virtual Reality (VR) user interface for coexistence of working operator and space robot is developed, which is composed of 3D space mouse, joystick and Head-Up Display (HUD) as part of the Mission Control Center (MCC). Well-designed system architecture makes the Hardware-in-loop (HIL) simulation possible and can be extended easily in the future. High-fidelity simulation system is capable of digitally and physically simulating the approach and capture process of an on-orbital servicing mission. The space tele-operation experiments particularly demonstrate the effectiveness and feasibility of the proposed simulation system.