Vision-Based Relative Navigation for Proximity Operations and On-Orbit Servicing Technologies
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Motivation
- On-orbit servicing requires reliable and precise estimation of the relative pose (i.e., attitude and position) between the service and target satellite and the accurate and fail-safe control of the service satellite.

Overview

Relative Navigation
- Rate Gyro / IMU
- Dual Quaternion based Estimator
- Actuators (12 Thrusters, 4 VS-CMGs)
- Vision

Absolute Navigation
- Dual Quaternion based Controller
- Attitude Controller (3DoF)
- Attitude & Position Controller (5DoF)

Dual Quaternion Multiplicative Extended Kalman Filter (DQ-EKF)
- Error Unit Dual Quaternions
- Dual Quaternion based Estimator
- Pose Estimate
- Velocity Estimation Error

Vision (cooperative case)
- BoxLoG response
- Data Association
- Pose Estimate (Dual Quaternion)

Vision Based Attitude (3DoF) Stabilization
- Vision Measurements
- Rate Gyro Measurements
- Attitude Tracking Error

Experimental Setup
- Autonomous Spacecraft Testing of Robotic Operations in Space (ASTROS)
- Absolute Navigation (5DoF) for a Docking Maneuver using Thrusters

Un-cooperative Vision based Relative Navigation relies on extraction, and registration of features from previously unseen scenes (in progress).

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Pose Estimation Error
- More compact (6 parameters) compared to EKF based on true unit quaternion (8 parameters)

Vision Measurements

Rate Gyro Measurements

Attitude Tracking Error

Pose Tracking Error

Results

Attitude Tracking using VS-CMGs (3DoF)

Controller

Simulation Environment

Tag detection and feature tracking (2D implementation)

Experimental Setup

Absoluteness

Relative Navigation

Artificial satellite and simulated target satellite (not shown)

Vision (cooperative case)

BoxLoG

Average FPS

Experiment

Apr 21

Our approach

Simulink Environment

Multi-camera setup

Color CCD camera

VS-CMGs (3DoF)