Methodology for Software-in-the-Loop Testing of Low Cost Attitude Determination Systems

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Overview

UMN CubeSat Missions

- **EXACT**: collect photons from Sun to understand solar physics
- **SOCRATES**: CubeSat ranging techniques using natural astrophysical signals

+/- 25 deg attitude requirements
Motivation

Mission Hardware & Software
- Gyroscopes, magnetometers, potentially sun sensors
- EKF fuses measurements
- Will use 1 or 2 vectors

Not New
- Similar algorithms have been developed previously
- Extensive published research on attitude determination

Challenge: How to test the integrated Attitude Determination System (ADS)
Objective

Low cost way to do software in the loop testing of an ADS
Sensor Characterization

Attitude Determination Sensors

- Gyroscopes
- Magnetometers

Zero Gauss Chamber
Embedded System Emulator

NanoMind A3200 Flight Computer

Pixhawk flight computer
Software in the Loop

Running on Pixhawk in real time

- Magnetometer
- Gyroscope
- Accelerometer (stand in for sun sensor)
Performance (Accuracy)

- $2\sigma \psi = 7.32^\circ$
- $2\sigma \theta = 3.75^\circ$
- $2\sigma \phi = 7.11^\circ$
Software/Hardware in the Loop Testing
Conclusion

● Methodology developed for software in the loop testing for low cost attitude determination systems

● Utilizes Helmholtz Cage, Zero Gauss Chamber
  ○ Can perform tests without these resources
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Questions
Software in the Loop (Environment)

Simulating UAV flight using jmavsim and Qgroundcontrol

- Magnetometer
- Gyroscope
- Accelerometer (stand in for sun sensor)
Helmholtz Cage

- Honeywell magnetics facility
- Program specified magnetic field
  - 3-axis
  - Cancels earth
- Simulate on-orbit environment for CubeSat