Nanosatellite Attitude Truth System Leveraging AprilTags Fiducial Markers

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**Problem**

How to verify control algorithm improvements and sensor accuracy for cubesat systems without expensive VICON systems? Can fiducial markers be used to have an attitude tracking response of 10 Hz or more with a <= 1 deg of accuracy using conventional webcams?

**Lab Objectives**

The Generalized Nanosatellite Avionics Testbed (G-NAT) lab at NASA Ames Research Center provides a flexible, easily accessible facility for developing hardware and software for advanced small spacecraft. The Lab facility includes:

1. An air bearing that provides 3DOF rotational motion
2. A Helmholtz cage that generates a magnetic field equivalent to that encountered in space.
3. A sun emulator bulb that produces a sun vector with a known orientation
4. An "attitude truth" system based on the open-source AprilTags software.

**References**


**RESULTS**

- Created turnkey attitude determination system with inexpensive cameras
- Established calibration protocol for AprilTags System
- 10-15 hz data acquisition rate of AprilTag attitude.
- Created runtime plot interface of attitude.
- Tested web-based interface for the G-NAT lab with video streaming, photo capture and real-time data acquisition available for remote collaborators.

**Device Architecture**

ApriTags* and other passive fiducial markers require specialized algorithms to detect markers among other features in a natural scene. Exploit the AprilTags detection we decompose Euler angles from the rotation matrix obtained from the projection matrix of the tag with respect to the camera reference using OpenCV built-in libraries. Knowing the position of camera orientation with respect to the air bearing pedestal rotation point tag attitudes are converted into inertial reference frame providing the "Attitude Truth" for the G-NAT Testbed.

*Open source tag detection package provided by University Michigan

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**Future Research**

- Perform verification of rotation transformation with GNAT Lab IMU testbed.
- Perform AprilTags on upcoming CubeSats missions, such as Biosentennial
- Create turn-key calibration procedure

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*3 Degrees of Freedom