Implementation of Solar Observation on a High Altitude Balloon Platform

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Mission Overview

- To prove the viability of solar observation on a high altitude balloon platform
- Provide an inexpensive and effective alternative to current solar observation methods

Mona Kea Observatory\(^1\)

Solar and Heliospheric Observatory\(^2\)
High Altitude Student Platform

- Launches every year in August or September from New Mexico
- Achieves a float altitude of 36 km for up to 20 hours
- Provides a live feed camera

2014 flight path
Concept of Operations

- Two orthogonal sets of photodiodes determine the payload’s attitude
- Two stepper motors control the payload’s attitude
Structure

- Elevation diode housing
- Intermediate Structure
- Base Housing
- Upper housing
- Cameras
- Azimuth diode Housing
- Base plate
Cameras

- **ADCS camera**
  - In flight calibration
  - $23^\circ \times 17^\circ$

- **GoPro Hero 3**
  - Post flight characterization
  - $122^\circ \times 94^\circ$
Photodiodes

- One set determines position on elevation, one determines position on azimuth
- Each set is comprised of two orthogonally set diodes
- Located in 3D printed photodiode housings
  - Each housing is baffled to a field of view of approximately 30°
Motors

• Two bipolar stepper motors with 200 steps per revolution

• Controlled by stepper motor drivers through the microcontroller

• Elevation motor
  • Stands on the arm of the intermediate
  • 1:1 gear ratio

• Azimuth motor
  • Lies in base housing
  • 4:1 gear ratio

• Microstepping
  • Drivers allow for up to 1/16th steps
Algorithm

- Microcontroller analyzes the difference in the readings of the orthogonal diodes and uses it to determine the payload’s attitude
- The microcontroller instructs the motors to change the payload’s attitude until it is oriented toward the sun
- Variable microstepping
- Limiting movement
  - $-360^\circ < \theta < 360^\circ$
  - $0^\circ < \Phi < 65^\circ$
- Real-time photodiode calibration
Calibration Algorithm

- Analyzes position of sun in ADCS camera
- Analyzes difference between orthogonal diode readings
- Builds and updates a model to calibrate the diodes
## Responses to Special Circumstances

<table>
<thead>
<tr>
<th>Circumstance</th>
<th>Response</th>
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<tbody>
<tr>
<td>Stray light or shadow</td>
<td>• Photodiode baffles</td>
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<td></td>
<td>• Filtered readings</td>
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<tr>
<td></td>
<td>• Constant platform rotation</td>
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<tr>
<td>Sun out of diodes’ field of view</td>
<td>• Gnomon</td>
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<td></td>
<td>• “Nudge” commands</td>
</tr>
<tr>
<td>Sun blocked by balloon</td>
<td>• Tracking system inactive</td>
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</tbody>
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HELIOS III - 2014

- System attained movement on azimuth only
- Captured over 75 partial images of the sun
- Validated accuracy of tracking system
HELIOS IV - 2015

- Established movement on both axes
- Focused cameras
- Improvements on power board, structural accessibility, ease of movement
- Implementing diode calibration
- Emphasis on engineering mission
  - Wide field of view camera
  - No hydrogen-alpha filtered science camera
References


Questions?