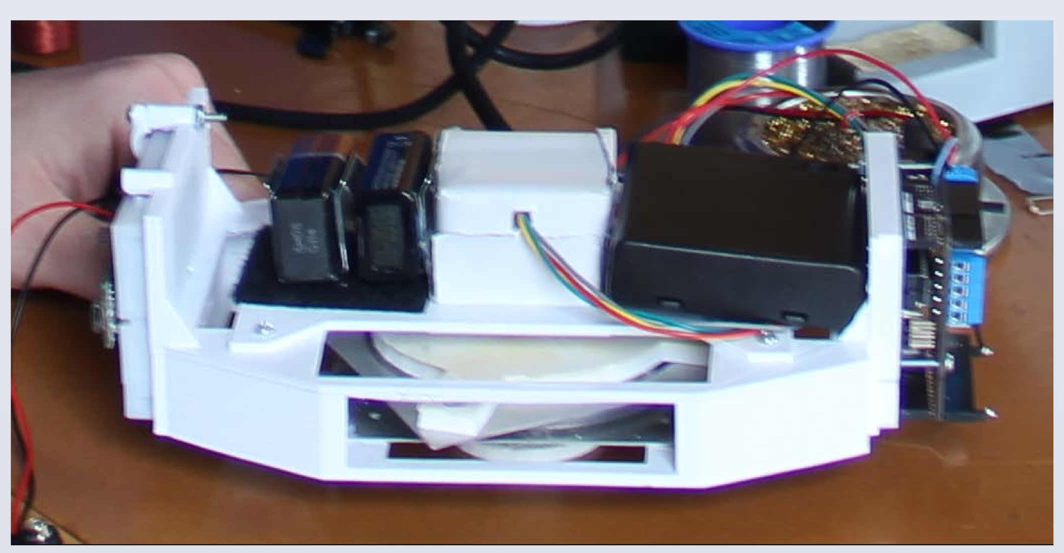
Controlled Heading Automation Device

Robert Coulson

DePaul University

Abstract

One of the most significant limitations of weather balloon-based data collection is that instruments and payloads cannot depend on particular orientations or predictable rotation. Several investigators have used payload heading control devices to overcome this limitation in order to collect directional data and record motion controlled video footage. The work described in this presentation builds on the Controlled Heading Automation Device (CHAD) developed by Kruger et al. (2016) and was carried out at DePaul University in summer 2017 as an undergraduate research project. Our goal was to record stable video of the shadow of the moon on Earth's surface during the August 21, 2017 solar eclipse. In order to improve reliability and performance we modified the hardware design of Kruger et al. in several ways. We successfully employed the CHAD during totality and were able to identify opportunities for modifications of hardware and software in order to further improve performance of the device.



Introduction

Originally developed by Kruger et al (2016), the CHAD utilizes common and inexpensive parts to provide accessible payload stabilization for the High-Altitude Ballooning community. In its original configuration, the CHAD uses a magnetometer as a primary sensor for controlling a stepper motor, and a 6-axis accelerometer/gyroscope for tilt correction and to correct for rotational speed. The mechanical pieces mainly consist of 3D printed parts, made openly available by the original designers.

This project began as a straightforward rebuild of the original device in order to collect stable in-flight video of the 2017 Solar Eclipse. During the process of construction, we made modifications to the original design to better suit our purpose, and to solve problems we encountered during testing. Here, we will focus on the modifications we made.

Methods

Gyroscope

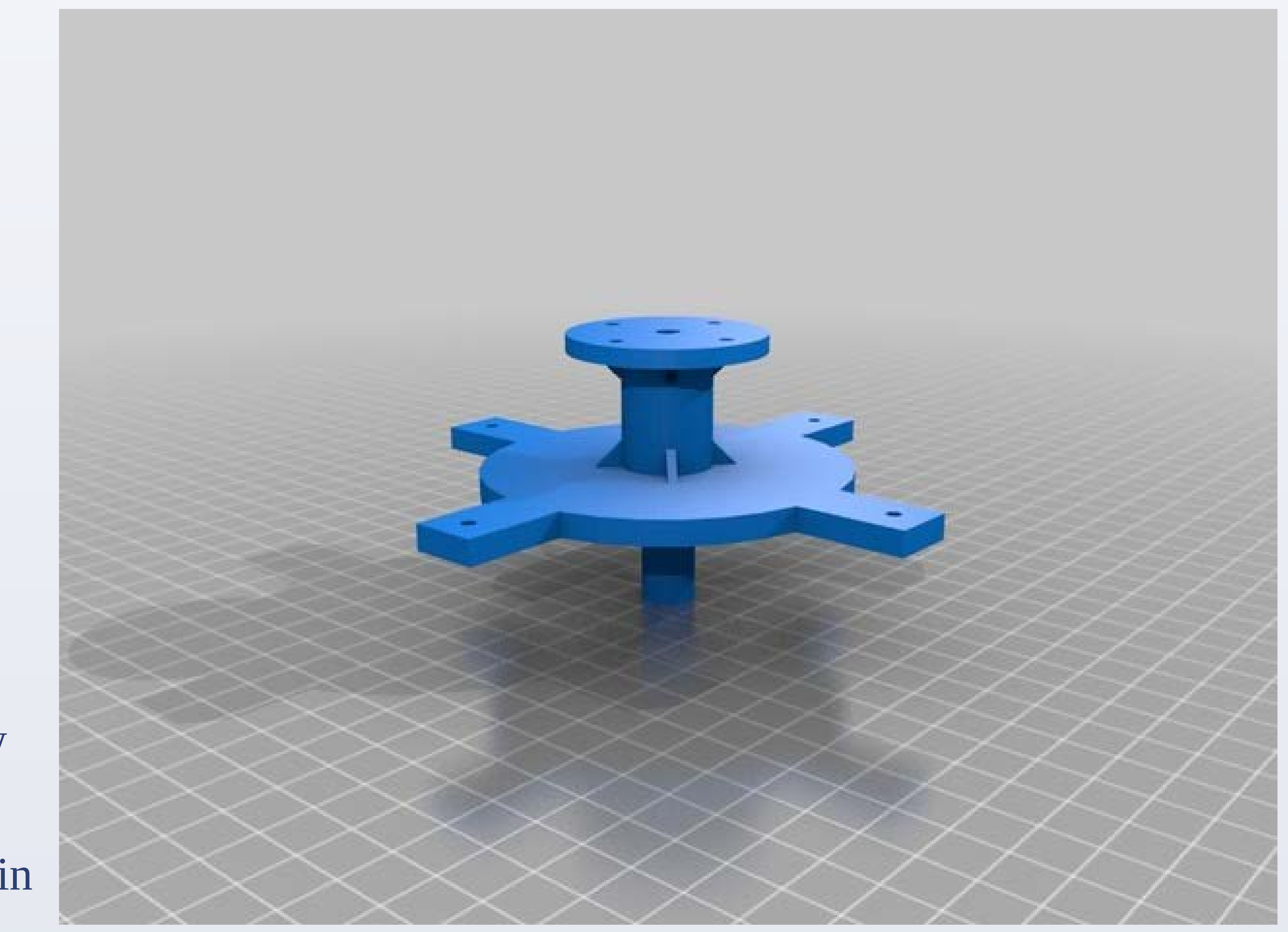
- Focused on stabilizing rotation, experimented with using gyroscope as primary sensor without magnetometer assistance

Connective Arm and Turntable

- Needed stronger connective arm due to wear from the motor shaft
- Redesigned connective arm to engage motor via set screw
- Mounted turntable with nylon lock nuts to allow for play in the turntable; reduced friction and removed need for lubrication

Power Supply

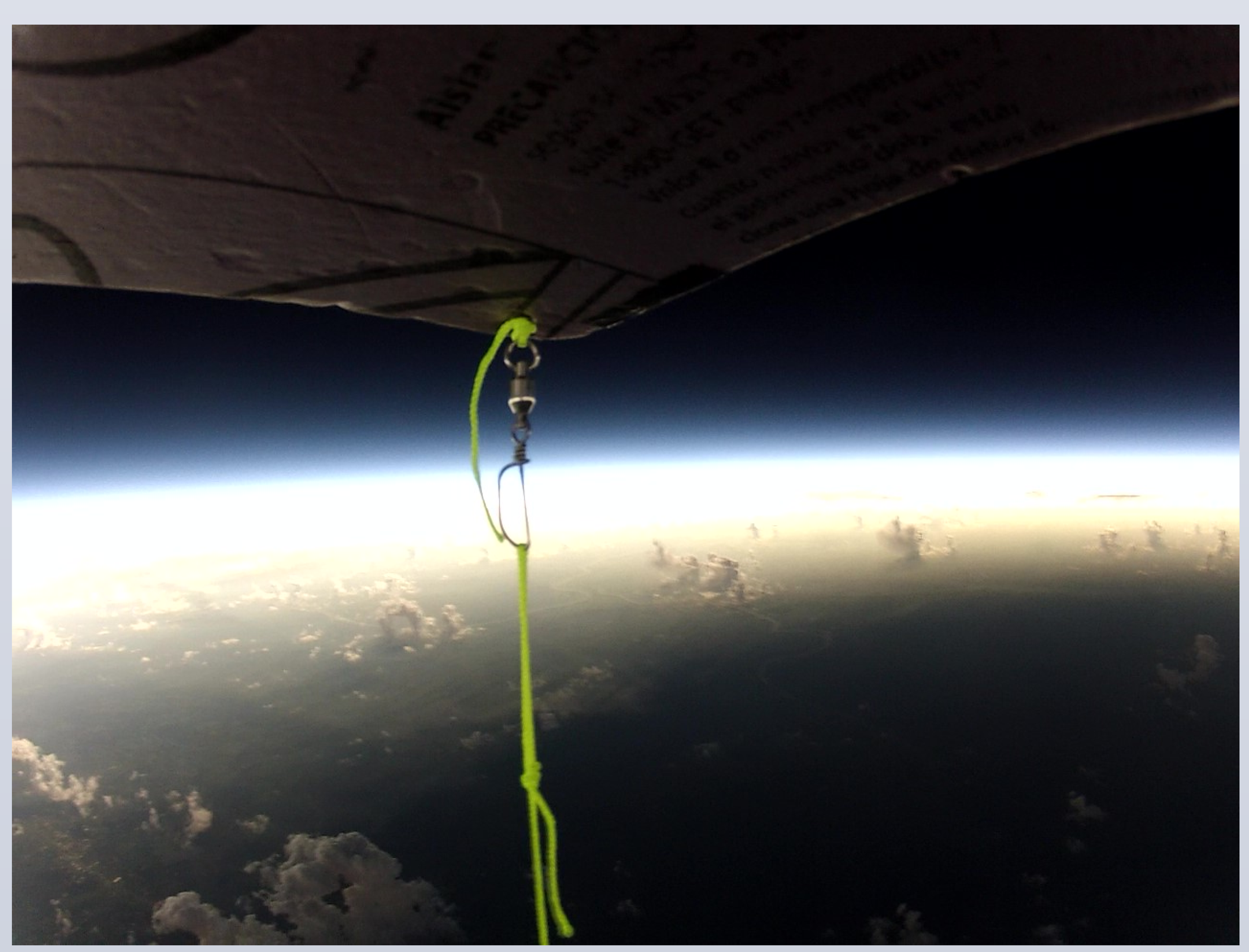
- Increased motor voltage to 12V
- Simplified power supply with jumper between Arduino Uno and motor shield



In-Flight Reset

- AHRS Module had a tendency to crash during ground testing
- Connected reset pin on AHRS to Arduino Uno to allow self-reset during flight

Results



We launched our CHAD during the 2017 Solar Eclipse from Perryville, MO. It was attached to a 1500g balloon which burst at around 100,000 ft.

- Gyroscope alone corrected high rotational speeds very well, with slight drift in position
- Connective arm successfully and reliably engaged the motor for the duration of the flight
- In-flight reset prevented any crashes, device was functioning until camera stopped during descent

Conclusion, Next Steps

Need to re-implement magnetometer for low-speed corrections

Microstepping to smooth the motor and increase precision

Mount sensors on rotating payload arm for increased accuracy

Redesign GoPro mounting arm for better camera orientation

References

Kruger, Andrew et al, "Active Heading Control Platform for Instruments Flown on High Altitude Balloons", *Proceedings of Academic High Altitude Conference*, 1–10 (2016).

Original 3D printed parts:
https://www.thingiverse.com/thing:1192277

URL for modified connective arm with set screw:
https://www.thingiverse.com/thing:2606420

Acknowledgements

Dr. Bernhard Beck-Winchatz, for his guidance as project advisor

Dr. David Jabon, for his assistance and expertise in troubleshooting, and for his assistance in redesigning the connective arm

Illinois Space Grant Consortium Higher Education Incentives Program Grant, for funding this project