Pointing Isn't Rude: A Proof-of-Concept HAB Stabilizer

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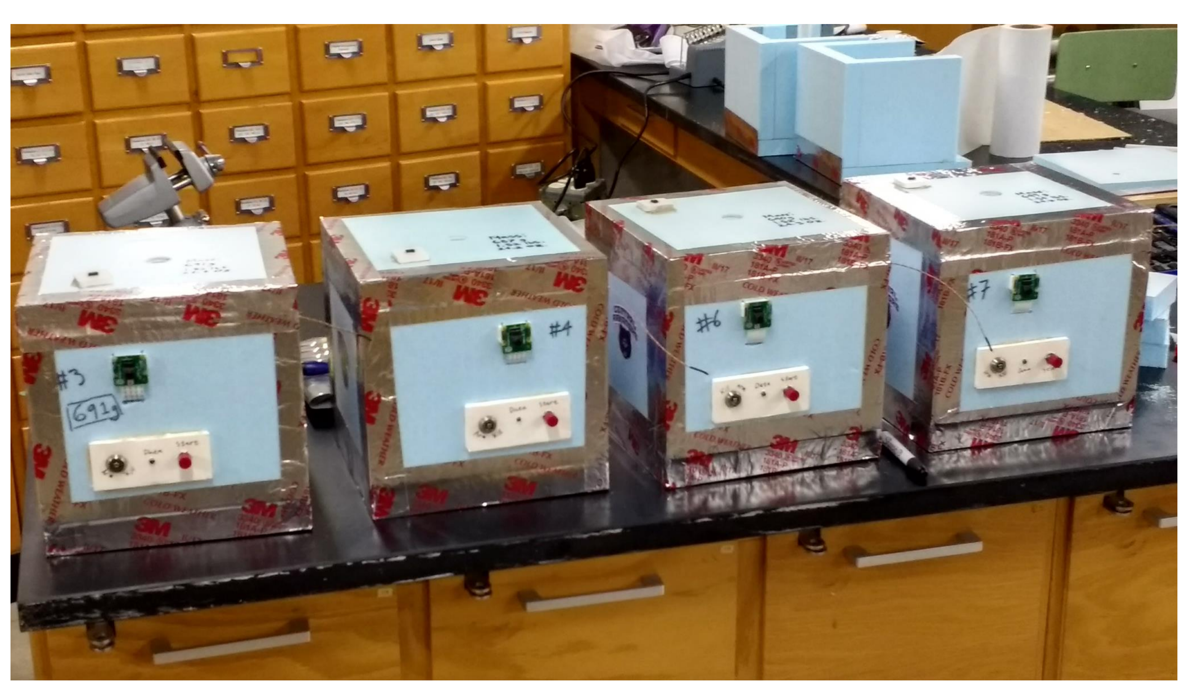
ABSTRACT

High-Altitude Balloons (HABs) are excellent platforms for research projects in physics, meteorology, engineering, and other related fields because of their low cost in comparison with other platforms that offer similar capabilities. One of the major drawbacks of HAB platforms, however, is their instability; lack of any fixed attachment point makes it practically impossible to use directional instruments in any controlled manner. While several HAB payload stabilization methods have already been developed, they all have limitations that leave something to be desired. For example, gyroscopes necessarily take up a large portion of the payload mass, leaving little room for instruments within the legal weight limits; servo motors promise low-cost, high-precision control, but it is difficult to design adequate control algorithms to compensate for the lack of stable attachment points; passive systems can be very cheap and relatively effective, but still lack precise attitude control capabilities. A method that does not appear to have been tried, however, is the use of cold-gas thrusters. This thesis details the design and construction of a proof-of-concept, cold-gas thruster, stabilization device and thoughts about the potential value of further development.

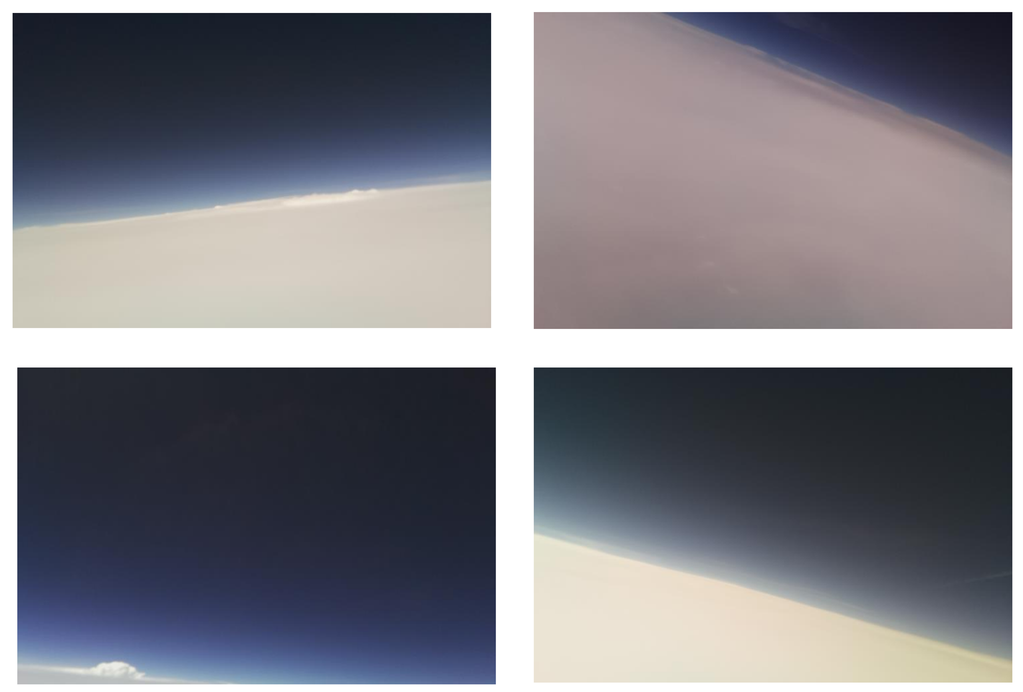
Previous Work

- One payload in 2016
- Seven payloads in 2017 (for the solar eclipse)



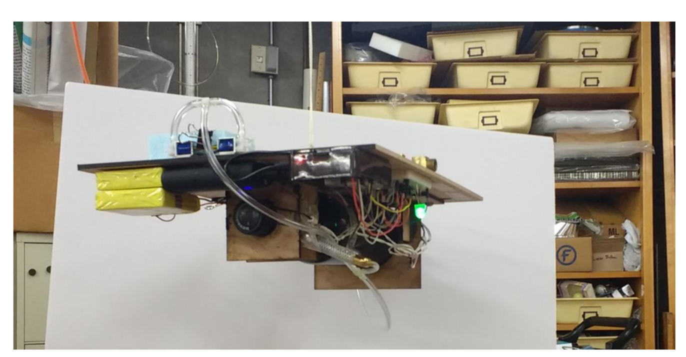
The Problem

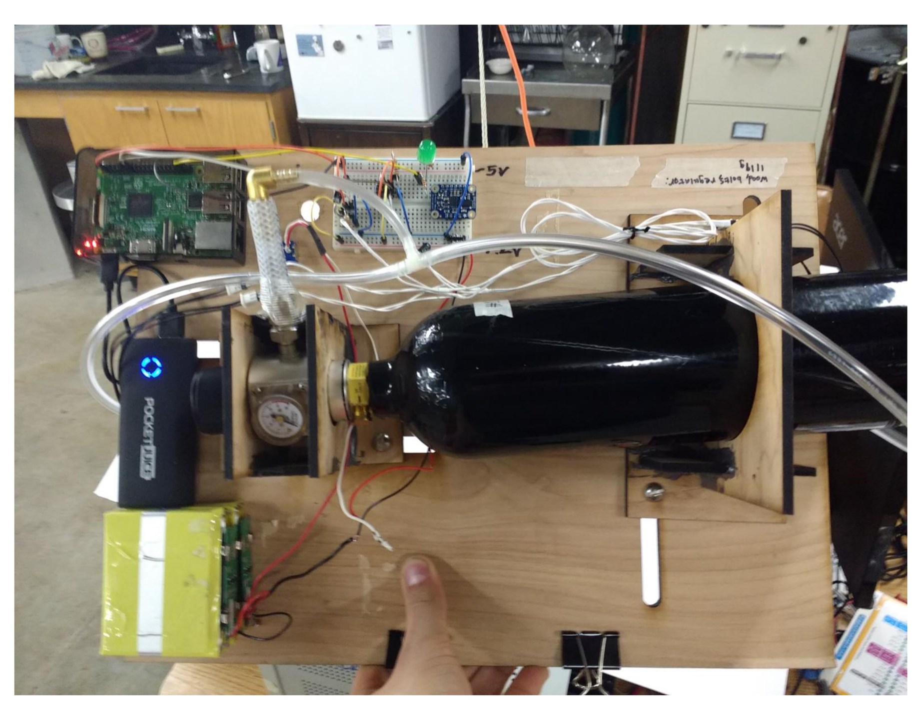
- HAB payloads are inherently unstable.
- Directional experiments can't be done.
- Other methods have had limited success.



Prototype

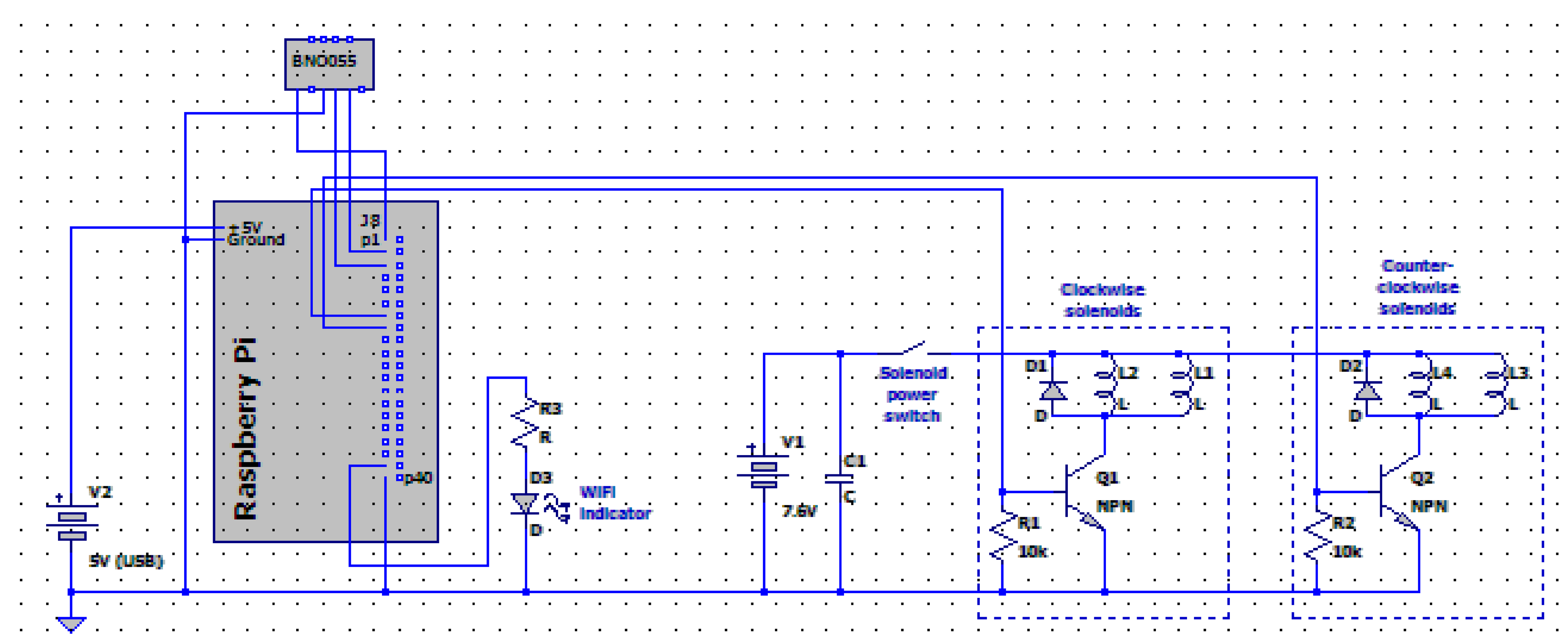
Controller Program
- Python 3
- Collects data from gyro sensor
- Decides whether or not to open a solenoid





Design

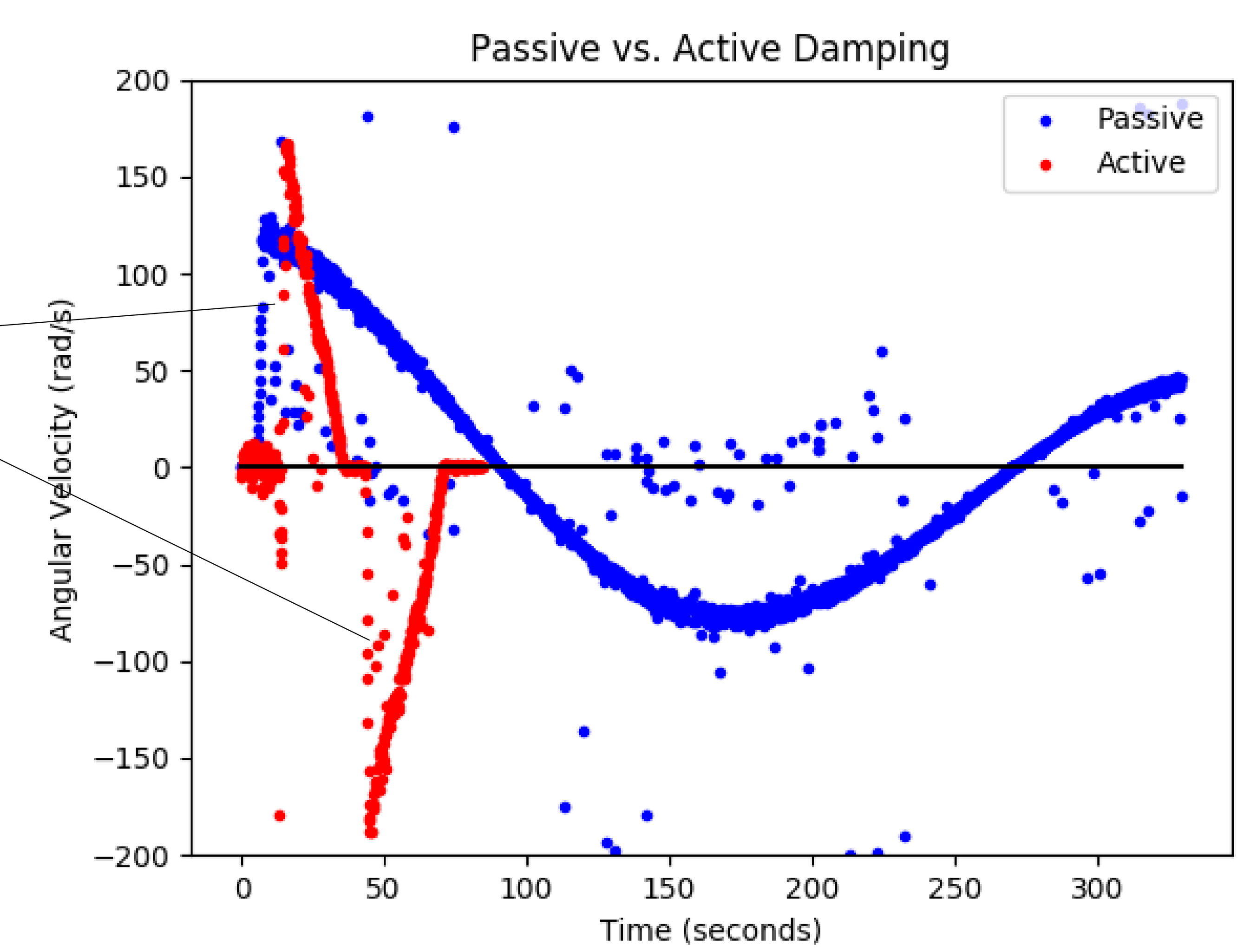
Problems
- Uses separate batteries for Raspberry Pi and solenoids, respectively. This means more weight.
- Raspberry Pi has an issue with I2C, so it doesn't really work with the BNO055.
- No way to balance current between solenoids.



Results and Conclusion

- Shows promise
- Must reduce weight
- Better solenoid valves
- Control more axes
- Different gyro sensor

Clockwise push
Counterclockwise push



Conclusion:
The passive forces acting (twisting of the string and air resistance) take far longer to dampen the motion than the active stabilization.

See a video of the device in action by scanning this QR code: