S✦N✦A✦K✦E✦

SATELLITE NAVIGATIONAL ATTITUDE KINEMATIC ENHANCEMENT

✦ AJ ROMERO ✦ HARVEY PERKINS ✦ STEPHEN KWOK-CHOON ✦

INTRODUCTION

Reaction wheels enable satellites to set and correct their orientation. This research project's goal was to design and build a reaction wheel test bed that could control its orientation and optically track objects.

PROCEDURE

1. Research and literature review
2. Development of requirements (Fig. 1)

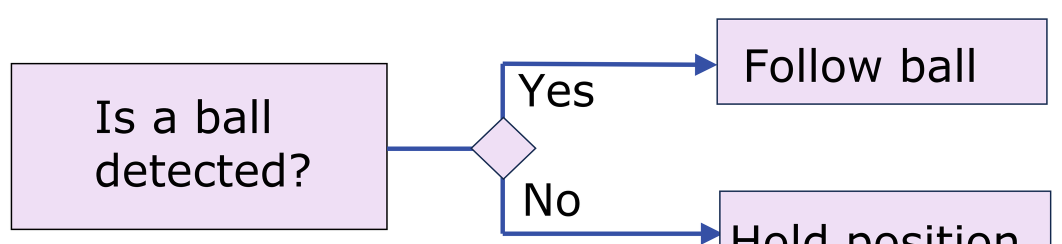

Fig. 1: System Level Decision Tree

3. Component selection and purchasing
4. Computer-Aided Design (CAD) model and electrical design
5. 3-D print and fabrication
6. Mechanical testing
7. Component testing
8. Component integration (See Fig. 5)
9. Controller implementation and tuning (Fig. 2)

Mechanical Iteration

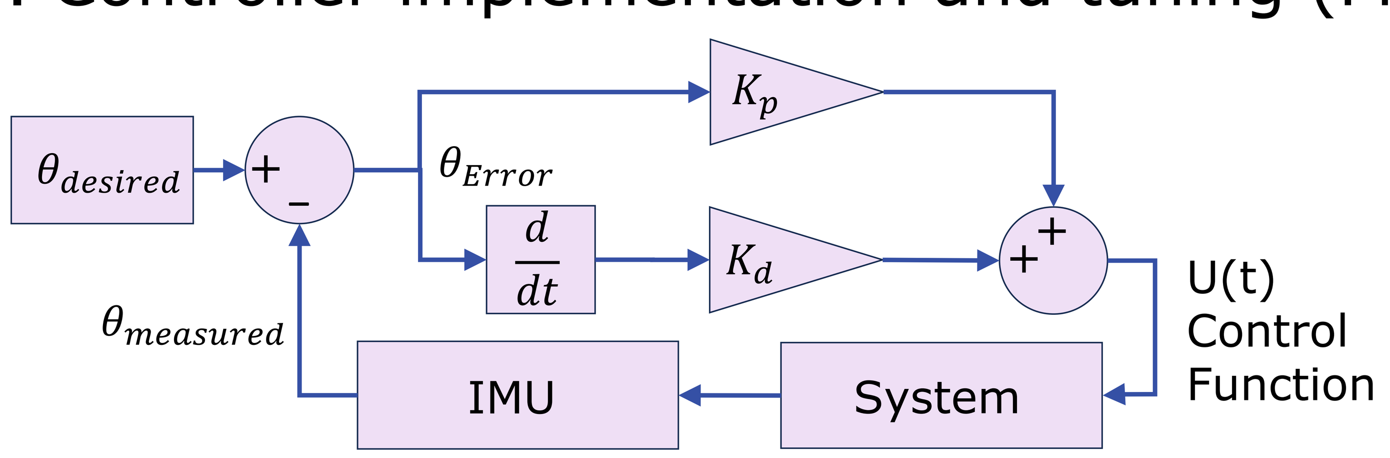

Fig. 2: Proportional Derivative (PD) Controller

Software Iteration

10. Integrated testing
11. Validation and data collection

CAL POLY
College of Engineering

RESULTS & DISCUSSION

A Proportional Derivative (PD) controller was chosen for the vehicle due to robustness and system requirements. While the controller is not optimal, it achieved satisfactory results after experimental tuning, as illustrated in Figure 3. The controller was able to rapidly drive the platform back to its original orientation after disturbance.

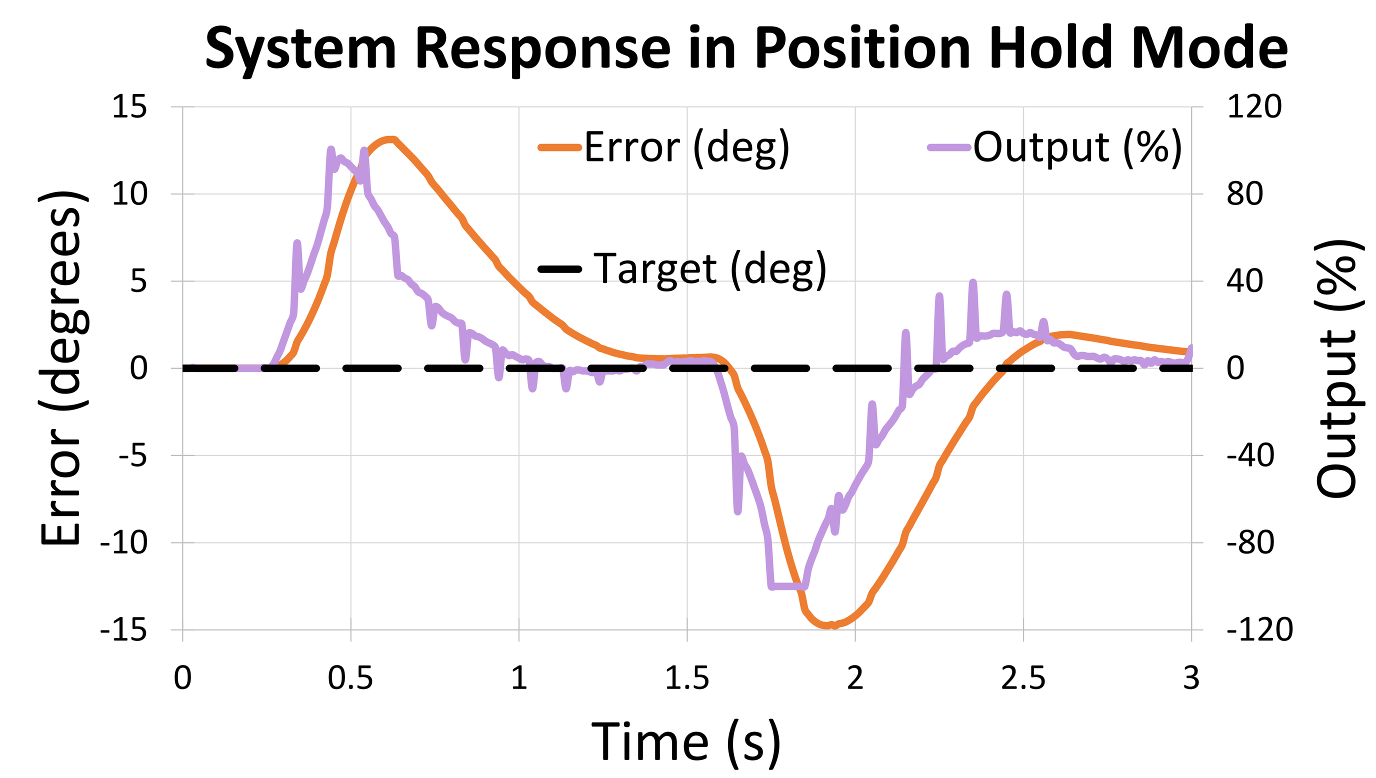

Fig. 3: Platform Orientation Control

The object tracking system was successfully able to track a tennis ball in real time (Fig. 4). This was achieved by using the vision library OpenCV [1] and works by identifying large regions of a particular color [2].

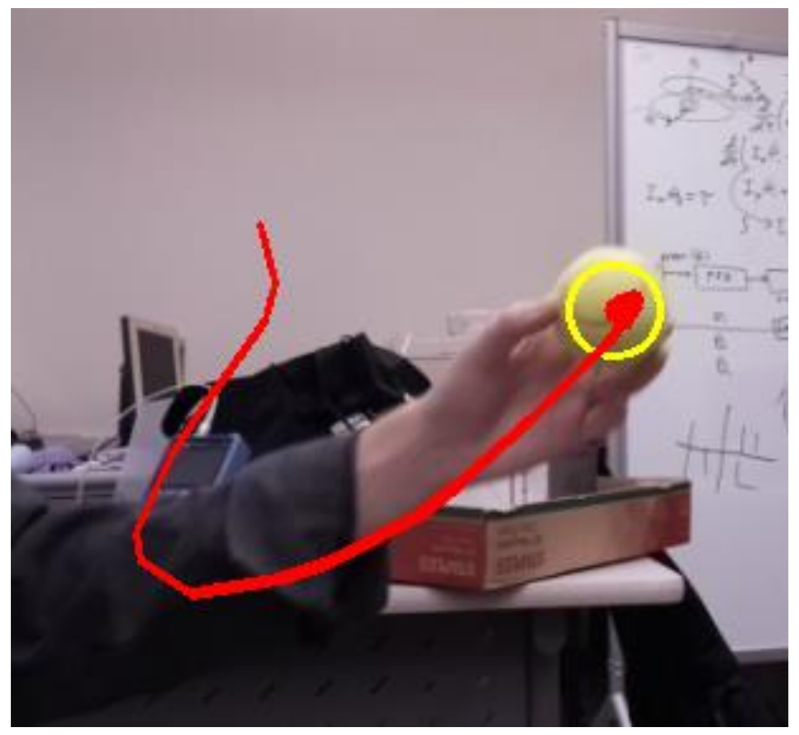

Fig. 4: Vision Tracking of Ball

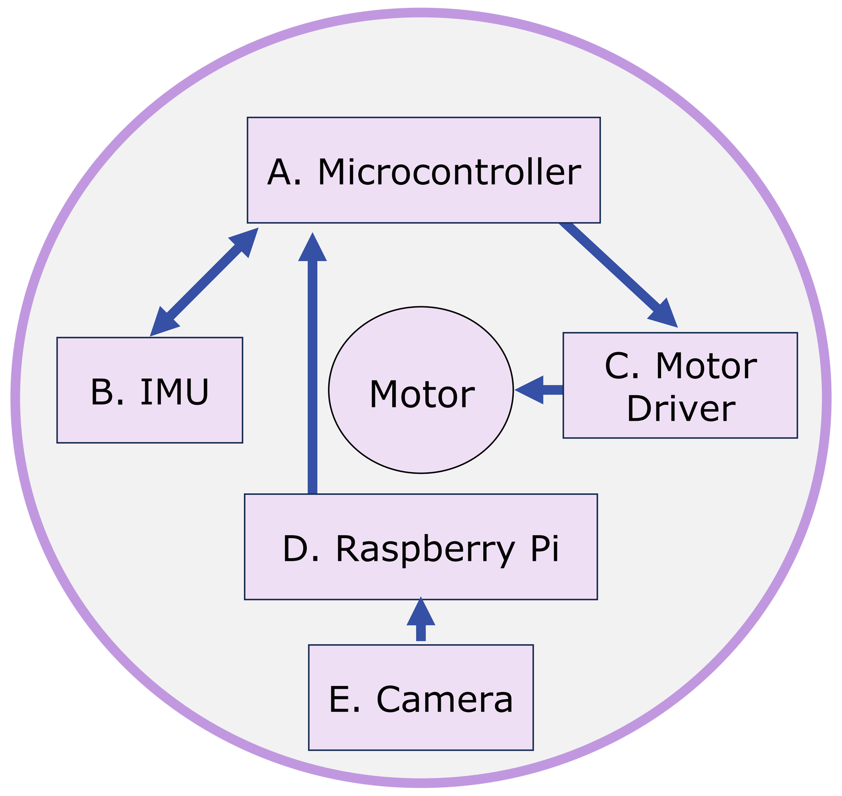

Fig. 5: System Data and Command Flow

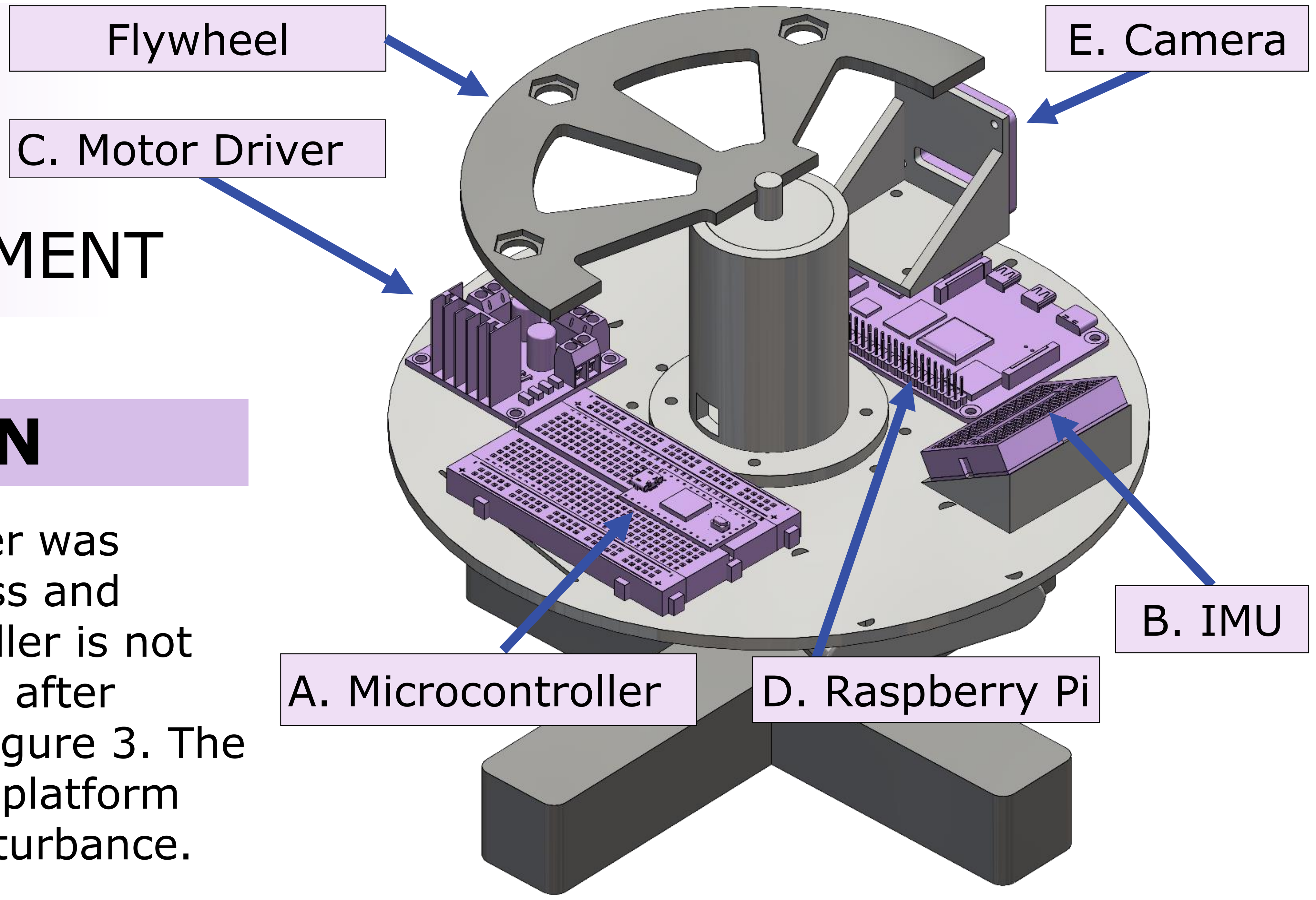

Fig. 6: Full CAD Model

The CAD model (Fig. 6) was based on prior work [3], and includes:

- Electronics (Raspberry Pi, batteries, Inertial Measurement Unit (IMU), Teensy 4.0 microcontroller, Voltage regulator, Motor controller, Pi camera)
- Base
- Satellite support (Fig. 7)
- Satellite platform
- Motor support
- Flywheel
- Camera bracket

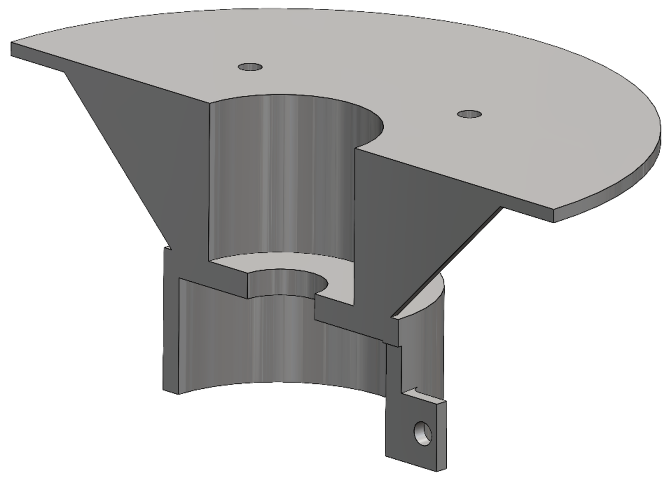

Fig. 7: Satellite Support

REFERENCES

1. *OpenCV*. OpenCV. https://opencv.org/
2. Rosebrock, Adrian. "Ball Tracking with OpenCV." *pyimagesearch.* https://pyimagesearch.com/2015/09/14/ball-tracking-with-opencv/. Accessed 7 August 2023
3. Grassin, Charles. "Reaction Wheel Attitude Control." *Charles' Lab.* https://charleslabs.fr/en/project-Reaction+Wheel+Attitude+Control. Accessed 23 July 2023.

ACKNOWLEDGEMENTS

This research was funded by Paul & Sandi Bonderson.