Optical Rotation & Imaging Observation (ORIO)

TEXAS A&M UNIVERSITY Engineering

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TEXAS A&M UNIVERSITY
ROBOTICS TEAM & LEADERSHIP EXPERIENCE

Intro & Problem Definition

Stars move across the night sky at the sidereal rate. Our planet's constant rotation and orbit are the main contributors for this movement. To take high quality images for accurate data interpretation in astrophotography, the camera will need to track these celestial objects for certain amounts of exposure time. This project focuses on designing and building a 3D printed equatorial mount that attaches to a tripod to aid in tracking celestial objects.

Approach & Methods

The design process that the team adopted a bottom up design, with research into what mechanisms to use for the controlled movements. The intention of the design was to ensure portability and ease of assembly.

Design Requirements

- Two manual mechanisms for alt-az movements in polar alignment
- Two motorized systems, belt and planetary gearboxes, for rotations about celestial coordinates
- Meant to be cheap while utilizing additive manufacturing and commercial fasteners
- Ensure load bearing capabilities for camera + lens

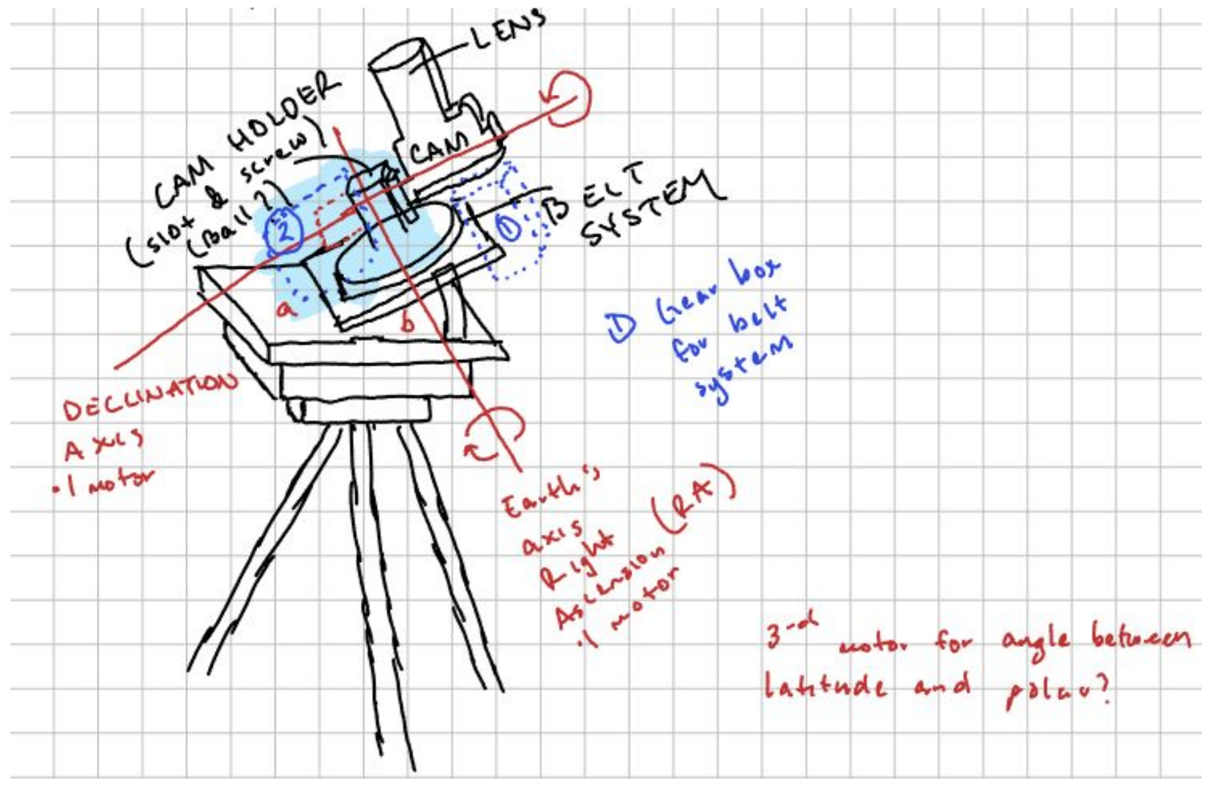

Figure 1: *The initial design sketch*

Cycloidal Drive vs Planetary Gearbox

We initially considered designing with Cycloidal Drives, and moved forward with modeling.

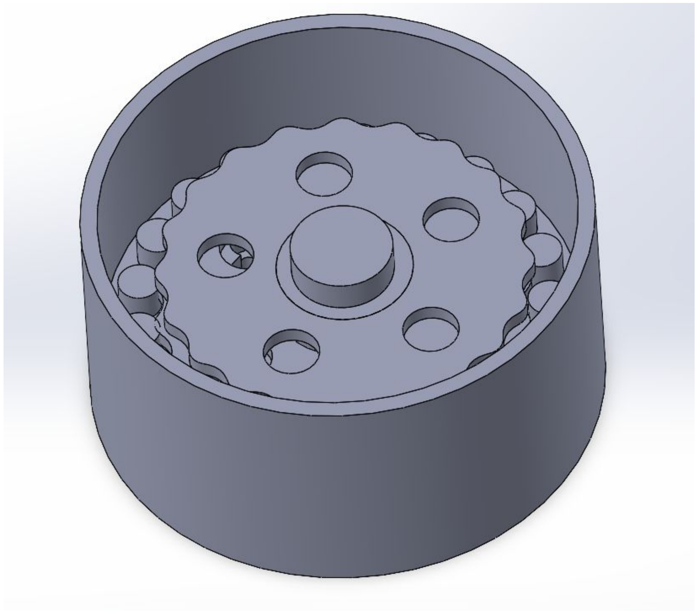

Figure 2: *The cycloidal drive assembly*

To have a functional belt system, planetary gearboxes were also considered using a NEMA 17 29 Ncm motor for rotation of the polar and right ascension axises.

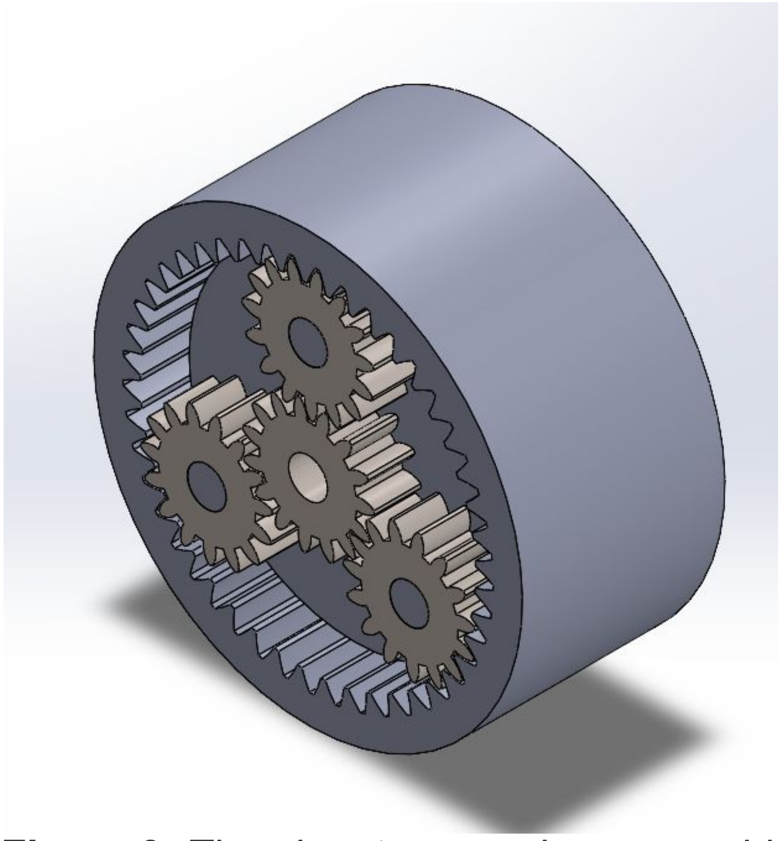

Figure 3: *The planetary gearbox assembly*

To reduce the force on a single gear, we planned on stacking planetary gear systems that will drive the belt pulleys. This method proved more beneficial than the cycloidal drives.

Upon further review, we decided to move forward with the cycloidal drive design to utilize their stability regarding backlash, the gaps between our mated parts. This allows for smooth movement, which is imperative for tracking.

Software

Currently in development is the controller for the ORIO equatorial mount. Using the ESP32's wifi connectivity, the mount will be able to access a web server built using JavaScript, CSS, and HTML.

The JavaScript allows communication between the web server and the ESP32, allowing the microcontroller to read inputs from the controller and use it to control the various motors.

For tracking of objects closer to Earth, data from JPL's Horizon project will have to be downloaded, parsed, and integrated into controls.

Electrical & Control

The equatorial mount moves along two degrees of freedom, each controlled by a stepper motor and its respective driver. Commands received from the web server by the ESP32 are sent to the stepper motor drivers and subsequently to the stepper motors themselves. Once commands are issued, no more controls are required and the mount will automatically track the celestial object that has been designated while moving at the same rate as the object. For now, stepper motors are setup in open-loop configuration.

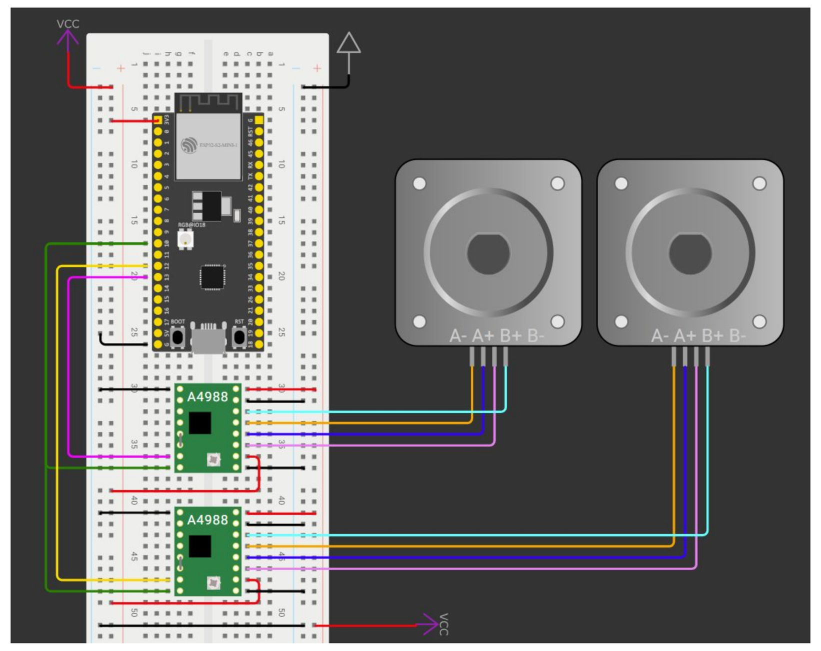

Figure 4. Wiring Diagram of System

The final setup of controls may have the stepper motors setup in a closed loop configuration to reduce drift in longer exposures. Depending on the processing power of our microcontrollers, guiding may also be implemented to further reduce error.

Next Steps

In the coming semester, our team plans to continue improving our project by:

- **Coordinate Movement:** Ensure adjustable mechanism for polar alignment and design a secure way to rotate about celestial coordinates.
- **Manufacturing & Materials:** 3D print the mount casings and base, laser cut gear systems out of wood, and purchase fasteners for complete assembly.
- **Software & Electronics:** Confirm the communication between controller, driver, motors, and mechanical systems for smooth movements with no backlash.
- **Prototype Testing:** Print out mechanical system components to test assembly compatibility, backlash, load bearing capabilities, and tracking.

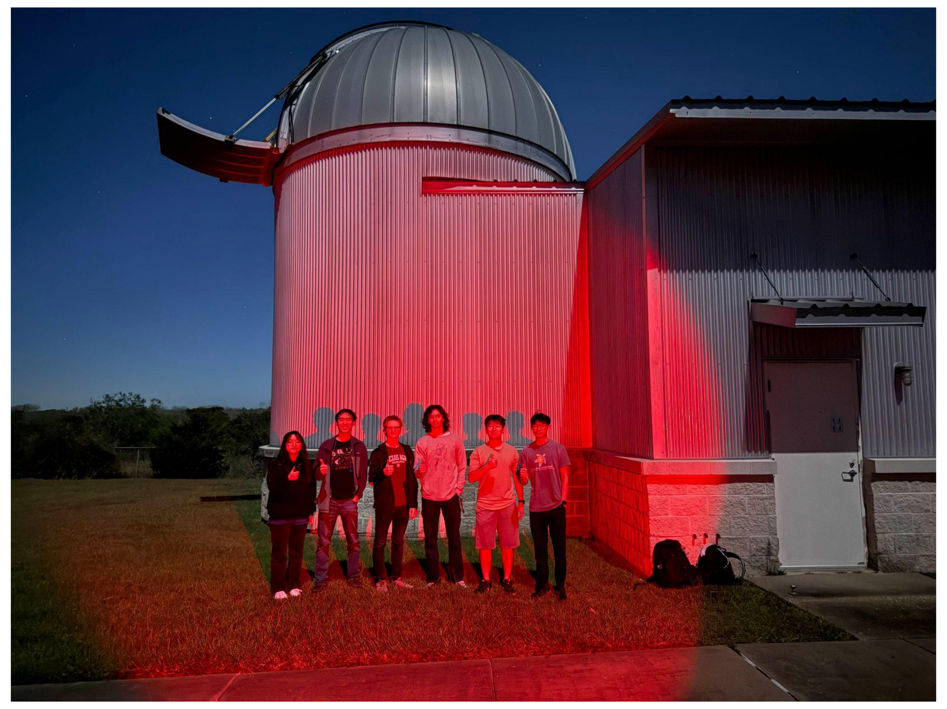

Figure 5: *ORIO at TAMU Observatory!*

This project is in collaboration with the Munnerlyn Astronomical Instrumentation Lab, through which we receive insight on how optical systems are controlled.

Documentation

In the interest of keeping our project accessible, our GitHub is linked in the below QR code