Automatic Antenna Rotor

Berkeley | EECS
Electrical Engineering and Computer Sciences

EECS 149/249A - **2023**

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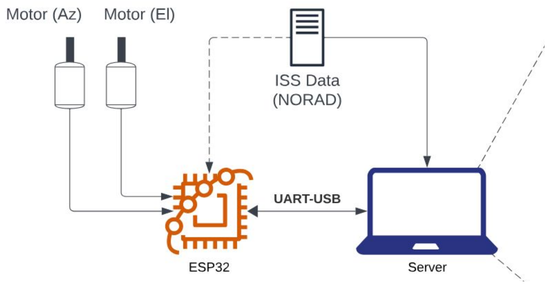
Motivation

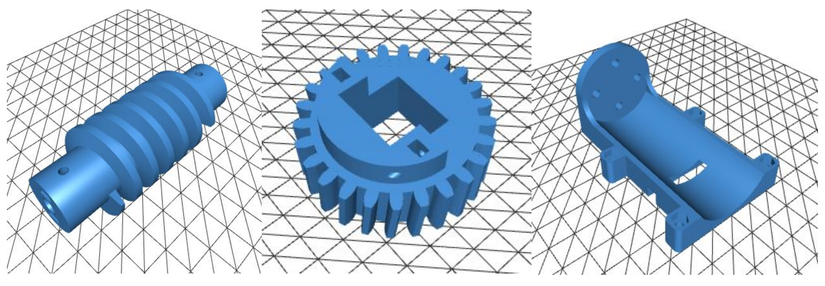
Making radio contact with satellites can be a difficult task that can be made easier through automation. We aim to build an azimuth/elevation antenna rotor that is able to automatically point towards an arbitrary satellite.

Hardware

We use 2 high-torque DC motors and magnetic absolute position encoders for the azimuth/elevation axes, an ESP32 MCU, and GPS for location and time sync data. Most parts have been custom fabricated with 3D printing and laser cutting.



General block diagram for hardware setup

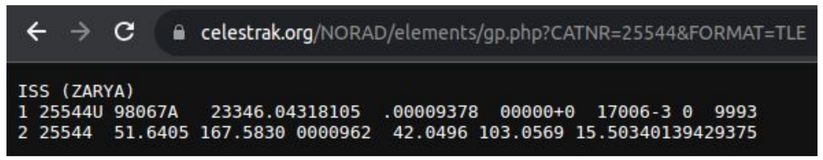


Some of our component designs (worm gear and motor mount)

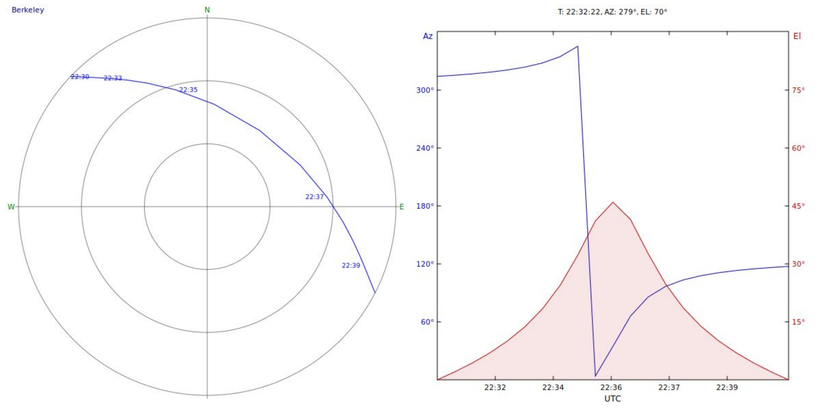
Core az/el mechanism and encoder test-fit

Trajectory Calculation

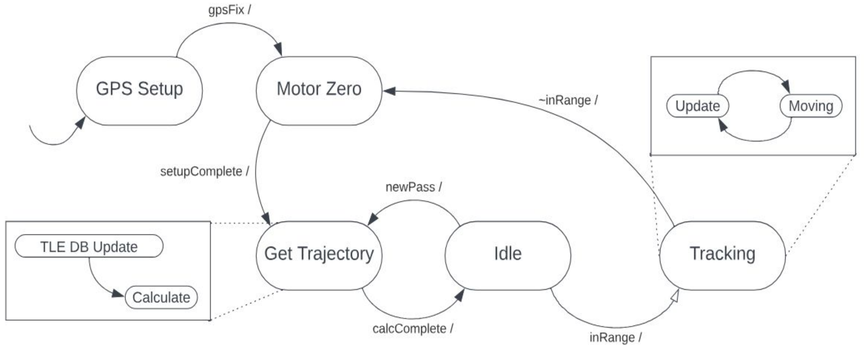
NORAD (North American Aerospace Defense Command) regularly publishes TLE (Two-Line Element) data for major satellites, which describes the current orbital state of the satellite. We can feed this data into the SGP4 (Simplified General Perturbations) model to calculate the trajectory of the satellite with reasonable accuracy ±1 week. The prediction is done on-board (ESP32).



Example TLE data API query (CelesTrak API)

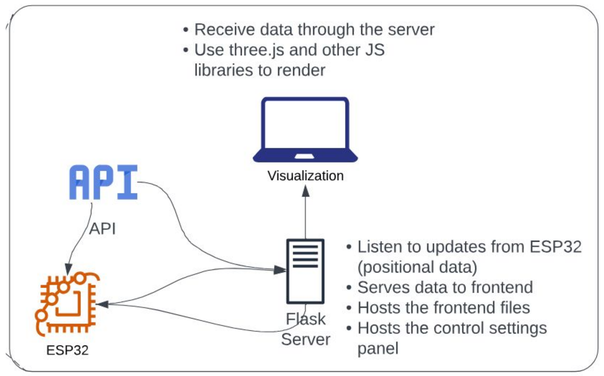


Example polar and az/el graphs generated by an open source tracking program (gpredict)



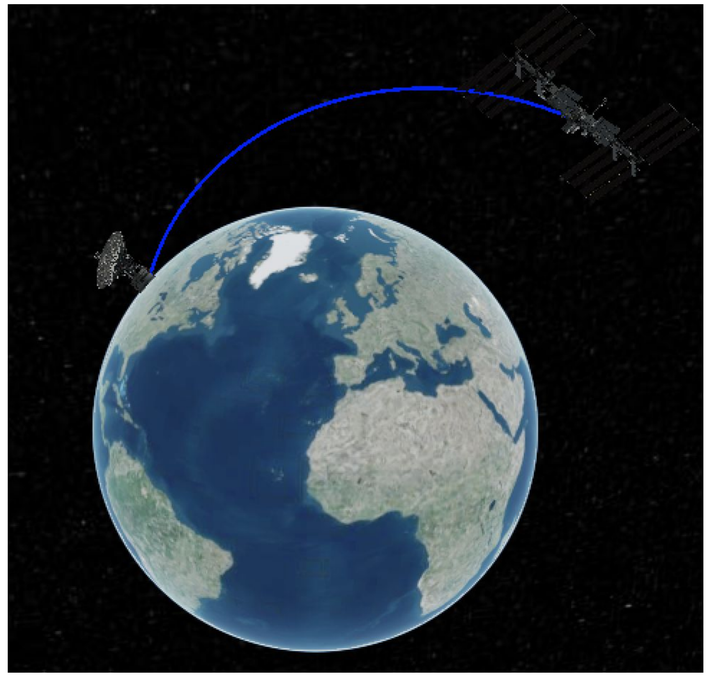
Our general control / prediction logic state machine

Visualization



General block diagram for our visualization / server stack

We used CesiumJS for the interactive and real time visualization interface. We get user longitude and latitude, as well as the ISS longitude, latitude, az/el data from our flask server. Though the real ISS orbits at an altitude of approx. 400 km, we adjusted the altitude while enlarging the ISS as well as the antenna for usability. We highlight the path from the antenna to the ISS to help visualize what the antenna is doing.



Our visualization interface