Optical Imaging, Object Tracking, and Motion Control Using a Snapdragon Single Board Computer on a CubeSat

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ABSTRACT

CubeSat constellation flight can facilitate space quantum link experiment and multi-view space observations. Optical imaging, object tracking, and motion control are critical in CubeSat constellation formation and operation as well as Rendezvous Proximity Operations (RPO) and release / reassembly among CubeSats. These complex optical sensing and operations require substantial computing power onboard the CubeSat.

We have adopted a NASA-suggested Snapdragon Single Board Computer (SBC). We have identified and a matched camera. The system is running under Android operating system, allowing use of a variety of available software and hardware. In addition, an LED-based LiDAR was selected to measure the distance between CubeSats for more accurate RPO and release / reassembly operations. We have used a 3D printer to build a new prototype CubeSat to accommodate the SBC and all sensors.

For experimental demonstration, we mounted the CubeSat on our motorized 6-degree-of-freedom CubeSat test platform developed earlier in our lab. Another CubeSat is suspended on our microgravity test platform and set into swing motions. We successfully demonstrated high resolution optical imaging using the Snapdragon SBC and the onboard camera. We further demonstrated both angular and linear motion tracking of the swing object.

We have made important progresses in developing CubeSat constellation flight, space quantum links, and multi-view space observations.

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PROJECT GOALS

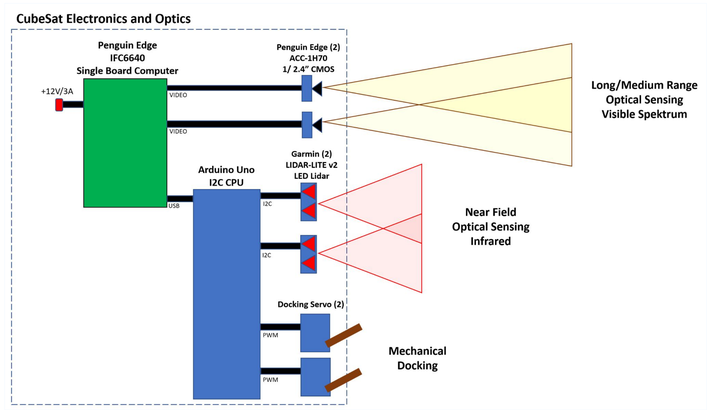
- Utilize only Commercial Off-The-Shelf (COTS) Components
- Rely solely on IFC6640 Single Board Computer (SBC) for data processing
  - Optical imaging
  - Object tracking
  - Motion control
- Fit optical system to meet 1U requirements (10cm x 10cm x 10cm)

COMPONENTS

- Penguin Solutions IFC6640 SBC
- Penguin Solutions ACC-1H70 Camera Modules
- Garmin LIDAR-LITE v4 LED
- Arduino UNO REV3

METHODOLOGY

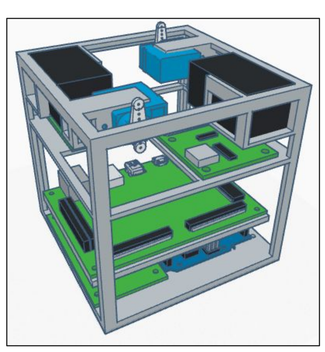
A simple PCB was constructed to run power and signal to the docking motors and LIDAR modules to the same location, limiting the number of wires and points of connection required within the CubeSat. The pushbutton to test the motors is simply to check proper motor function. Engagement of the docking system is contained within the same code to run the two LIDAR modules. The ACC-1H70 camera modules are connected to the IFC6640 with 41-pin ribbon cables supplied by the manufacturer.

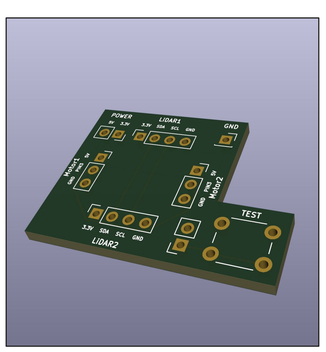


For testing and ease of application, the motors and LIDAR modules are currently connected to an Arduino, with the LIDAR verifying and supporting data collected from the camera modules.

The IFC6640 came from the manufacturer with the Android 4 operating system, however preliminary testing proved this system to be limited and insufficient. Android 9 was flashed onto the board for programming, enabling the construction and downloading of programs required for the CubeSat's optical sensing capabilities, including the software necessary for the CubeSat to communicate with the gimbal to perform object tracking in its current state.

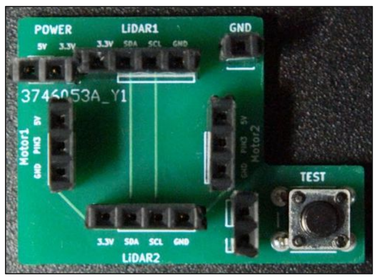
While initially testing the SBCs ability to perform object tracking via connection to the Gimbal stabilizer, it was found that the system required a nearly complete CubeSat chassis to be sturdy enough for accurate data acquisition. To combat this, a preliminary chassis design was developed to contain each of the optical system's components for testing purposes.



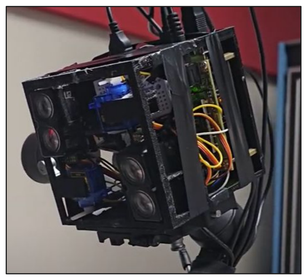


** Design solely for testing purposes.

RESULTS

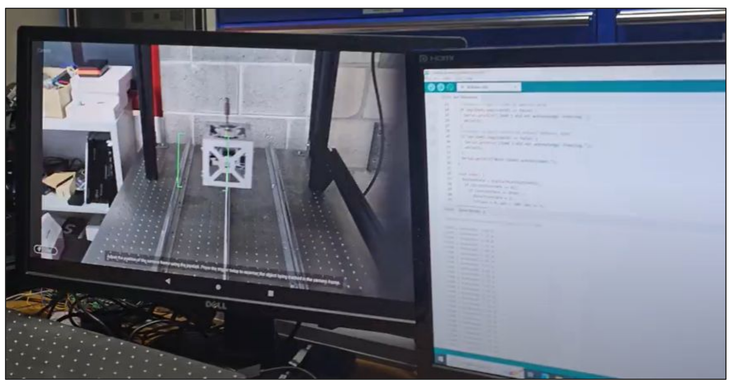


PCB for LIDAR and servo motor connections



Close-up of optical system in 3D printed cube

Pictured above is the setup of the CubeSat mounted on the gimbal. Below displays the tracking software (left) and the LIDAR readings (right).



CONCLUSIONS

The IFC6640 is a powerful SBC that is more than capable of performing optical sensing. Experimental successes in optical imaging, object tracking, and motion control prove the IFC6640 to be a viable option to supply the processing power necessary for safe and successful Rendezvous Proximity Operations, and docking / undocking procedures. Use of single board computers in CubeSat applications will prove vital in continuing research developments.

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