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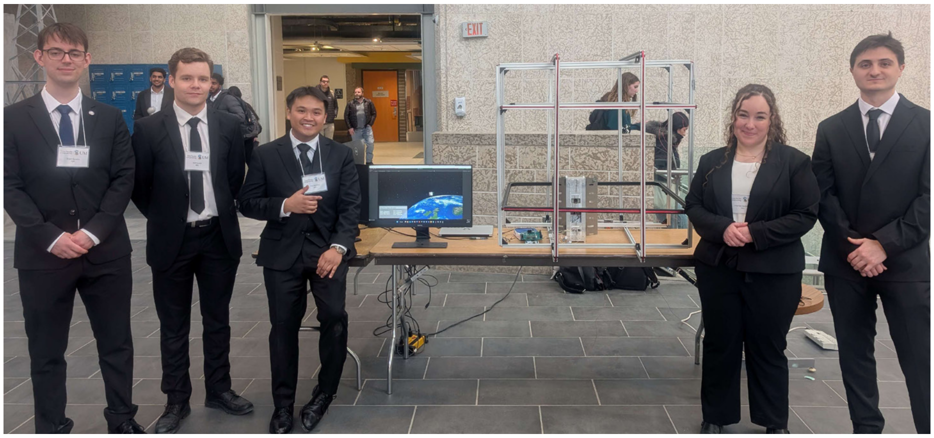
Design and Implementation of a Real-Time Space Environment Simulator for CubeSat Verification



When designing mission-critical systems to send to space, how can you be sure that everything will function exactly as intended?

Verification is a crucial aspect of a satellite project, providing confidence in a complex system, especially for satellites where physical access to hardware is impossible after deployment. However, proper methods can be out of reach for small teams and research groups developing CubeSats, which are often limited in time and funding. Making CubeSat verification more approachable was then decided by the team as a suitable capstone project, bringing to life the Real-Time Space Environment Simulator for CubeSat Verification.

The system consists of four modules: a space simulation model, an interface board (for connecting the simulator to the CubeSat), an Earth magnetic field emulator (to create a dynamic, physical magnetic field similar to the field felt in space) and a graphical user interface (allowing the user to monitor the CubeSat using live plots and a 3D visualization of the satellite in space). Additionally, the team created a pair of detumbling and pointing algorithms (used by a CubeSat to adjust its orientation in space) to test the effectiveness of the overall system.

Each module works together to produce a testing system capable of emulating a satellite's sensor readings and responding to any resulting actuation using a mix of simulated data and emulated magnetic fields. The system effectively makes the satellite believe it is in space. In this state, several orbital scenarios can be emulated to verify the proper functionality of the satellite's hardware and software, such as reducing spin induced by deployment (detumbling) and adjusting the satellite's orientation. During these scenarios, the user can concurrently monitor the satellite's response in real-time using a series of live plots and a 3D visualization of the satellite's current orbital position and attitude.

The system successfully verified the detumbling and pointing algorithms created during the project while running on the UMSATS's TSAT-6 CubeSat for over four hours. Accelerated testing done purely inside the simulator allowed for algorithm verification to be performed several times faster.

Future considerations for the simulator include facilitating testing to verify that a CubeSat's solar panel and battery configuration will power it during an orbital mission. The University of Manitoba's STARLab and UMSATS research groups are currently collaborating with the team to integrate their ongoing CubeSat projects into the simulator and verify their functionality, proving to be an invaluable tool for CubeSat testing.