Tiny VRSE
(Virtual Reality Space Experience)

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Abstract

Capturing 360° and VR footage in space during student missions reduces the barrier to entry for those seeking to explore these technology applications. This project is the continuation of a NASA funded rocket integrated payload project for RockSat-X 2020. By recreating a smaller version of the team’s RockSat-X payload for this High-Altitude Balloon platform we can test the viability and accessibility of this design and its technology for small affordable student projects, as well as the viability of the RockSat - X 2020 Mission objectives. The payload consists of a mini 360° camera which is extended beyond the payload and captures footage of the flight. The programmable boom arm is fully 3D printed in PLA and controlled by consumer microcontroller and prebuilt sensor components. The footage will be compiled with the RockSat-X 2020 mission footage and previous DemoSat Fall 2019 Mission footage to be incorporated in a VIVE VR experience. Additionally, the video will be utilized by institutions for STEM education outreach and the technology can be used to develop viable industry methods and standards.

1. Introduction

This paper describes Tiny VRSE (Virtual Reality Space Experience) the ongoing DemoSat Spring 2020 Project, and the second DemoSat project used by Red Rocks Community College as a testing ground for the CCofCO RockSat-X 2019-2020 team. This project enables students to comparatively study and prepare systems in a high-altitude situation before the final flight of their payload on an Improved Terrier Malamute rocket through NASA Wallops Flight Facility in the Summer of 2020.

1.1 Background

During the Fall 2019 initial formation of the current CCofCO RockSat-X team, NASA Goddard Spaceflight Center negotiated an offer to sponsor the team to launch a extendable and retractable 360° video camera aboard the 2019-2020 Mission. The team is comprised of students from both the Red Rocks and Arapahoe Community Colleges. This year-long mission was broken down into researchable segments where the team could test its proposed designs and hypotheses using different COSGC (Colorado Space Grant Consortium) projects. By challenging the design, we hope novel problem solutions will emerge through the process of analysis and discovery. Not only will these developed technologies help to train the team members as future engineers in a variety of STEM fields, however it will enhance the space community with a clearer vantage point of the new techniques that can be used to give students and participating public citizens easier access to the experience of scientific progress and the space environment.

1.2 Theory and Hypothesis

Tiny VRSE is a miniaturized version of the RockSat-X mission payload. It is challenged with being designed to be more compact, portable, lightweight, and cost effective than its larger counterpart. The design is comprised of miniaturized mechanisms, a majority of 3D printed components, miniature consumer microcontroller
boards and sensors all within an approximately 400-gram 7 x 7-inch payload. The payload carries within it a system that can extend a scissor arm from inside, out into the high-altitude environment, while recording both regular internal and 360° external video footage and collecting environmental data. The payload is minimized from an aluminum milled system comprised of parts nearing 14lbs in weight with an in-magnitudes much higher budget requirement than approximately $300.00. The system was challenging to design to meet all of the required specifications however it enabled students to look at the scope of the rocket payload design and add features to both that have enhanced the performance of each system and has shown that the technology can become more cost effective and portable than previously considered using other methods.

2. Methods

The payload extends a MADV Mini 360° into the environment at approximately 1,000 ft in altitude. The cameras and sensors begin recording and taking data when powered on during string set-up. The camera can be programmed to retract when the balloon reaches a set lower altitude than is average during the DemoSat B style flight. This ensures that the retraction will occur prior to touch down. On-board sensors such as a distance meter will convey the retraction or extension to the system, and report data to the micro SD on a Raspberry Pi. Other sensors listed in 2.1 Materials will collect internal payload and external atmospheric environment data. Testing this specific 360° camera for cold resilience and viability in complex or sporting applications will help promote its use in further projects. The camera records in pre-programmed intervals that are stored on a large capacity (400G) ultra-fast streamlined SD card. The footage will be used to create a VR experience comprised of DemoSat Fall 2019 footage from Gram Kersey’s team at the Community College of Denver., RRCC DemoSat Spring 2020 footage, and CCofCO RockSat-X 2019-2020 footage, and will include an interactive 3D Model of the rocket payload.

2.1 Participants

Our partnerships include advisors and staff at COSGC including the director Chris Khoeler, Assistant Director Bernadette Garcia, Corey Huffman, and many other supporting staff. Our sponsorship comes through NASA Goddard Spaceflight Center and NASA Wallops Flight Facility who is also manufacturing payload components. The team has made many collegiate institutions and student collaborative partnerships. The student-driven team is comprised of students from both Red Rocks Community College and Arapahoe Community College making up the Community Colleges of Colorado (CCofCO) team. Advisement from those institutions comes from Barbra Sobhani, the RRCC Trefny Honors Program Director, and Jennifer Jones the ACC Astronomy Program Chair. Student collaboration includes partnerships with Stacey Barbarick from the 2018-2019 RockSat-X team at RRCC, and Graham Kersey from the Community College of Denver DemoSat 2019 team lead by Dr. Joel Thompson, and Bri Trefner the team-lead from the Colorado School of Mines Rocksat-X team this year.

2.1 Materials

The team will print the entirety of the designed Scissor Arm system in cost effective PLA. The system is controlled by consumer microcontrollers and sensors including: a Raspberry Pi Zero, which controls the noir Camera System, a CMX219 Raspberry Pi Camera V.2 Noir; a Raspberry Pi 4 Model B or Arduino Uno to control the MADV Mini System, which will be connected to the larger microcontroller via USB connection. The operating system is Raspbian - Lite on the Pi Zero and Lineage OS with Android App compatibility specifically ARM6 compatibility for running the 360° app on the Pi 4. The step motor system controls a linear actuator rail system, with a pre-built-in motor controlled by the Pi 4 via an Adafruit TB6612FNG stepper motor break out board. A VL53L0X Adafruit Time-of-Flight Distance Sensor detects the distance of the arm extension and retraction and stores the data on the Pi 4. A BME680 Barometric Pressure and Humidity Sensor acts as an accurate altimeter and controls the timing of extension and retraction while collecting external data. An ML8511 UV Sensor will collect external radiation data and a HTU21DF temperature sensor will collect internal humidity and temperature data. An ADXL335 Tri Axis Accelerometer will record flight speeds. A cold-proofed Energizer Lithium Ion Battery Pack and power toggles connected to LM2596 DC-DC Buck/Step Down converter units that give power to the system.

2.2 Procedures

The cameras begin recording during string set-up before lift-off. The arm extends through an aluminum flap just at lift-off completion. Data is recorded throughout the flight. Should the balloon lower sufficiently during flight the altimeter will trip the condition to retract the arm, however the altitude is sufficiently low enough it should avoid this prior to touch-down. The program includes safety cut-offs for extreme humidity issues near the back enclosed electrical systems compartment, which is separate from the open flap section. The program also includes cut-offs for power surges or voltage irregularity.
to mitigate electrical damage or attempt to hold the arm in a retracted position and preserve the camera. The boom arm is also programmed to retract upon a certain reduction of voltage supplied to prevent failure of retraction before complete power loss. Data are stored on the high-speed micro SD of each Pi. If the Arduino UNO R3 is used it will require an external SD device which uses an I2C Real-Time Clock Module and micro SD Card Adapter, however this is a contingency for issues that may arise through further testing.

2.3 Design and Analysis

The printed parts were developed in CAD and will soon be printed in PLA and integrated with the rest of the payload. The design will be tested for temperature, humidity, and overall resilience to expected conditions. The payload will also be tested using the recommended COSGC tests. Data accuracy testing and Camera record rate are imperative to the success of the primary goal of the payload to collect footage, therefore this will be largely focused upon in electronics and program testing. Camera power efficiency and system battery draw rate will be closely monitored and calculated for duration efficacy. The angles and positions for the field of views of both cameras will be analyzed and tweaked as necessary to gather footage of the desired viewpoints.

3. Progression

The parts are ready to be printed and constructed from CAD drawings. The electronics are assembled and being tested for general operations. The housing is awaiting full assembly with printed parts. The system is scheduled to be launched in Summer 2020.

4. Conclusion

Tiny VRSE will challenge students to rework their designs to meet weight and size constraints, comparative high-altitude and sub-orbital environmental physics and weather will further challenge the designs and encourage new thinking in developing camera-arm systems for atmospheric and space footage collection. Virtual reality footage and experiences help spur and encourage student and public participation in atmospheric and space sciences. Student projects like Tiny VRSE enhance the way the industry looks at the portability and cost efficacy of video and virtual experience creation. Decreasing costs with increasing capabilities brings projects of this caliber and space right to our fingertips.

5. Acknowledgments

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