Virtual Reality in space: The next frontier for space exploration

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INTRODUCTION

Recent developments in Virtual Reality (VR) allow for low-cost remote presence: the feeling of actually being present in another place with high quality 360 degree 3D stereoscopic viewing. This opens up possibilities for anyone to experience and engage in space flights. Meanwhile, that same visual data can be used for operations requiring high precision spacial data and for 3D model reconstruction. The introduction of small, low-power embedded systems with GPU computing makes high-performance real-time artificial intelligence (AI) processing in space possible. We propose to combine these two systems (VR and AI) together to enable remote presence along with localized mission critical analysis and decision making.

MISSION GOALS

The first mission goals are to validate the hardware and software of the VR subsystem for use in space, and to capture, encode, and transmit an image of the International Space Station (ISS) from which the CubeSat is deployed. A 6U CubeSat, the TechEdSat8 is part of an ongoing series of launches which includes an Exo-Brake system as non-propulsive means of de-orbiting small payloads from orbital platforms. In alter flights, we envision ways the VR subsystem can aid with real-time visual analysis of the Exo-Brake.

IMPLEMENTATION

Hardware:
- Nvidia Jetson TX2
- Connect Tech Orbitty Orbiter carrier board
- Leopard Imaging stereoscopic camera

Software:
- GNU/Linux operating system using Ubuntu version 14
- FFMPEG (for video capture and transcoding)
- Perl (for batch processing)

JETSON TX2 SPECS

System on a Chip (SoC): Nvidia Tegra X2 “Parker”
CPU: 4x ARM Cortex A57 + Nvidia Denver2 (dual-core and 2Ghz hexa-core)
GPU: Nvidia Pascal (256 cores, 1300Mhz)
RAM size: 8GB
Built-in RAM: YES
Internal storage: 32GB
SD card: Other slot type Max size: 128GB
PROS: Allows buffering raw, uncompressed HD video Real-time encoding and complex AI capabilities
CONS: Nominal 9V required

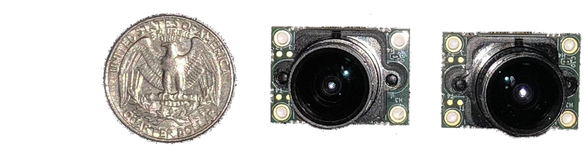
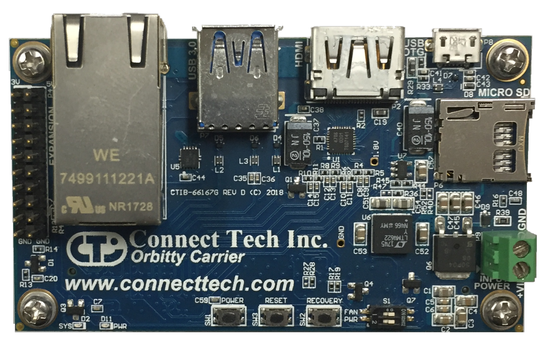


Image source: http://connecttech.com/product/orbitty-carrier-for-nvidia-jetson-tx2-tx1/



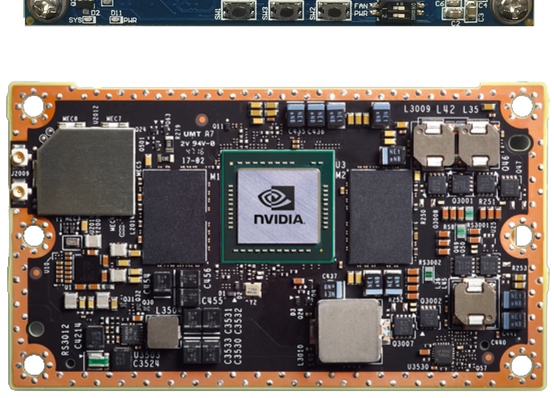


Image source: https://developer.nvidia.com/embedded/buy/jetson-tx2

EVENT SEQUENCE

Capture ten seconds of raw, uncompressed video at resolution 3840x1080.

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Transcode raw video using H.264 codec while maintaining original resolution 3840x1080.

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Transfer H.264 video file to an Intel Edison board (on same CubeSat as Nvidia TX2) via serial UART and/or 802.11n WiFi.

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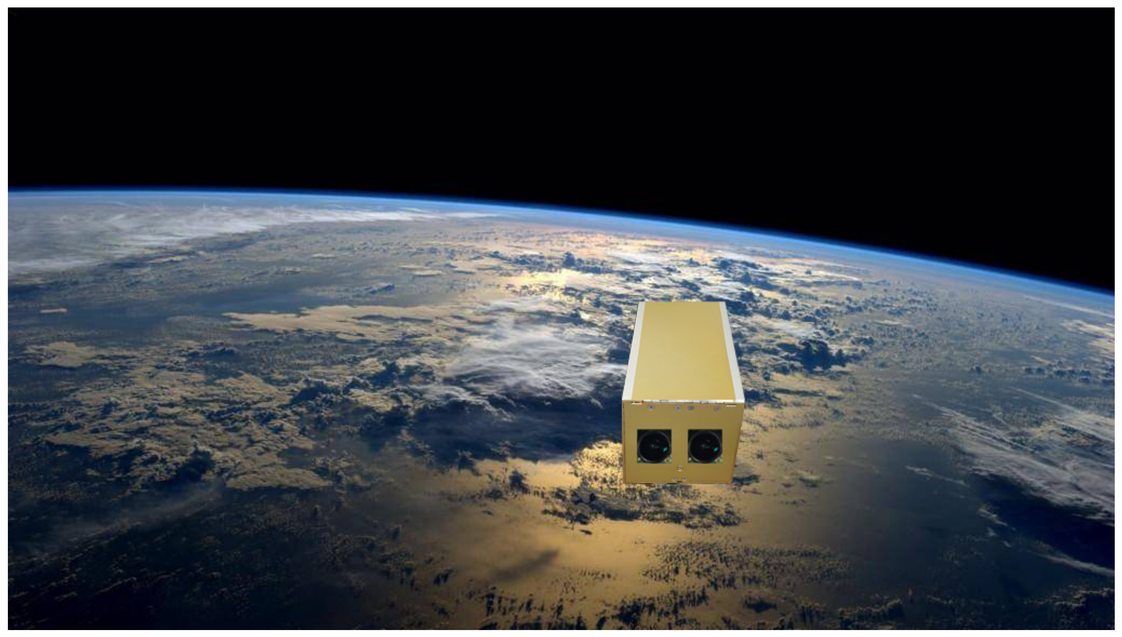
Intel Edison board packetizes H.264 video file into small chunks to be sent via Iridium satellite phone connection back to base station.

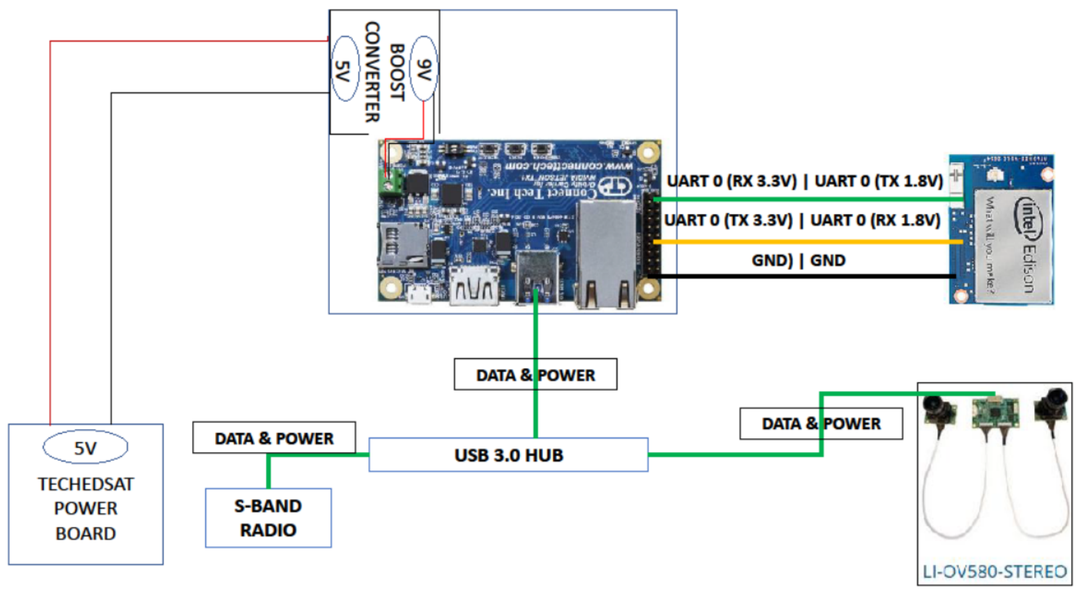


Earth Image Credit: NASA/Reid Wiseman

VR SUBSYSTEM

The work presented here is the first in-space demonstration and validation of a VR payload experiment integrated in the upcoming TechEdSat8 (Technology Education Satellite) CubeSat flight scheduled for launch in Summer 2018. The initial VR subsystem uses an Nvidia Jetson TX2, a CTI Orbitty Orbiter board, and a Leopard Imaging stereoscopic digital camera system. The subsystem will capture HD quality 3D video/images and transfer the data to an onboard Intel Edison board to be transmitted to Earth via Iridium satellite communication. Later flights can incorporate multiple cameras to capture full 360 3D video processed and stitched in real time on the TX2, and transferred directly via a high speed S-band radio (this radio is also being tested on the TechEdSat8 flight).

HARDWARE BLOCK DIAGRAM



FUTURE MISSIONS / APPLICATIONS

Low-cost, small form factor, high-definition VR capture cameras and on-board AI compute engines open up a wide range of space mission opportunities. These include:

- Real-time remote 360 3D VR and Augmented Reality (AR) viewing
- Video sequence auto selection and optimization
- Lost image / data reconstruction
- ExoBrake deployment vision recognition and analysis
- Vision-based CubeSat stabilization and orientation
- Generate and transmit local 3D models on-the-fly
- Real-time AI and AR assisted missions
- Moon and Mars autonomous vehicles