Implementation of Structure from Motion from a Cube Satellite in Low Earth Orbit

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Abstract

The University of Georgia Small Satellite Research Laboratory's Mapping and Ocean Color Imager (MOCI) mission utilizes Structure from Motion (SfM) to recreate 3D structure from a sequence of overlaping images.

We propose to optimize SfM by inserting assumptions based on properties of an orbiting body. We will use a feature detection algorithm to match similar keypoints.

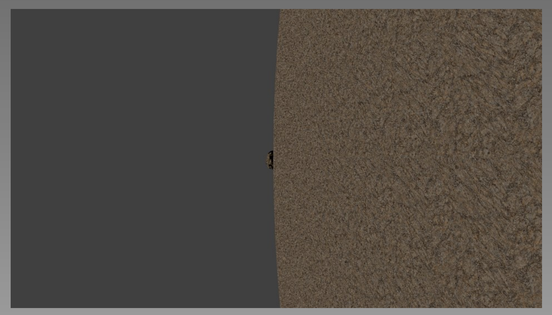
In order to further the development of our satellite, we also will implement our algorithms on both a GPU and FPGA.

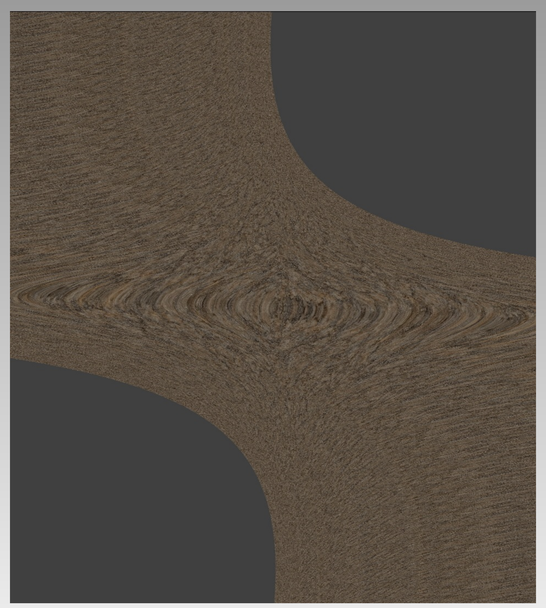
Objectives

- Implement the Scale Invariant Feature Transform (SIFT) algorithm and create a 3D point cloud.[1]
- Calculate the Epi-Polar projection of a feature point by image and time.[2]
- Find techniques to speed up SfM processing.

Methods

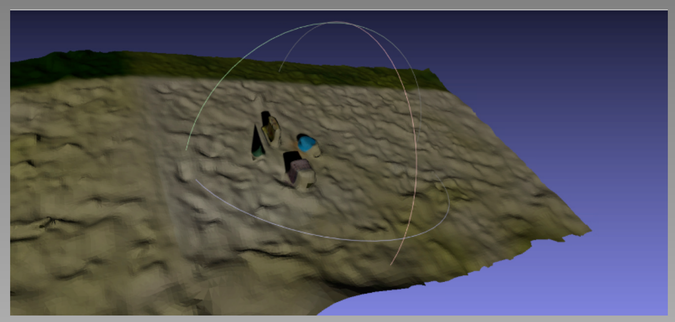
- Simulated controlled orbital image collection using Blender
- Processed images using OpenCV in Python, C++, and in VHDL
- Conducted trade studies of various hardware configurations
- Conducting trade studies of various existing complete Structure from Motion packages





Results

- Complete Structure from Motion algorithms based on SIFT currently take between 0.9-3.3 hours to compute.
- Barring thermal and power issues, MOCI will use a GPU to process images.
- Successful Epi-Polar projection simulation of a feature with feature curves.



Conclusion

Structure from Motion is Feasible from Low Earth orbit; however, further research needs to be conducted on hardware due to potential thermal, radiation, and power draw.

Since MOCI will be constrained to an orbit, identifiable patterns of an individual feature can be extrapolated and used increase the number of assumptions we can make about the feature.

Blender Camera Information

References

[1] Lowe, David G (2004). Distinctive image features from scale-invariant keypoints. International journal of computer vision, 60, 91-110.

[2] Bolles, Robert C., H. Harlyn Baker, and David H. Marimont. "Epipolar-plane image analysis: An approach to determining structure from motion." International journal of computer vision 1.1 (1987): 7-55.

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