

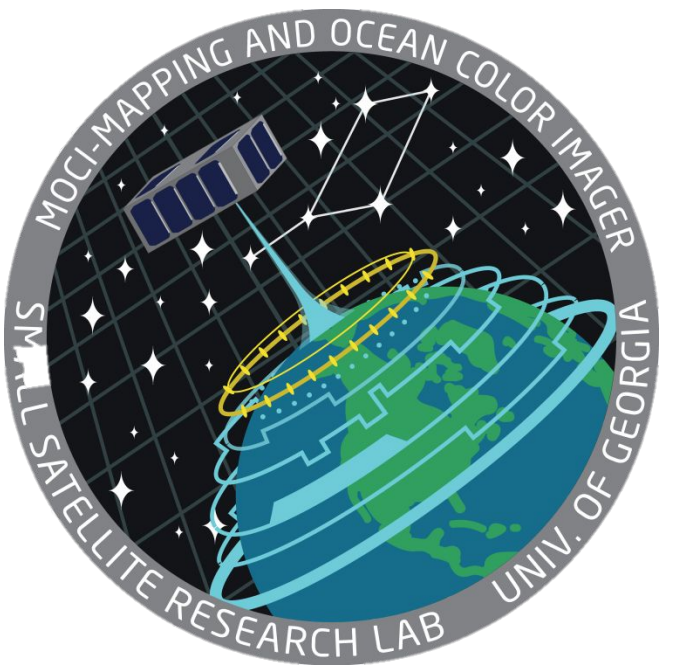


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# Accuracy of Dense Point Clouds Given Varying Image Quality

Mapping and Ocean Color Imaging Satellite (MOCI Sat) – University Nanosat Program 9 – AFRL

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## Overview

Structure-from-Motion (or SfM) is an increasingly popular 3D modeling technique that allows images captured at different angles to be synthesized into a full 360-degree view of an object. 3D models generated by SfM (which usually consist of an image layer laid over a point cloud) have a wide array of functions across the academic, commercial, and defense sectors; in particular, the UGA Geography and Oceanography Departments are particularly interested in the application of SfM-generated models for understanding coastal phenology and health on the eastern shores of the United States. An undergraduate-led team has been formed at the University of Georgia to develop a new SfM technique that uses satellite imagery to create 3D coastal models. This team has received funding from the Air Force Research Laboratory to develop a SfM-focused CubeSat (to be named MOCI) with possibilities of launch. In order to develop new SfM software that operates on a large scale, the UGA CubeSat team must understand how current SfM software adjusts to decreases in image resolution, as the images captured by the UGA satellite will have a much lower quality than typical UAV-generated imagery. In this experiment, the researcher will determine the rate at which the density of SfM-generated point clouds decreases as image quality also decreases using standard commercial SfM software. By recording the number of points generated in each SfM point cloud, the researcher will be able to quantify a decrease in quality for these models.

## Orbital Imaging Process

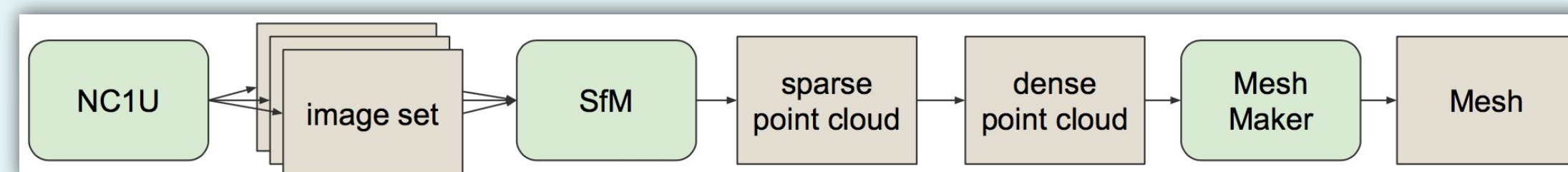


Figure 1

The MOCI satellite currently utilizes the GomSpace Nanocam (NC1U) for gathering imaging data. It is possible for the MOCI satellite to utilize the existing system seen in Figure 2 which shows a hypothetical SfM workflow. It works as follows:

1. Image set is captured with NC1U unit, using different angles to maximize perspectives
2. Run SfM on the image set with final software product on-board satellite
3. Generate sparse point cloud using keypoints generated by SfM
4. Generate dense point cloud using sparse point cloud
5. Use external mesh generation software to create texture on dense point cloud

As this experiment focuses only on point cloud quality (and mesh quality is directly related to dense point cloud quality), Step 5 is omitted.

## Methods

- Test data from Landsat 8 (which, at 30m, has a similar resolution to the future UGA CubeSat) was downloaded from the USGS Earth Explorer Website. A target area was defined around the Lake Lanier area of north Georgia between 32.177 degrees N and 34.611 degrees N and 84.322 degrees W and 82.760 degrees W; images were selected for use if they were mostly free of cloud-cover.
- Ten images with different coordinate centers were selected between November 2015 and March 2016 that met this criteria.
- These images were then opened with a free, open-source software called GIMP (GNU Image Manipulation Program) in order to adjust image quality; the GIMP program allows one to save an image with varying quality by compressing the size of the image. Each of the ten images was saved with four different quality levels: 15, 30, 60, and 90 (note: the images saved at “90” ended up with a larger file size than the original images).
- An original Landsat image of Lake Lanier is shown in Figure 2 and an image compressed at quality 15 in shown in Figure 3.

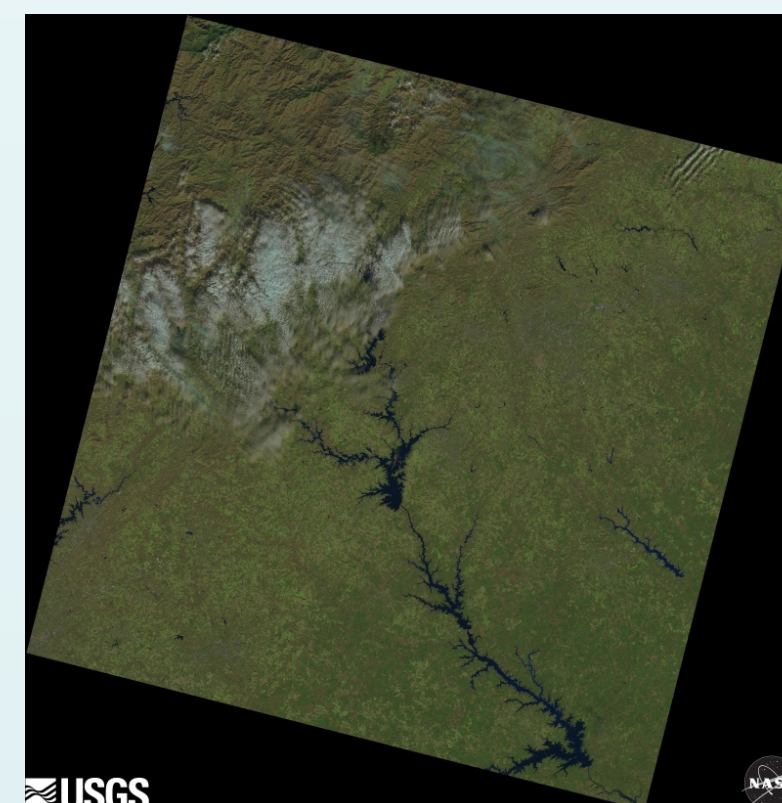


Figure 2

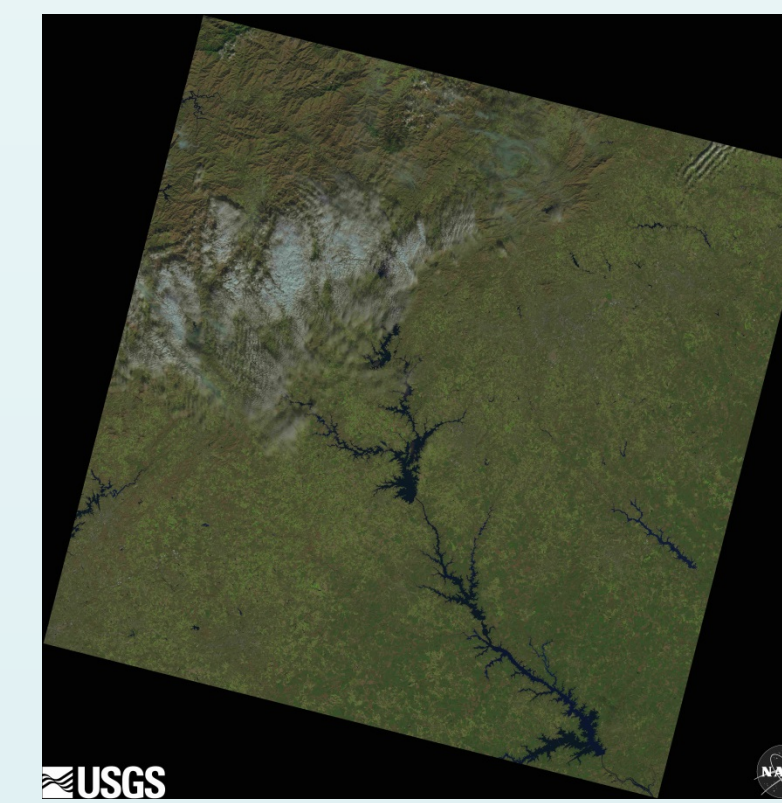


Figure 3

- The images saved at the “15” level had a file size that was approximately 26 percent of the original image, the images saved at the “30” level had a file size that was an approximated 50 percent of the original image, and the images saved at the “60” level had a file size that was around 92 percent of the original image.
- Using these fifty images, five different SfM models were generated using Agisoft, a leading commercial SfM software whose license has been purchased by the University of Georgia.
- Ten images of a time, each from the same quality category, were loaded into Agisoft and aligned for orientation purposes on “High” accuracy, which yielded a certain number of tie points.
- This process was then repeated an additional four times for each quality category (15, 30, 60, 90, and original) and the average number of tie points in a quality category was recorded and analyzed.

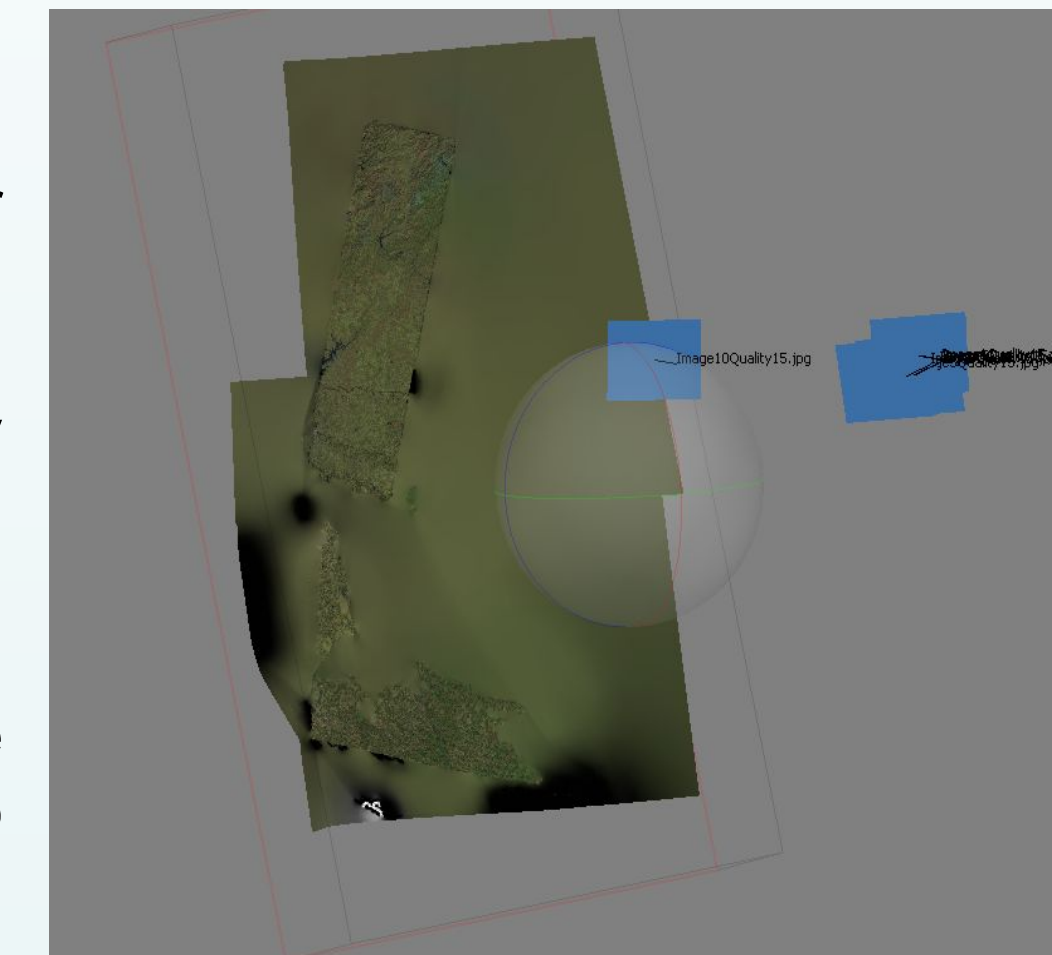


Figure 4

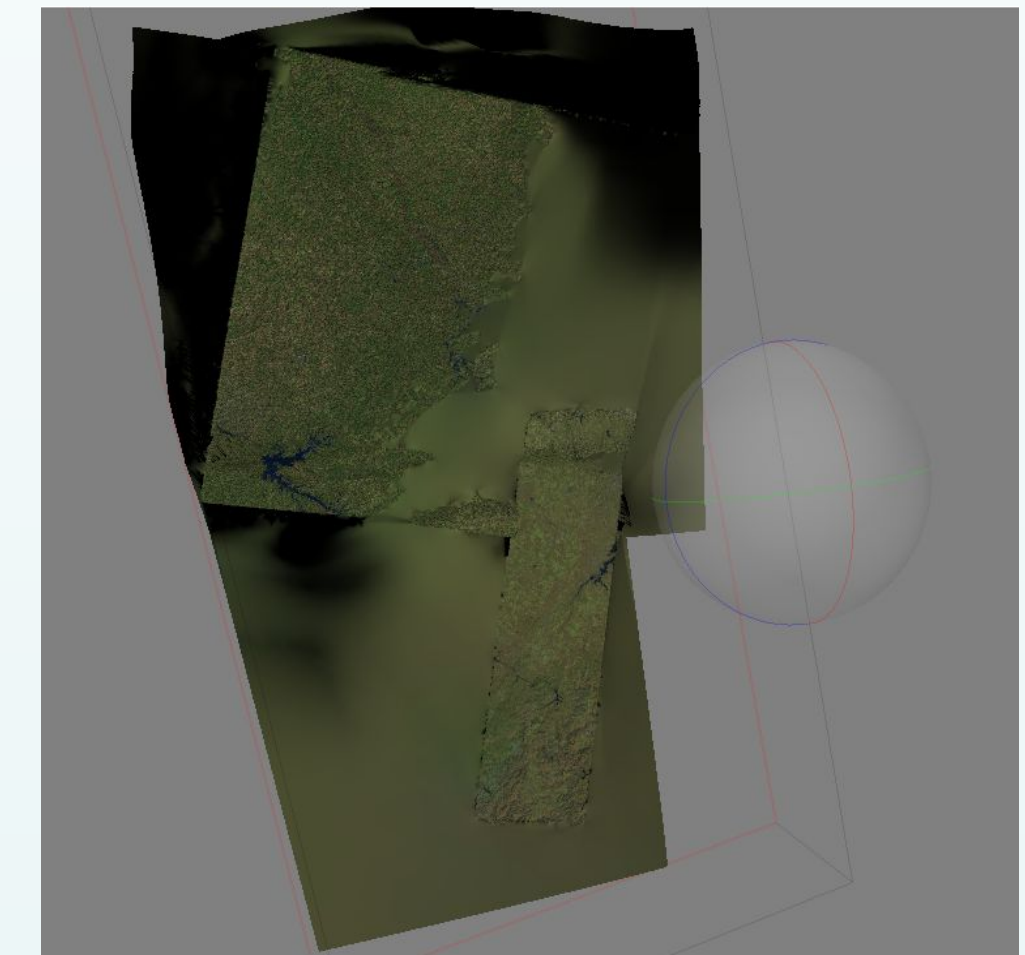


Figure 5

## Results

- The results of the experiment were inconclusive due to several sources of error within the experiment. The largest source of noise in the data is due to the inconsistent processing abilities of Agisoft; the number of tie points calculated from the same images varied greatly between each quality category and each model produced. Inconsistency is modeled in Figure 6 with the difference in tie points per category.
- Other sources of error that exist in the experiment but were not necessarily considered when analyzing results are: GIMP's inability to save images at a linear rate (i.e. saving an image at quality 15 did not correspond to 15 percent file size), lack of calculations to determine the relationship between tie points and SfM model quality, light differences between images, and lack of repetitions on model creation in order to potentially reduce variability.
- SfM models were produced that somewhat accurately depicted landscape (although extra noise correction/mesh generation procedures were omitted). Figure 4 represents the model produced with the “15” quality while Figure 5 represents the model with original images.
- While this experiment did not yield conclusive results, it did reveal a new issue with commercial SfM software packages (consistency) that can now be addressed when producing an in-housing software product.

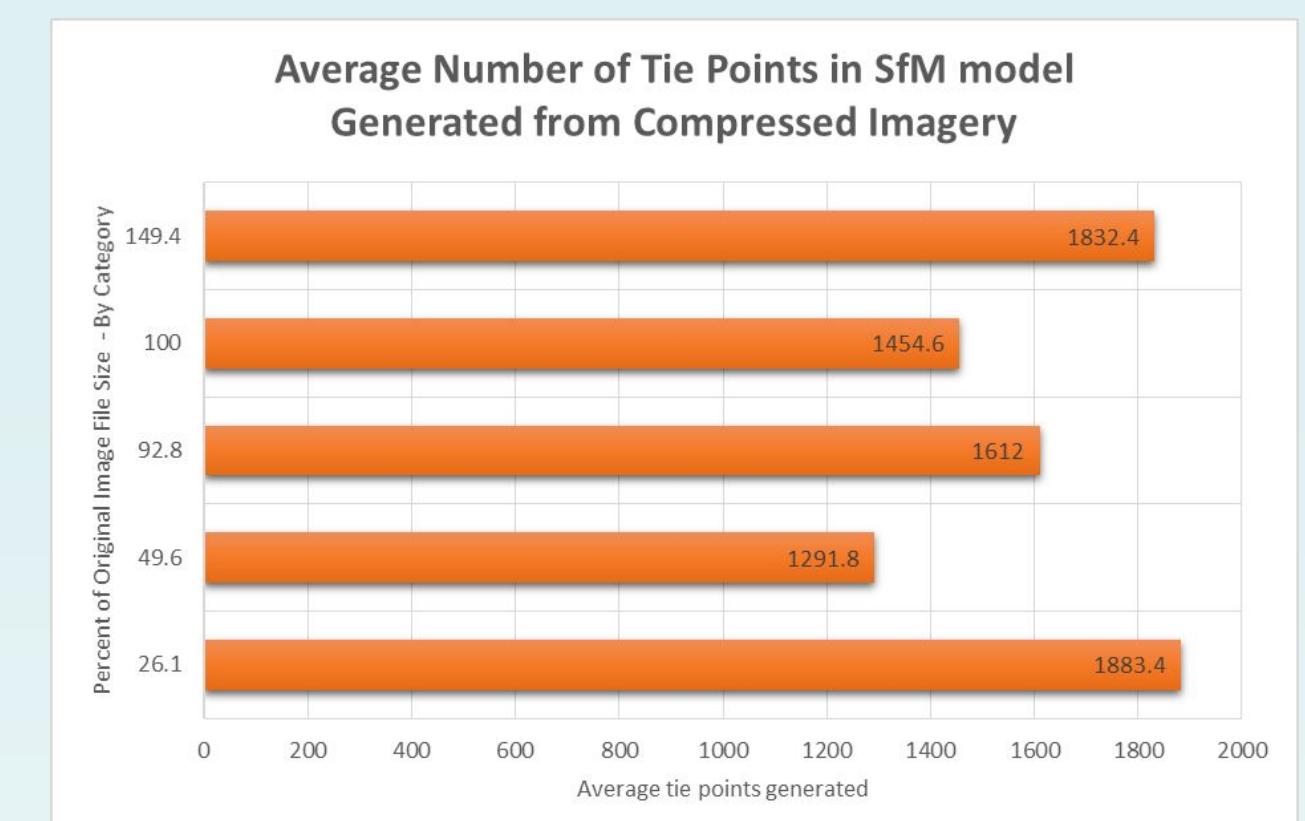


Figure 6