High Resolution 3D Modeling Using Oblique Pictometry and Lidar Data

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Abstract

As part of a larger project to develop a high resolution model of the Virginia Tech campus, we processed over 8,000 non-georeferenced aerial oblique images of Blacksburg area collected by Pictometry in 2019. We sequentially: (a) produced an initial camera position estimate from image footprints in Python, (b) calibrated the image set by creating approximately 200 ground control points (3D GCPs using position and elevation) and over 2,500 image marks manually generated with Google Earth, and (c) after adding final fine referencing using RTK GPS, we calculated the 3D original camera positions using Pix4D software.

This challenging project used unconventional methods to establish camera location and orientation by using imagery that was not created with 3D modeling in mind (i.e. low image overlap) and calibrating model cameras using Google Earth derived data for GCP construction.

Finally, we used RealityCapture software to fuse lidar imagery with our georeferenced image set to produce a 3D model that combines the spatial accuracy of lidar with the high point density of Structure from Motion (SfM) models. We expect to use the final constructed model for several applications, including to support indoor mapping and navigation and interactive, augmented reality 3D printed maps for people with visual impairments.

Relevant Software & Technology

Google Earth is an open source geobrowser that allows users to view 3D models of the earth rendered from satellite imagery

Pix4D is a photogrammetry software used to generate point clouds, meshes, digital terrain models, and orthomosaics.

RealityCapture is a photogrammetric reconstruction software that creates 3D models (among other products) from unordered imagery.

Real-Time Kinematic (RTK) GPS uses a *base* GPS unit to feed corrections to a *rover* GPS used to capture the locations of objects. Corrected points are accurate to within 2 to 5 cm.

SURE Aerial is a photogrammetric reconstruction software with emphasis on aerial imagery captured from large frame nadir cameras.

Acknowledgments

We wish to thank Grace Fernandez for the collection of the RTK GPS points and VT Enterprise GIS and Seth Peery for providing the Pictometry oblique imagery.

Processing the Imagery

Imagery Preparation

To make the image set more manageable, we first added the obliques to a map view in ArcGIS Pro. On top of the images we created a numbered fishnet grid to mark different areas for reconstruction.

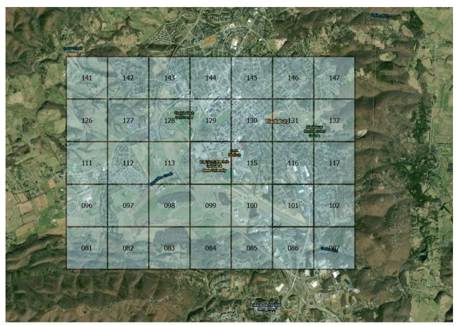
The images were run through a Python script in order to estimate the camera position within 100 meters based on image footprint metadata.

Manual Data Processing

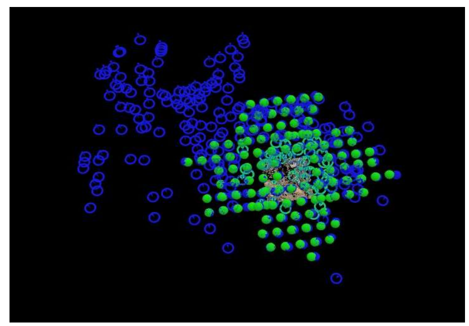
Using Google Earth, at least 10 recognizable landmarks were located within each tile and their coordinates were recorded and used as input for Pix4D as Ground Control Points (GCPs). The location of GCPs were hand-marked in each image. These helped the automated algorithms adjust the locations of the images to within 5 meters. The most commonly used points within images were manhole covers, building edges, and street arrows. A second round of adjustment used an RTK GPS to source much a smaller set of highly accurate locations within the study area.

Enhanced Model Creation

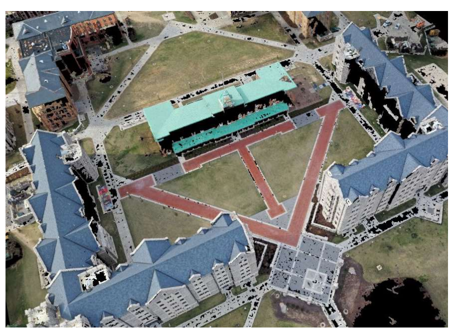
Pix4D can be used to align images, but also to build point clouds, orthophotos and 3D meshes. However, products derived from Structure from Motion data can have significant noise that makes reconstruction difficult. More advanced reconstruction software, often supplemented with lidar data, can improve the reconstructions. We used SURE Aerial and RealityCapture to post-process the Pix4D results as shown below.



Fishnet grid of project study area tiles in ArcGIS



Here is a point cloud of a fully calibrated cell in Pix4D



Initial Pix4D Model

SURE Aerial Model

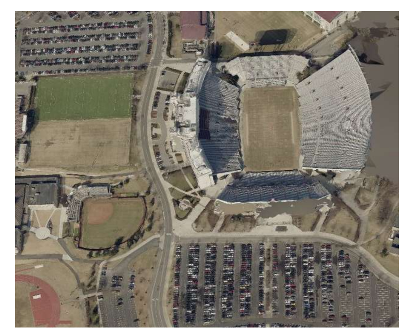
Pictometry Dataset

- Data set includes 10k+ oblique images of Blacksburg area (2019) by Pictometry
- Parameters and Output:
  - Penta 85mm camera
  - Images: 6576 x 4384 pixels (29 MP)
  - Flight Altitude: ~1,475 meters AGL
  - Ground Sampling Distance = 10 cm
  - Point density: 50 points per square meter

Next Steps

The outputs generated from this project will hopefully lend themselves to further exploration of technologically enhanced geovisualizations. For example, SURE Aerial has interactive model capabilities that allow users to incorporate geodata into the output. This can then be selected and viewed in the model itself.

Another application of these models is to use them for increasing the accessibility of geodata to the visually impaired. We will use the mesh output as one input into an tactile 3D printed map, augmented by touch interaction and audio feedback. This would allow individuals with visual impairments to have access to useful, physical maps that accommodate their disabilities.



RealityCapture 3D model of Lane Stadium, Fused with Lidar