Three-dimensional characterization of grapevine canopy using UAV-SfM point clouds

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GEOSPATIAL VITICULTURE

There are many factors that can contribute to the quality and quantity of winegrapes. The size and shape of the vine canopy are two metrics that can help determine health and performance of the vine. Different canopy shapes can determine characteristics of the berry, such as anthocyanins, while the structure and density of the vine canopy can be used to estimate both fruit yield and vine performance. Measuring the canopy in 3D has various applications, such as yield estimation, pesticide application, general vine health, and estimating grape quality. Using precision viticulture (PV) to obtain highly detailed geospatial datasets (e.g., point clouds, aerial imagery), the structure and density of the canopy can be assessed and analyzed.

Fig. 1: Phantom 4 Pro

Fig 2: RTK unit

REMOTE SENSING

Though many methods of PV exist, most are cost-prohibitive to vineyard managers. Satellite and manned aircraft can produce high-resolution imagery, but at an expense higher than is practical for utilization. In recent years with implementation of UAV technology, these PV methods have become both cost and user friendly enough to be implemented by vineyards in their management plans. With the quality of these high-resolution data sets, management at the per-vine level is possible. Studies have shown that digital cameras carried by UAVs can create a Structure from Motion (SfM) point cloud with comparative levels of accuracy to lidar methods. Using this SfM point cloud, the canopy shape and density can be estimated.

Snavely, 2006

Fig 3: SfM keypoint matching to create 3D model

METHODS

Image collection took place on 3 separate days in July and August. Each day consisted of 6 flights collecting Nadir facing images, oblique images at 45°, and oblique images at 60°, all taken from a height of 25m and 50m. For each day there were also LAI estimates collected with a ceptometer, 3 readings per vine.

Imagery was imported into Pix4D where 9 point clouds were created, 3 for each day. These were then manually georeferenced with 7 ground control points (GCPs) throughout the vineyard. Point clouds were then exported as .las files and imported into ArcGIS Pro for analysis.

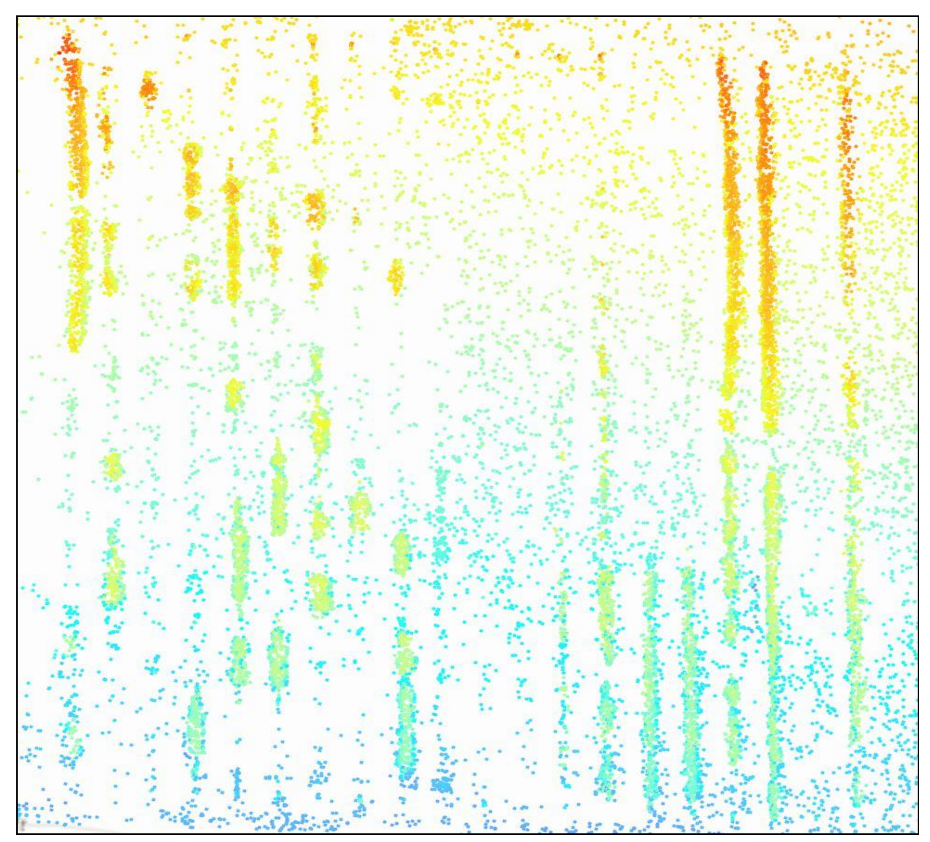

Fig 4: SfM point cloud imported into ArcGIs Pro

Fig. 5: Georeferenced point cloud of test plot in Pix4D

DATA PROCESSING AND ANALYSIS

Once imported, .las files were classified and extraneous points were removed. Z-values were normalized to represent above ground level heights instead of elevation. Polygons 1m² were created over each of the vines and point statistics were extracted from each polygon. The point statistics were then run in a regression with the LAI estimate averages for each of the 148 vines.

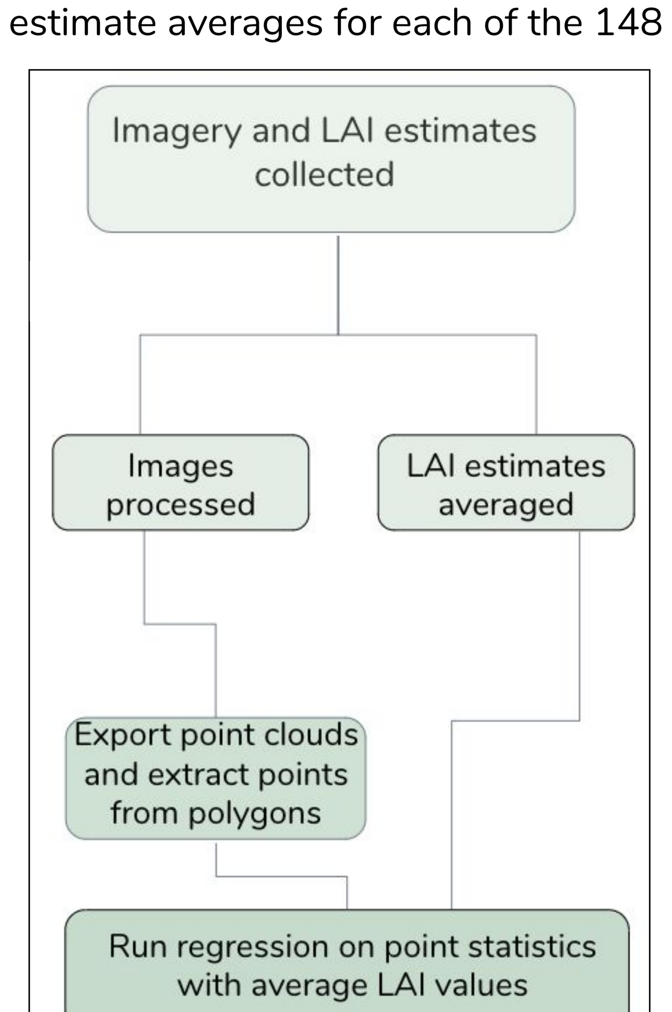

Fig. 6: Processing and analysis

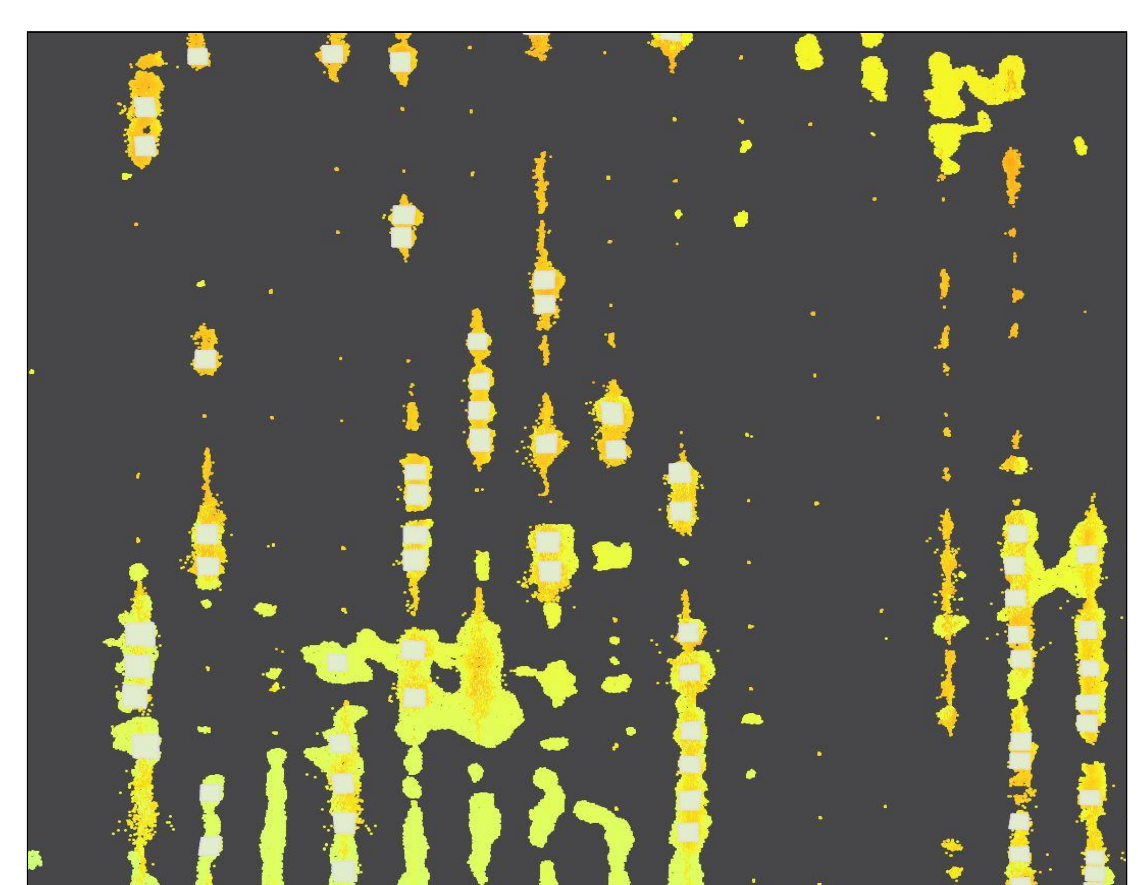

Fig 7: Normalized point cloud with individual polygons

STUDY SITE

Cimarron Valley Research Station (CVRS)

- Stillwater, OK

Fig. 8: Test plot with GCP markers

OBJECTIVES

1. To determine the optimal data collection procedure to model via SfM winegrape canopy in three-dimensions
2. Following Mathews and Jensen (2013), assess the replicability of winegrape canopy structure/density estimations from SfM point clouds

PRELIMINARY RESULTS

After processing both the LAI and point cloud data collected on one of the three days, a relationship appears to exist between the point densities and the LAI estimates. Processing needs to be replicated for the other 2 days of data collection and the .las files analyzed for the other point statistics.

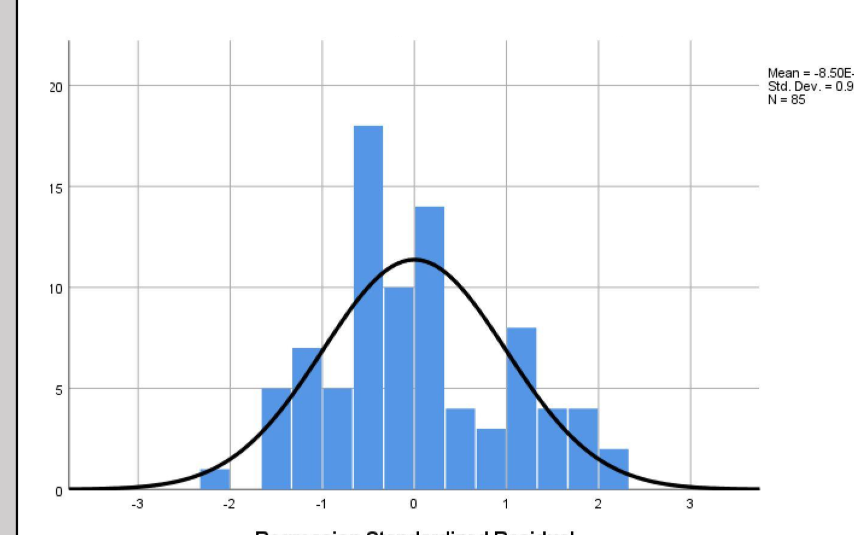

Fig. 9: Histogram of residuals

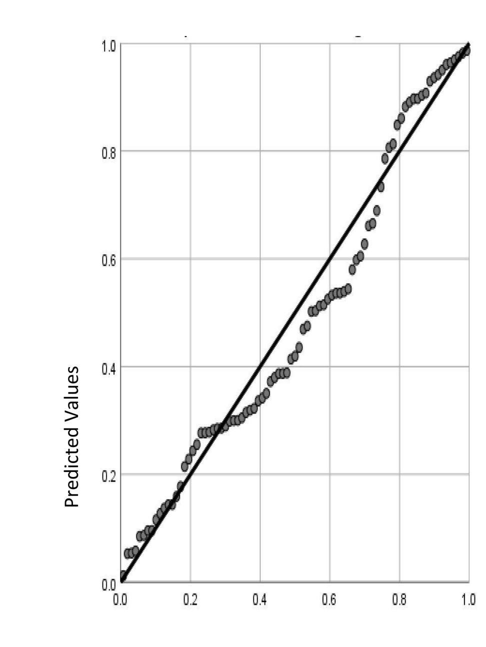

Fig. 10: P-Plot showing predicted LAI vs observed LAI estimations

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