3D Modeling of Ultra-High-Resolution UAV Imagery using Low-Cost UAVs and Structure from Motion

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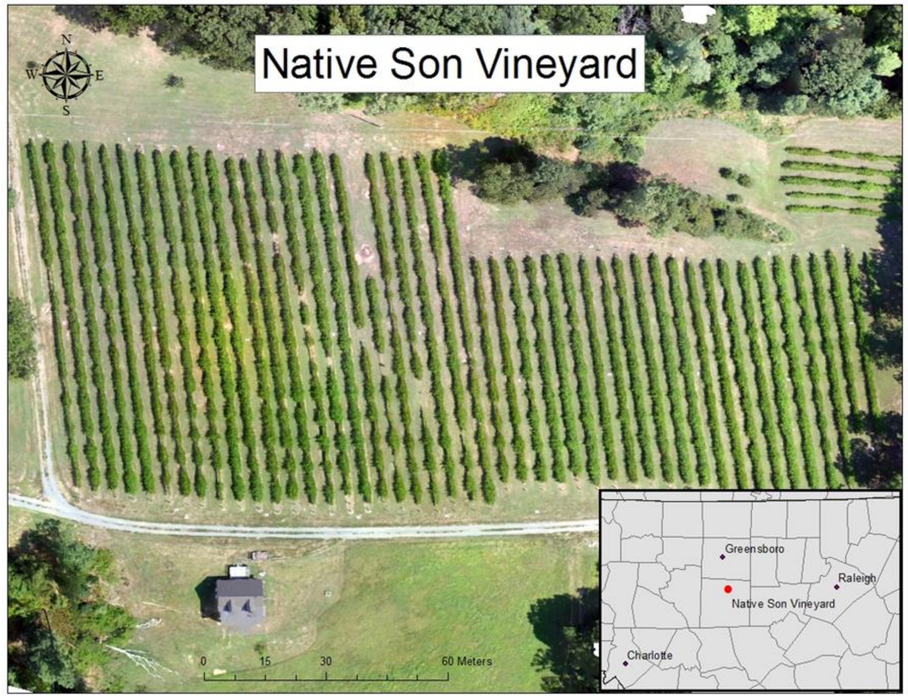
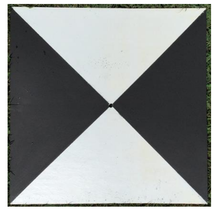
Introduction

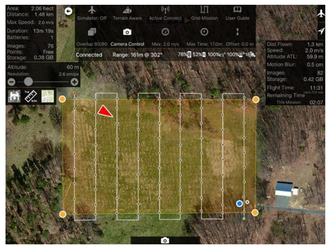
The availability of advanced low-cost unmanned aerial systems (UASs), aftermarket applications, and a competitive market for processing software have provided researchers new opportunities for employing high resolution remote sensing in research. The UAS allows for the capture of close range aerial imagery that can then be used to generate dense point clouds using structure from motion (SfM). A variety of digital products can be created form these dense point clouds such as three-dimensional models, digital elevation models (DEMs), digital surface models (DSMs) and orthomosaics. This research looks at methods and accuracies associated with the creation of digital mapping products from dense point clouds generated from imagery captured by two low-cost UASs.

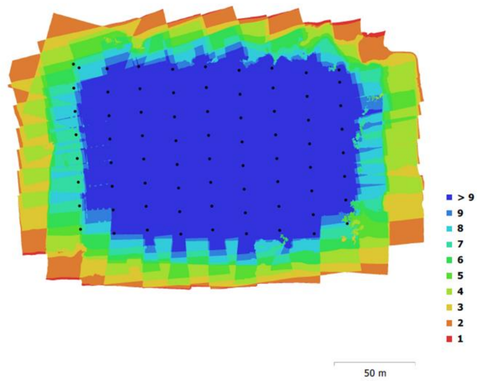


Methods

The UASs were used to capture imagery over a 2-hectare vineyard in the Uwharrie mountains of North Carolina. Aspects of imagery collection, such as altitude, ground control, camera types, flight paths, and target styles, were investigated for their impacts on accuracy. Thirty-one ground control points were created in the vineyard using a survey grade GNSS receiver and total station for use in georeferencing. The number of ground control points used for georeferencing were reduced until a significant difference in accuracy was found using t-tests.





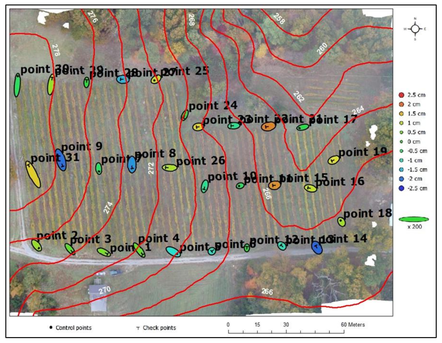


Day Six Control Point Scenarios and Accuracy Outcomes.

Flight Code	Check	Control	X Err (cm)	Y Err (cm)	Z Err (cm)	Tot (cm)
NSV_60m_D6_2	15	15	1.182	2.084	1.291	2.722
NSV_60m_D6_3	15	15	1.313	1.934	1.308	2.679
NSV_60m_D6_4	19	11	1.022	1.874	1.513	2.617
NSV_60m_D6_5	22	8	1.206	1.853	1.206	2.519
NSV_60m_D6_6	24	6	1.219	1.922	1.518	2.736
NSV_60m_D6_7	25	5	1.230	1.985	1.907	3.015
NSV_60m_D6_8	26	4	1.017	3.151	1.938	3.837
NSV_60m_D6_9	27	3	2.217	2.917	6.559	7.513

Results

Five ground control points were shown to be the least amount of ground control needed before accuracy began to change significantly. Four flight altitudes were tested with 80-meters generating the least error. Orthomosaics created from structure from motion and imagery collected using a 20-megapixel global shutter camera had total RMS errors between 2-4 cm.



Conclusion

The use of a low-cost UAS in collecting imagery for use in modeling and mapping applications has been found to be reliable and reproducible and yields a sub decimeter level of accuracy. It truly represents a new level of scale available to researchers that was previously unattainable and at a low cost. The products produced from this process allow researchers the ability to more easily move to larger scale data sets, helping answer questions in a variety of research agendas that cannot be answered with smaller scale data sets.