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**Vineyard High Resolution Imagery
Analysis with Arc Map**

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1 INTRODUCTION

1.1 MOTIVATION

With recent advancements in high resolution imagery (HRI) collected by unmanned aerial vehicles, a wide range of remote sensing applications have emerged. Precision agriculture is one of the emerging research field that are highly demanding the use of HRI, because remotely sensed imagery can offer effective procedures to identify and classify agricultural sites monitoring their condition through to time for effective management and production yield increase.

HRI offers countless levels of spatial detail which is suitable for visual analysis and mapping purposes, that markets like the wine industry are pursuing to use in order to identify areas of poorly performing vines so that they can be put under specific treatments in order to alleviate vineyard production inconsistency to yield a higher quality product.

Current remote sensing techniques for agricultural land management like Normalized Difference Vegetation Index calculations for image classification and estimation of Evapotranspiration levels, are not easy processes to accomplish unless a set of image analysis tools are available.

These reasons and the need for a transition from an experimental stage to an operative stage of these type of processes motivate the achievement of this project which goals are set to describe and implement a set of tools and analysis for HRI using computer aid from the soft-wares packages like ArcMap from Esri and PhotoScan PRO from Agisoft.

This project present the maps obtained from mapping a section of a vineyard site of a winery in Lodi, CA, and perform a series of data processing steps to create products for better analysis of the images using ArcMap.

1.2 BACKGROUND

At Utah State University the AggieAir team is using their unmanned aerial vehicles(uav) to measure Evapo-Transpiration (ET) from vineyards using high resolution Near Infrared (NIR), Red Green Blue (RGB), and Thermal imagery. In addition to AggieAir other estudies demonstrate the identification of vineyard canopy Leaf Cover Area based on HRI from UAVs, as found on articles by the remote sensing journal (Mathews and Jensen 2013), which uses and structure from motion (SfM) method to generate point clouds that can be classified into non-ground points(vegetation) and ground points(soil). Other investigations such as the one presented by the University of Paris (BRIS and IGN 2012) uses satellite aerial imagery to delineate vineyards



and analyze the overall condition of the sites, and the study presented by (Aksoy et al. 2009) which emphasize the importance of the analysis of remote sensing data to obtain useful information from multi-spectral imagery with the implementation of detection and segmentation algorithms. These and many other studies are great resources to be combined, in order to generate tools which allow the easy analysis and interpretation of vineyards HRI by endusers.

2 PROJECT OBJECTIVES

2.1 WHAT ARE SUITABLE ARCMAP TOOLS FOR REMOTE SENSED HRI ANALYSIS?

- This objective is intended to explore and demonstrate which ArcMap tools can be utilized and re-purposed, using modeling and scripting automation, for HRI analysis.

2.2 HOW CAN VINEYARD'S CONDITION BE BETTER DISPLAYED FOR ANALYSIS IN A MAP FROM HIR?

This objective is intended to identify the most suitable mapping presentation of the vineyard conditions so that the state of individual plants can be located and assessed, based on the following tasks:

- *Task1:* Obtain NDVI calculations from HRI.
- *Task2:* Classify soil and vegetation areas based on NDVI values of HRI.
- *Task3:* Perform statistical analysis on vegetation NDVI calculations, for the estimate of vineyards canopy concentrations.

2.3 HOW CAN VINEYARD'S HRI ANALYSIS BE AUTOMATED USING SCRIPTS FOR ARCMAP TOOLBOX CREATION?

This objective is intended to generate a single tool from the tools explored during the completion of objectives one and two, for the easy analysis of HRI datasets.

3 METHODS

3.1 DATA COLLECTION

Data for this project was obtained using AggieAir's UAV platform (Figure 1 shows AggieAir's platform on the field.) and USGS web services. The description of the data obtained is as follow:

- RGB imagery flying @ 500 meters of altitude.



- NIR imagery flying @ 500 meters of altitude.
- Thermal imagery flying @ 500 meters of altitude.
- Multi-band Landsat imagery for the same date of AggieAir's flights corresponding to August 09, of 2014.

The imagery obtained from AggieAir provided a resolution of 15 cm (6 inches) per pixel compared with Landsat imagery for which the resolution obtained vary between 15 and 90 meters. The purpose of having these two dataset sources is to have a comparison point for the HRI analysis results.

3.2 DATA PROCESSING

The processing of the imagery consisted in the creation of four ortho-mosaics based on images overlapping and control points that permit the geo-referencing of the images using the software suite (Agisoft Professional Edition 2012). Agisoft is a 3D modeling software based on still images where overlapping is present so that the object to be reconstructed is present in at least two of the images. The software is capable of constructing a mosaic even when no control points are present, but for the completion of this project AggieAir data provided the control points from their imagery datalog that is created on each flight. For the control points only the Latitude, Longitude and Altitude information were used. The resulted mosaics are as shown on Figure 2, the mosaics are loaded on google earth for the verification of the geo-referencing of the images.



FIGURE 1: AGGIEAIR'S MINION AIRCRAFT ON LAUNCHER BEFORE MISSION.

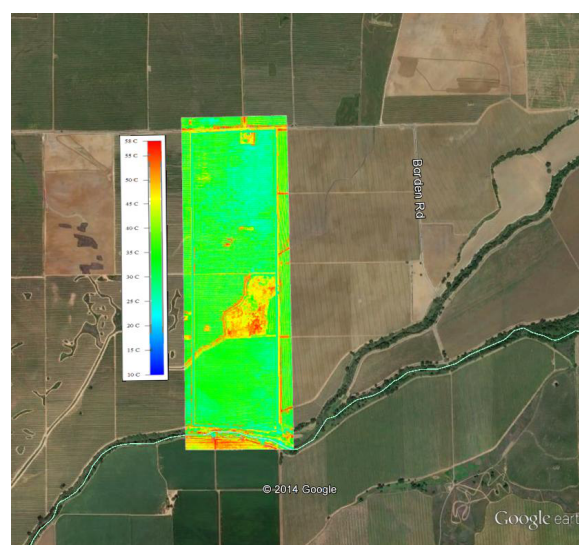


FIGURE 2: THERMAL IMAGERY MOSAIC GENERATED BY AGISOFT.



3.2.1 RED GREEN AND BLUE BANDS MOSAIC

AGGIEAIR RGB MOSAIC



FIGURE 3: RGB MAP GENERATED BY ARCMAP OVER ESRI WORLD IMAGERY BASEMAP. THE X PRESENT ON THE MAP REPRESENT THE LOCATION OF THE CONTROL POINTS.



3.2.2 NIR BAND MOSAIC

AGGIEAIR NIR MOSAIC



FIGURE 4: NIR MAP GENERATED BY ARCMAP OVER ESRI WORLD IMAGERY BASEMAP. THE X PRESENT ON THE MAP REPRESENT THE LOCATION OF THE CONTROL POINTS.



3.2.3 THERMAL IMAGERY MOSAICS

AGGIEAIR THERMAL MOSAIC MORNING

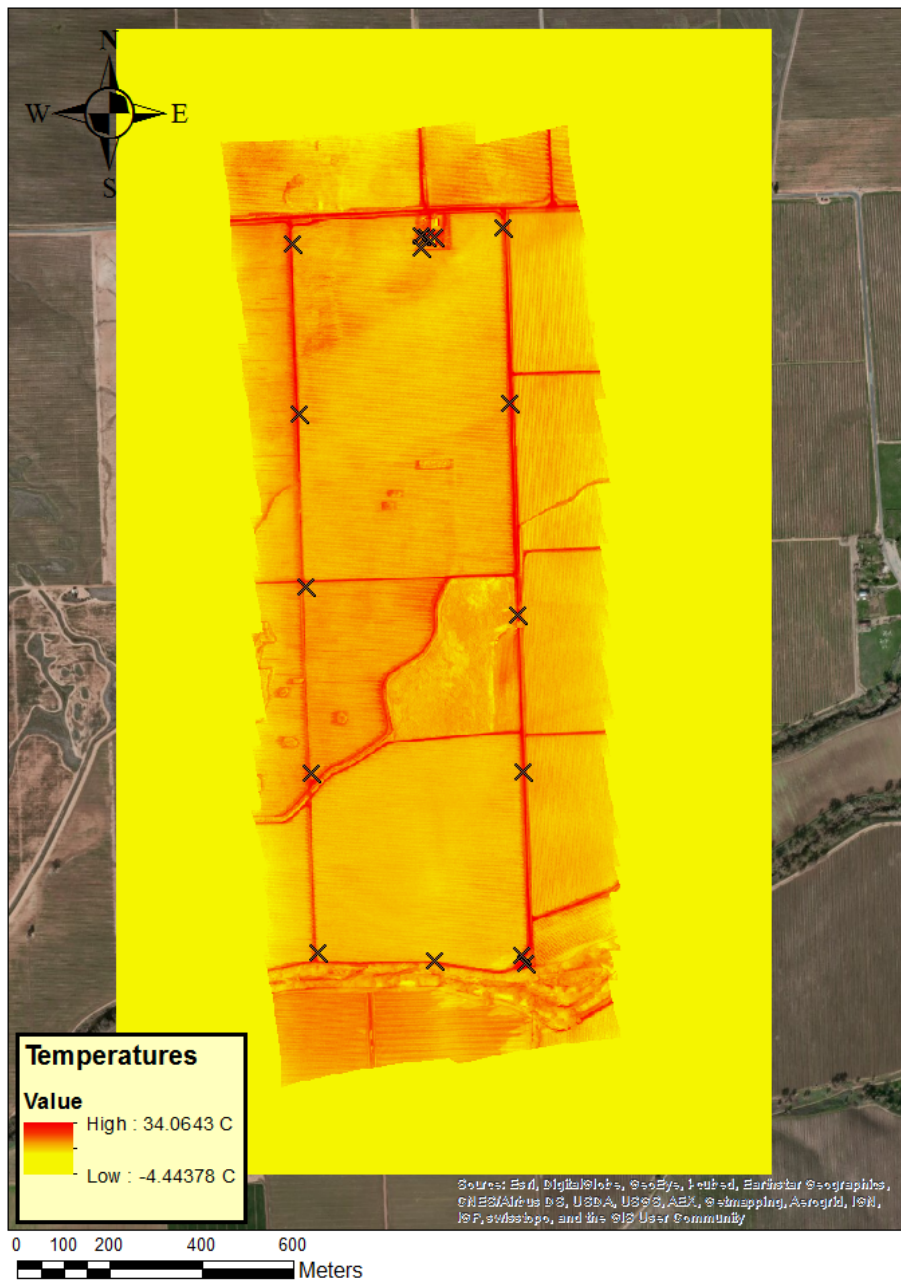


FIGURE 5: THERMAL MAP OF MORNING AGGIEAIR FLIGHT, GENERATED BY ARCMAP OVER ESRI WORLD IMAGERY BASEMAP. THE X PRESENT ON THE MAP REPRESENT THE LOCATION OF THE CONTROL POINTS.



AGGIEAIR THERMAL MOSAIC AFTERNOON



FIGURE 6: THERMAL MAP OF AFTERNOON AGGIEAIR FLIGHT, GENERATED BY ARCMAP OVER ESRI WORLD IMAGERY BASEMAP. THE X PRESENT ON THE MAP REPRESENT THE LOCATION OF THE CONTROL POINTS.

The mosaics in .kmz format were loaded into ArgMap using the tool "KML to Layer", once loaded raster's of the images are obtained with each color band separated. For example figure 3, the RGB imagery is formed by red, green and blue bands, arcmap permit the access to each band individually for analysis and calculations. From the thermal maps on figures 5 and 6, each pixel represents a temperature level, a significant difference in temperature between these maps can be observed which validate the change in ambient temperature from morning to afternoon and functionality of the thermal sensor used to obtain the map. Most of the analysis of this project is being done on the RGB and NIR(see figure 4) maps, but the thermal



imagery will play an important role once the tool proposed on this project is completed so that measurements of ET levels can be obtained.

3.3 ARCMAP TOOLS

The following set of tools were used for the analysis presented by this project. These tools fulfil objective 1 described above, because they fit very well the requirements of easing the visualization of the data for better understanding of the problems of the area. The utilization of these tools is combined in the model shown on figure 7.

- *Raster Calculator*: Tool used to create NDVI raster layer from Red and NIR bands of the imagery.
- *Reclassify*: Tool used to classify Soil and Vegetation layers from the NDVI values, high NDVI values correspond to vegetation and low NDVI values correspond to soil.
- *Focal Statistics*: Calculates for each input cell location a statistic of the values within a specified neighborhood around it (Esri Arcmap 2013).
- *Hillshade*: Creates a shaded relief from a surface raster by considering the illumination source angle and shadows (Esri Arcmap 2013).
- *Contour List*: Creates a feature class of selected contour values from a raster surface (Esri Arcmap 2013).
- *3D analyst*: This tool is used after the analysis map is generated to create profile graphs of the vineyard rows polygons, which allow to identify the condition of individual vines.

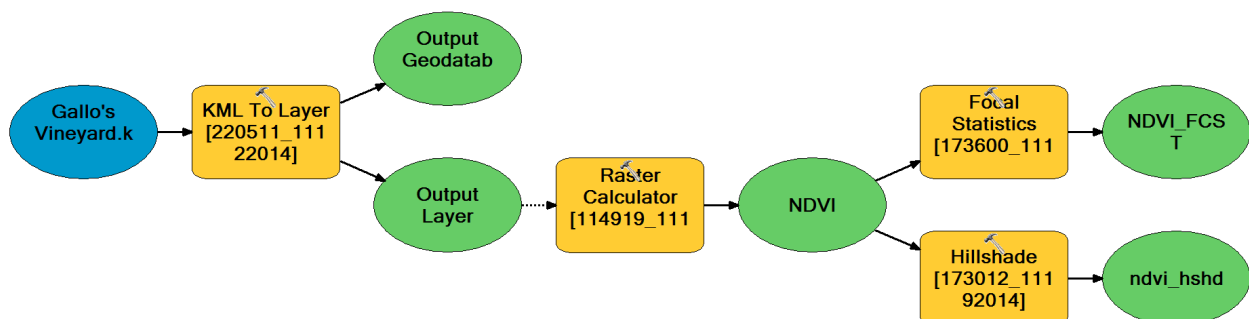


FIGURE 7: ARCMAP MODEL CREATED FROM TOOLS USED FOR VINEYARD IMAGERY ANALYSIS.



3.4 DATA ANALYSIS

The analysis of the data was based on the NDVI values obtained from the NIR and Red bands of the vineyard imagery, based on the following formula:

$$NDVI = (NIR - RED) / (NIR + RED) \quad (1)$$

Vineyards are mostly organized in rows, because of this fact, the analysis of individual plants can be performed only if the rows and vegetation clusters can be identified. This process was performed using the combination of the tools *Reclassify* and *Focal Statistics* based on a circular filter of radius equal 3 times the cell size of the NDVI raster already classified into soil and vegetation.

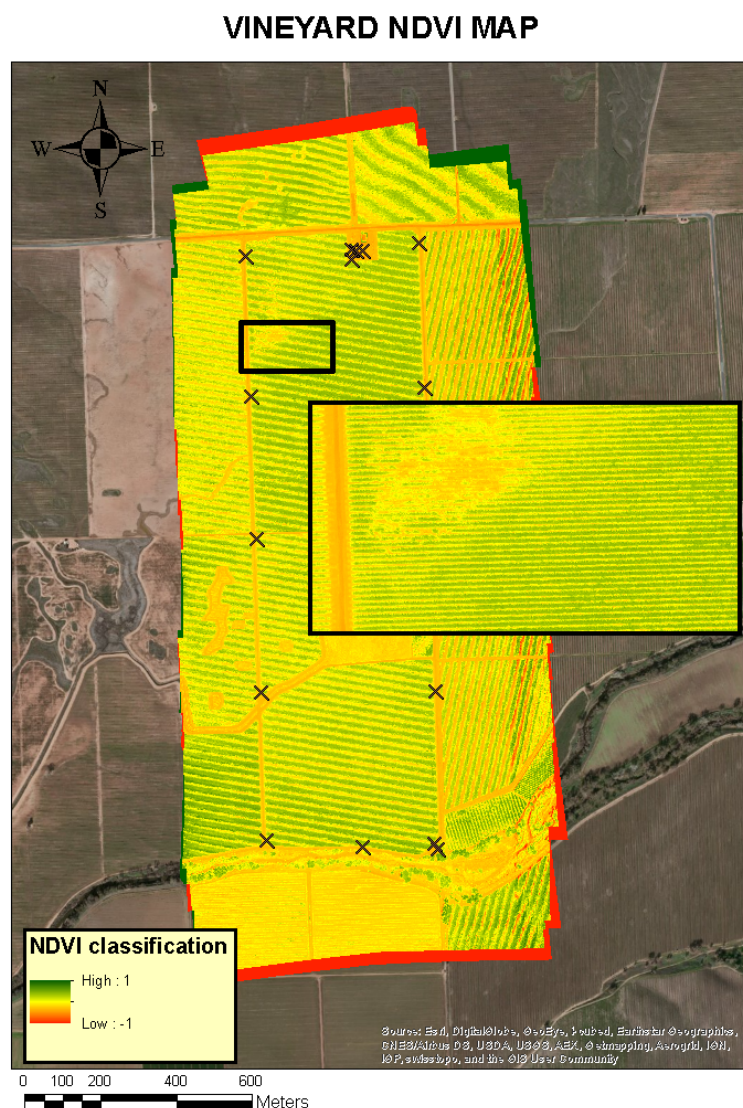


FIGURE 8: NDVI MAP GENERATED BY ARCMAP OVER ESRI WORLD IMAGERY BASEMAP. THE X PRESENT ON THE MAP REPRESENT THE LOCATION OF THE CONTROL POINTS.



4 RESULTS

VINEYARD NDVI ANALYSIS

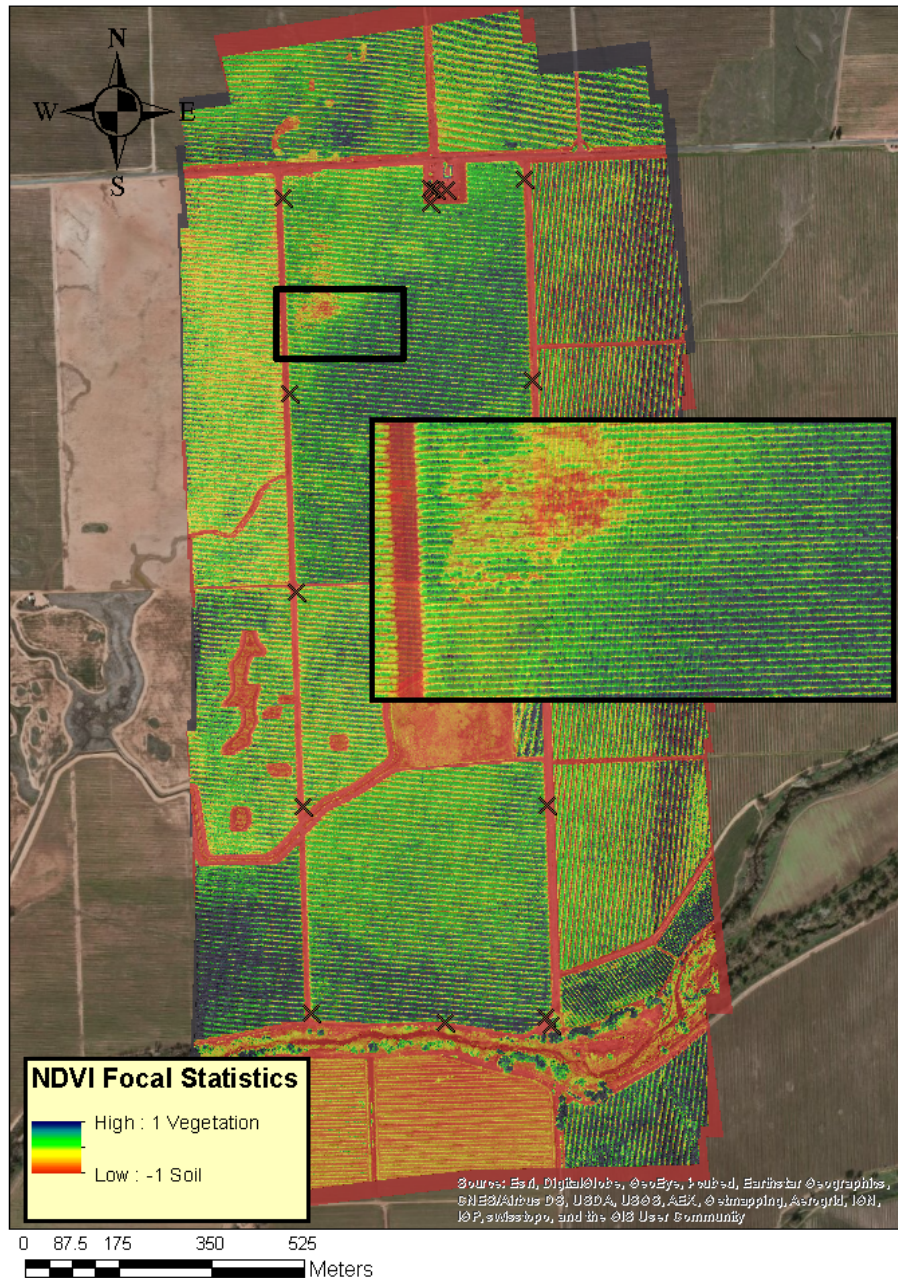


FIGURE 9: MAP BASED ON FOCAL STATISTICS AND HILL SHADE EFFECT GENERATED BY ARCMAP OVER ESRI WORLD IMAGERY BASEMAP. THE X PRESENT ON THE MAP REPRESENT THE LOCATION OF THE CONTROL POINTS.

The map shown on figure 9 represent the final result of the set of tools mentioned above. The map shows a scale bar indicating the level of the soil and the vegetation on the map, dark green areas correspond to clusters of well conditioned vines, as the green color degrade the condition of the vines becomes more critical. Critical areas are considered as dry spots where more areas of bare soil are present. In addition, the map clearly shows how in the middle of the field is where the best conditioned vines are found, which can be a consequence of the density



of plants. It is good to mention, that the level of detailed found on this map can not be found on the NDVI map itself. The square box on the maps shown on figures 8 and 9 correspond to a zoom in to the same area, so that the difference between maps can be appreciated.

5 CONCLUSION

In summary, this project shows various type of visualizations from a single aerial image to a complete detailed map from where useful information can be obtained. The last visualizations presented on figures 8 and 9 clearly establish a difference between a mosaic and a map since areas of critical vine conditions can be clearly identified. The methods were successful and two of the three objectives proposed were obtained. Suitable tools for vineyard analysis and data visualization were successfully identified. This is a significantly complicated and results obtained so far are not enough to account for as a final product, future work will focus on exploring new tools and techniques so that ET measurements can be obtained from thermal imagery.

6 AKNOWLEGMENTS

After completion of this project the author would like to thank the AggieAir team for providing me with the data for this project and guidance on the utilization of ArcMap tools. This project development will be continued in benefits of AggieAir HRI analysis tools.

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