The potential of cost-effective UAV technology to replace costly technologies in Precision Agriculture

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Abstract

The use of satellite and aerial remote sensing for agricultural applications has exponentially expanded since the past decades. One such agricultural application that is highly dependent on the use of advanced hyperspectral and multi-spectral remote sensing and GPS technology to boost crop harvests and viability, while reducing the number and amount of inputs, like water, fertilizer, land, and others required to grow crops, is Precision Agriculture (PA). Although PA has been credited for the increased crop yield and productivity in the United States and worldwide, its dependence on costly technologies has been a major hurdle for it to be used by small-scale farmers locally and globally. This project aims to reduce the dependence of PA on costly and complex remote sensing technologies through the use of alternate and cheaper options such as low/medium-priced Unmanned Aerial Systems (UAV), popularly known as drones, equipped with only high-resolution cameras capable of, to a certain extent, mimicking the functionalities that are offered by costly technologies. Such low-cost technology is anticipated to enhance the efficiency and profitability of the agriculture sector through the provision of easier technologies to small-scale farmers.

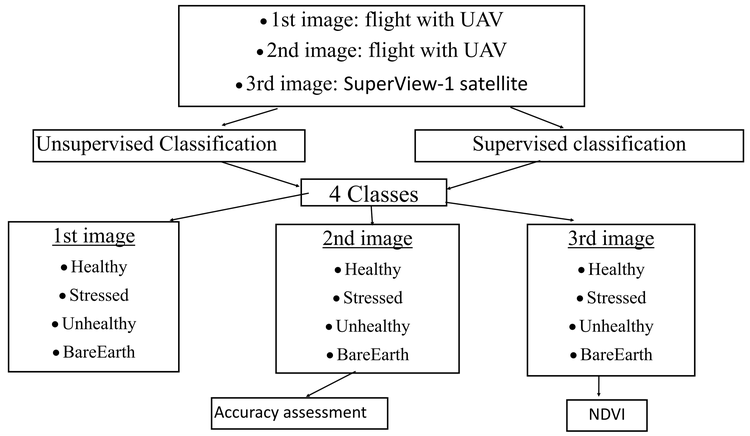
Introduction / Background

The research project is currently being implemented on a wheat farm owned by Davis farms (Grandview, Texas). Multi-temporal (at different growing stages) UAV imagery using DJI Mavic air 3D are being acquired with the purpose of producing 3D maps for qualitative and quantitative analysis. This includes crop-health assessment through the generation of crop-health indicator indices such as the Normalized Difference Vegetation Index (NDVI). A similar analysis from high-resolution multispectral imagery of the area, acquired from commercial satellite operators, Apollo imaging, will be undertaken and the accuracy, validity, and reliability of the UAV-based PA application will be assessed.

Field

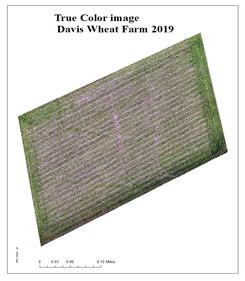
The plot of land is 100 acres and Mr. Davis owns half of the land. So while conducting the assessment we made sure to only focus on his 50 acres North West portion of the land when flying the drone. Drone deploy software was used for accurate capture of images and control of the drone.

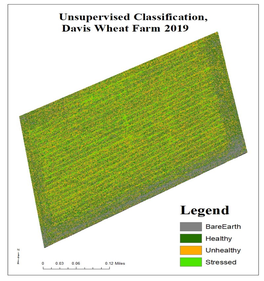
Flow chart

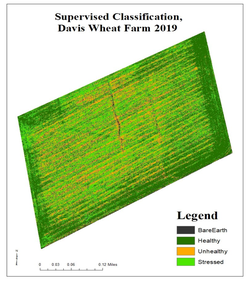


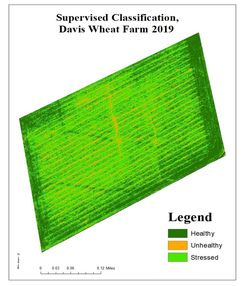
Results

Flight 1 Images:

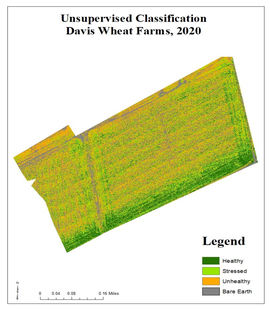


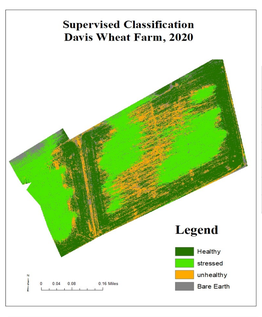






Flight 2 Images:

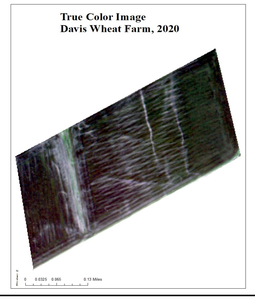


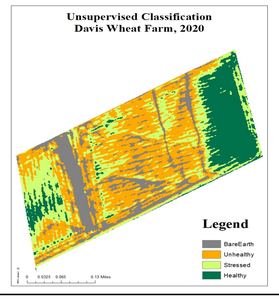


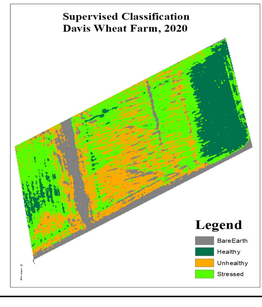
Accuracy Assessment

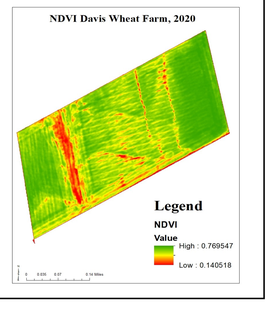
	A	B	C	D	E	F
1	class	rast_refpo1	rast_refpo2	rast_refpo3	rast_refpo4	Groundtruth
2	healthy	9	0	1	0	10
3	unhealthy	0	10	1	0	11
4	stressed	1	0	7	4	12
5	bareEarth	1	0	1	6	8
6	total	11	10	10	10	41
7	Accuracy	0.780487805				

Satellite Images:









Discussion

- The first flight was taken during the first stage of growth which is approximately one month of growth, and during this stage, it is normal for the wheat plant to seem under stress because their shaft and roots have not yet fully grown. Our analysis revealed that supervised classification gives a more accurate analysis over the unsupervised classification, so we are going to focus on analyzing the results from supervised classification.
- The second flight was done during the second growth stage of wheat which is approximately two months and our analyses using datasets from both sources (aerial photo and satellite image) revealed a similar pattern of growth in some parts of the agricultural field. For example, classification based on the aerial (drone) photo shows an estimated 30 acres kilometer of stressed vegetation on the northwestern fringes of the agricultural field; on the other hand, the satellite image-based assessment of the same area including image classification and NDVI analysis shows a more or less comparable area of stressed vegetation. The third image is a satellite image that was obtained a month after the second flight. A third flight with the drone was planned near the same time as the satellite image acquisition but was canceled due to the current health crisis.
- In this scenario, near 2/3 of Davis wheat farm's crop is experiencing stress and with the help of drone images, the farmer can respond immediately to this problem and its root causes that are impacting the agricultural productivity, unlike satellite images that are acquired at wider time intervals and require complex processing steps before being delivered to the user.
- The results obtained from the data analysis are considered reliable as an accuracy assessment was done, and it revealed that there was a 78% level of accuracy which considered to a good level of certainty.

Conclusion

The application of Precision Agriculture (PA) done through the analysis of Davis Wheat Farm using supervised classification of drone images and satellite acquired images showed us that remote sensing in agriculture does not require high-end costly satellite images to obtain accurate results. There are clear similarities between the results obtained by the UAV and the satellite, with a slight advantage to the UAVs (drone) over satellite for farmers who want to assess the health of their crops because of its flexibility and fast results.

One major concern of PA for farmers was cost. As observed there was a wide price difference between the results of the drone and those of the satellite. The Mavic Air drone combo cost was $1000 with insurance, and from then an individual can assess the health of his field conveniently with no added cost for as many times as they want for years. On the other hand, a single image obtained from Apollo satellite imaging cost between $350-$500 depending on the area being evaluated. The extremely low cost of drone images is a major advance in PA and farmers can now take advantage of this technological advance to improve the yield of their crops overall. Furthermore, UAVs offer an added flexibility of obtaining images of any desired area at any desired time, while for satellite images one has to wait for the satellite to pass through that area.

We can not also forget one major advantage of UAVs over satellite in precision agriculture is the ability of UAVs to assess small scale areas and provide clear results. As it is our case of Davis Wheat farm which is only 50 acres, results from the UAV were slightly more clear that satellite images which were a little pixelated.

All in all, advance in Precision Agriculture using UAVs have made it possible for small scale farmers as well as large scale farmers to have in their hands the ability to analyze the health situation of their fields at a lower cost with fewer expenses.

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