The use of UAS imagery equipped with multispectral camera for Precision Agriculture applications

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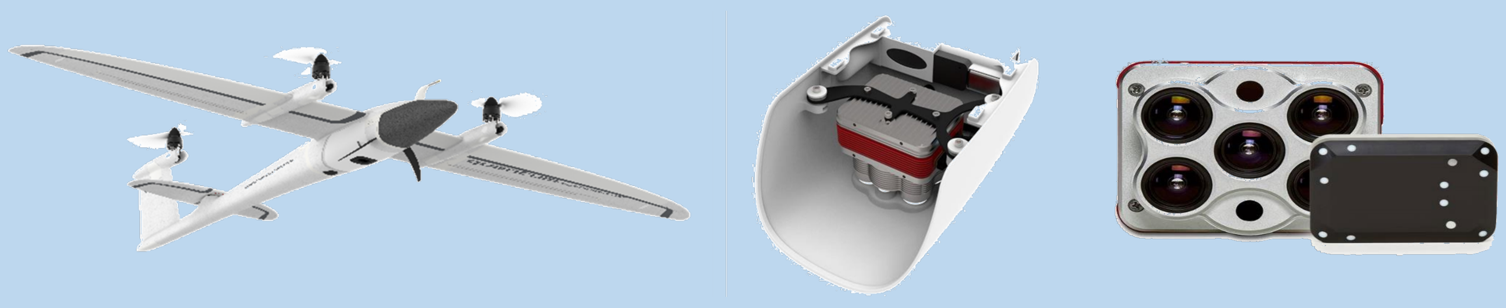


Figure 1. The data were acquired with a MicaSense RedEdge-MX camera mounted on a Quantum Trinity F90+ UAS.

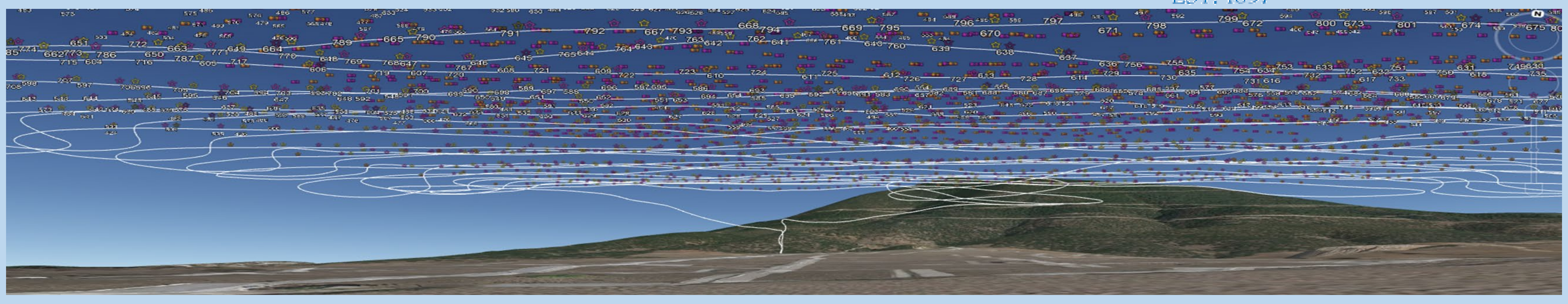


Figure 2. Surveying over the study area for the acquisition of 4040 multispectral images.

Abstract

Precision Agriculture (PA) tends to become a contemporary trend nowadays, as agriculture constitutes a really big part of economy with great social impact around the world. Among the advantages of using Precision Agriculture (PA) are the decrease in cost, time and human resources.

Aerial remote sensing data processing and interpretation is a modern way of recognizing and classifying vegetation, within high resolution and precision imagery outputs, which can be utilized for further image processing and classification such as in Normalized difference vegetation index NDVI, Modified Chlorophyll Absorption Ratio Index, MCARI, and Modified Soil-Adjusted Vegetation Index, MSAVI. The application of such thematic products may lead to the best decisions for the most prominent ways of interference during the entire cultivation process. Using unmanned aerial systems (UAS), onboard sensors and GNSS for better precision and of course high residual multispectral images with several bands which can give precious information after being post processed, the data acquisition phase has become relatively easy and with the lowest cost, not to mention the frequent update upon request. In this work, we present a multispectral flying platform. The proposed solution is based on a commercial Quantum Trinity F90+ drone equipped with a combination of a high-resolution RGB camera UMC R10C and a multispectral MicaSense RedEdge-MX camera.

Introduction

Global plant production has come to the point where the rapidly growing population and the reduction of natural resources makes it more than critical to find new ways to improve productivity. Close range remote sensing techniques could be the key for introducing new practices for vegetation monitoring that would not only increase the amount and the quality of the production, but also environment protection would be a priority too.

The contribution of unmanned aerial systems (UASs) in monitoring different aspects of earth cultivation improvement has several advantages:

- they can fly at low altitudes and provide high-quality images with high resolution which allows a more detailed inspection of vegetation
- flexibility of the scheduled flights concerning the needs of the conditions
- the use of different systems that can be adjusted on UAS, such as multispectral cameras, in order to succeed different spectral ranges (visible, infrared, thermal) of visualizing the vegetation
- create digital surface models (DSMs) with the use of high-quality overlapping images

The above mentioned make it clear that UAS is a reliable and cost-effective tool that can collect data such as digital images for being used in agroforestry and vegetation monitoring with excellent precision and avoiding manual fieldwork inconsistencies.

Methodology

In this work, we are presenting, in summary, the methodology that was followed in order to have a better perception of the vegetation of a pilot area, applying several spectral ratios to the model that we created using the Quantum Trinity F90+ and the multispectral camera MicaSense RedEdge MX, which was mounted on it. The image georeferencing was established with PPK (Post Processing Kinematic) technique by using the RINEX data recorded from the Hexagon SmartNet GNSS Network, which in turn ensure extremely high accuracy. This work analyses the use of UAS in precision agriculture, emphasizing in the great potential of UAS high-resolution multispectral image data and the appliance of different Vegetation Indices. After the flight of the Trinity F90+ with the mounted multispectral camera, the collected data were processed using automated photogrammetric procedures and produced multi-band ortho-images where several described Vegetation Indices were applied.

Table 1 .Relative geolocation error for the photogrammetric model

	Geolocation Error X [%]	Geolocation Error Y [%]	Geolocation Error Z [%]
Mean [m]	-0.000500	-0.001690	0.001384
Sigma [m]	0.744996	0.242442	0.319213
RMS Error [m]	0.744997	0.242448	0.319216

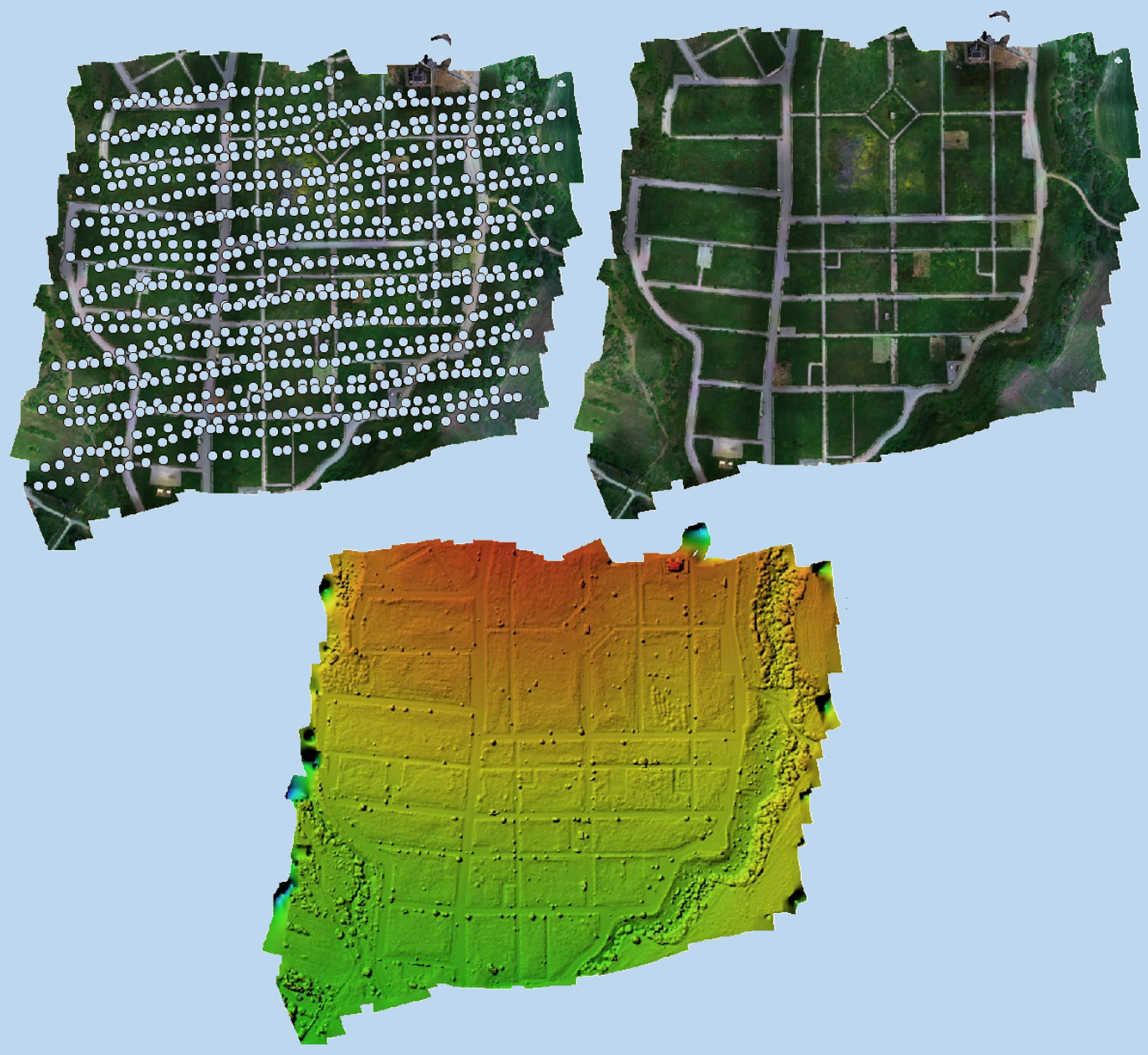
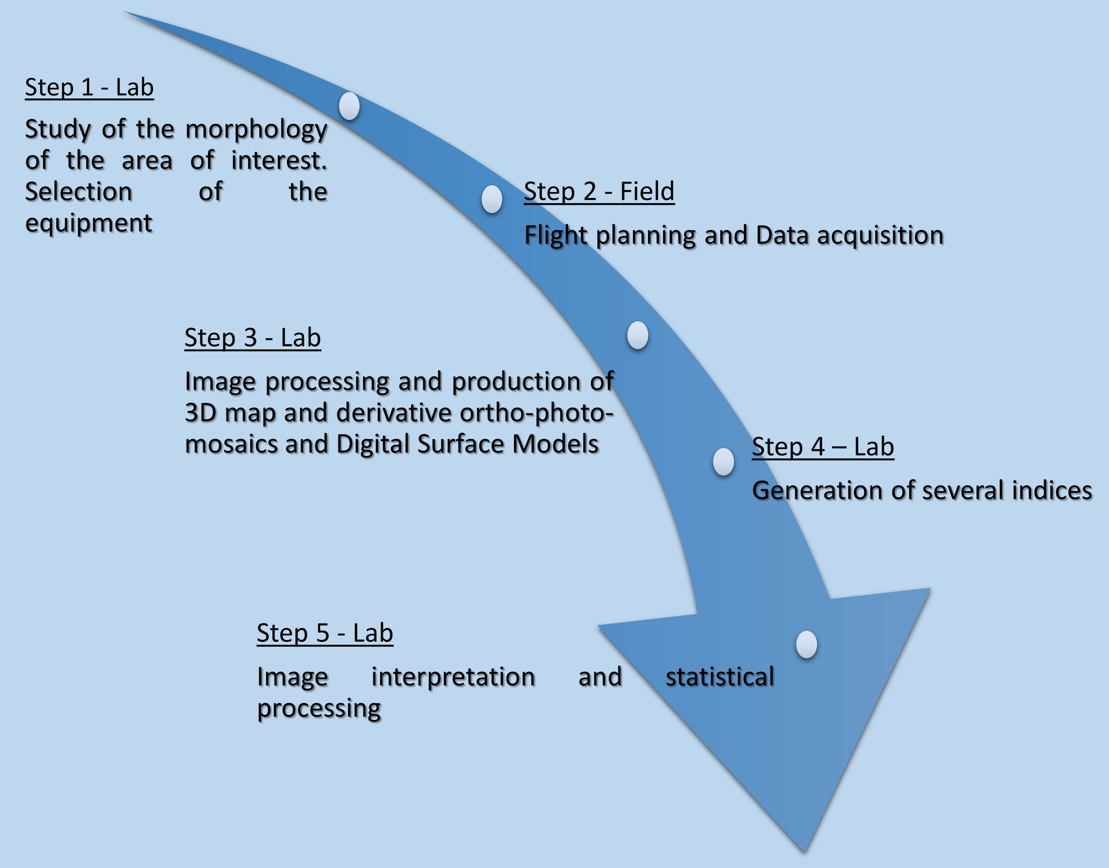


Figure 3. Map view of the camera locations at the time of the image acquisitions. Ortho-photo-mosaic and DSM as results of the photogrammetric processing.



Results

Figure 4. **Normalized Difference Vegetation Index** (NDVI) is calculated using the red and near-infrared wavelengths of the spectrum reflected by vegetation. Healthy vegetation absorbs most of the red light that hits on it and reflects a large portion of the near-infrared spectrum. Unhealthy or sparse vegetation reflects more red light and less near-infrared.

Figure 7. **Blue Normalized Difference Vegetation Index** (BNDVI) is much similar to NDVI except that instead of the red wavelength of the spectrum it uses the blue wavelength of the spectrum (NIR-Blue)/(NIR+Blue). This is an indicator of for areas that are sensitive to chlorophyll content.

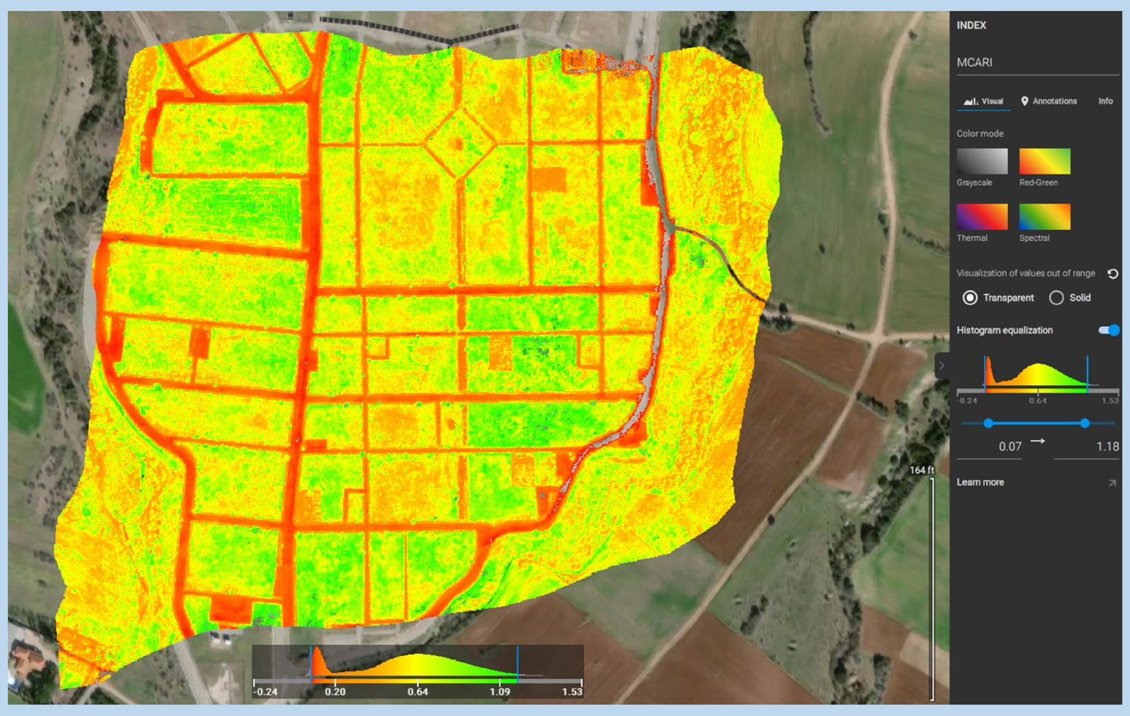


Figure 5. **Modified Chlorophyll Absorption in Reflectance Index** (MCARI) gives a measure of the depth of chlorophyll absorption and is very sensitive to variations in chlorophyll concentrations as well as variations in Leaf Area Index (LAI). MCARI values are not affected by illumination conditions, the background reflectance from soil and other non-photosynthetic materials observed.

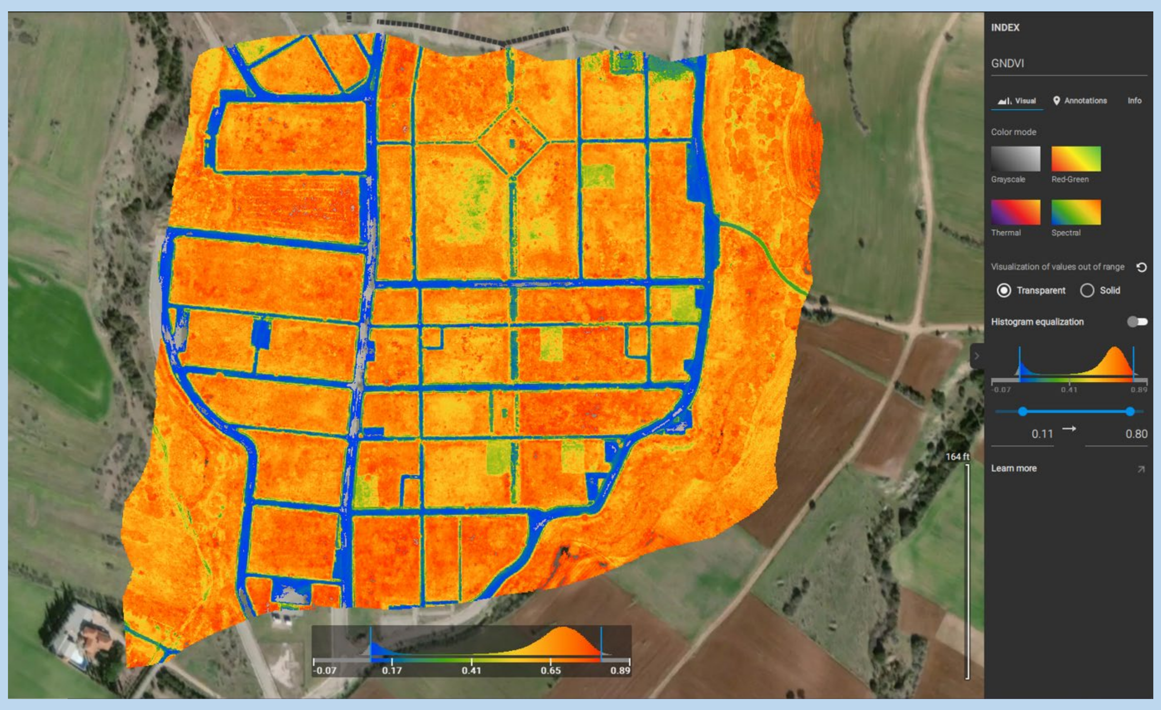


Figure 8. **Green Normalized Difference Vegetation Index** (GNVI) uses the green and the infrared wavelengths of the spectrum (NIR-Green)/(NIR+Green). Its results give an indicator of the photosynthetic activity of the vegetation cover. It is most often used in assessing the moisture content and nitrogen concentration in plant leaves and is preferred when the multispectral data do not contain an extreme red channel. Compared to the NDVI index, it is more sensitive to chlorophyll concentration and is used in assessing depressed and aged vegetation.

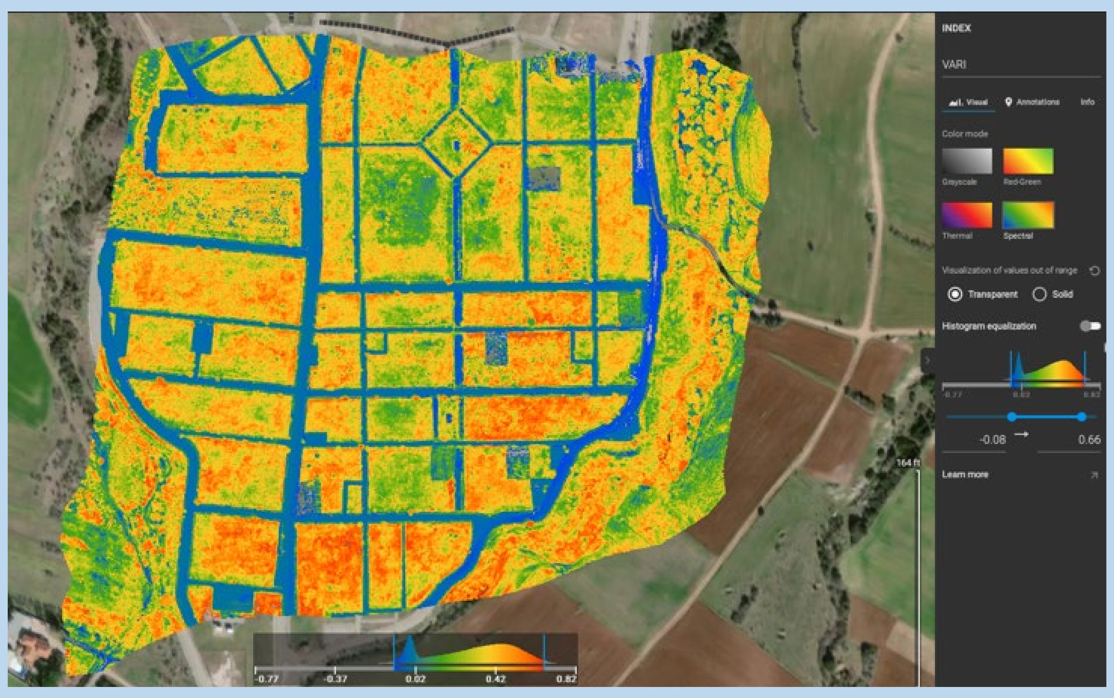


Figure 6. **Visible Atmospherically Resistant Index** (VARI) index is perfect for RGB or color images since it works with the whole visible segment of the electromagnetic spectrum (comprising red, green, and blue color bands). Its specific task is to enhance vegetation under strong atmospheric impact while smoothing illumination variations.

Discussion - Conclusions

As satellite imagery is very often compromised by cloud cover (as it happened in the case at hand for several days) and, apart from radar imagery, UAV imagery may be **the only affordable source of aerial views** on demand, not only for scientific but also for production purposes. Nowadays the increasing need in precision farming led the scientific community to find the strategies that could improve the crop production and reduce the use of pesticides that cause environmental pollution. Using several indices, we can reliably spot the unhealthy crop and help farmers to make the right decisions in order to save their income.

The rational use of pesticides and fertilizers in agricultural areas is of high importance as they maintain and ensure the quality and quantity of the crop production. It is a fact that several issues may affect these processes, such as:

- Uneven spread of chemicals.
- Skipping or overlapping some crop areas while spraying
- Climatic condition impacts such as wind which can affect the direction of spraying
- Possible damage to plants when using ground sprayers
- Human exposure to chemicals.

UAVs' abilities to be controlled from a distance on the ground as the surface varies, and help creating high-resolution field maps, is essential for spraying the correct amount of chemicals in real time. UAVs could reduce the amount of pesticide and fertilizer application by 15–20%, simply by using a low volume of spray, which in turn contribute to minimizing the amount of chemicals that enter and pollute the groundwater. It is estimated that a UAV based pesticide application could be up to five times faster than traditional ways and can remarkably reduce the concern of chemical drift.

Undoubtedly high-resolution UAV images could be a fast, reliable, and low-cost resources of data in farming and could possibly even remove the need of field inspections entirely. The offered number of spectral bands provided by the used multispectral camera can increase the limits of the image interpretation concerning vegetation analyses.

However, the UAV approach for precision farming represents an extremely dynamic sector. In the future the equipment and methods related to this approach will be extensively used. The main limitation in our work was the lack of ground spectrum measurements, which could give a more complete aspect of the surface electromagnetic radiation reflectance .

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