B1.8 Precision agriculture mapping – drones

Drones have been widely applied in the agriculture sector in the past few years. Incorporating artificial *intelligence* (AI), *sensors*, *microcontrollers*, and the *Internet of Things* (IoT) into the drones can help overcome the challenges faced by the farmers, such as livestock monitoring, wide land area, crop spraying, and in-depth crop health analysis.

A drone is typically equipped with global positioning systems (*GPS*), *propellers*, *brushless motors*, a *flight controller*, and electronic *speed controller* (ESC), and it is controlled by the *radio channel transmitter and receiver.*

What makes a drone interesting is that it can be modified according to our own needs by installing some hardware and algorithms on it. It can perform tasks such as in-depth analysis on the plant and soil conditions; 3D mapping of the agriculture land; and pesticides and fertiliser distribution, which is very difficult to be achieved by manual labour, especially for thousands of hectares of land. Compared to remote sensing using satellites, employing drones in precision agriculture provides a higher functionality, and enables a better spectral and spatial resolution.

Different types of drones are currently available on the market which can be applied in precision agriculture.

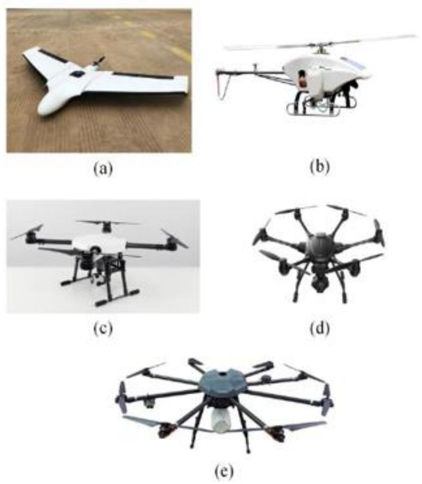
Drones can be distinguished into two groups:

a) Fixed wing drone.

b) Multi-rotor drone.

Fixed wing drones consist of a pair of wings which passively generate lift for the drone as it cuts through the air at a specific angle whereas a multi-rotor utilises the speed and direction of the motors to move.

A multi-rotor can be further divided into a single rotor, a quadcopter, a hexacopter, and an octocopter. Compared to the fixed wing drone, a multi-rotor has a lower flight speed, distance, and duration because it needs a huge amount of power to generate lift and stays aloft.



a) Fixed wings, b) single motor, c) quadcopter, d) hexacopter, e) octocopter (Source 3)

Commercial drones

Parameters of some commercial drones used for precision agriculture:

Drone	Commercial drone suitable for mapping and crop monitoring					
	Type	Flight time	Max Speed	Max Distance	Max Altitude	Camera
DJI Phantom 4 RTK	Quadcopte r	30 min	16 m/s	7 km	56 m	20 mp CMOS sensor (GSD to 5 cm)
Delair UX11	Fixed-Wing	52 min	15 m/s	47 km	122 ,	RGB, multispectral camera (GSD to 5 cm)
DJI Matrice 200	Quadcopte r	38 min	22.5 m/s	8 km	–	Camera comes separately

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Drone	Commercial drone suitable for crop spraying task				
	Type	Flight time	Flow Rate	Max Distance	Tank Capacity
DJI Agras T20	Hexacopter	15 min	6 1/min	3 km	20 l
DJI MG-1P	Octocopter	20 min	0.53 1/min	5 km	10 l
Hylio AG-122	Octocopter	15 min	4.3 1/min	2 km	22 l

From: https://www.fig.net/resources/proceedings/fig_proceedings/fig2017/

Sensors

Sensors on drones are an important part of the technology. Technical equipment also contributes significantly to the price of the drone. How do sensors work?

The *sensors* can detect very subtle differences in vegetation that would remain hidden under normal observation. Drones that are equipped with *multispectral* or *thermal cameras* will help identify a wide range of issues related to plant and soil health. They can show early signs of pest infestation, stress and disease which will allow farmers to take quick action and mitigate the issue before they become a serious problem.

Another benefit of drones in agriculture is that because they are so easily deployable, farmers will be able to collect data on a more regular basis, giving them up to date insight on the state of their fields and allow them to keep on top of any problems before they escalate.

Which are the most important applications of drones in farming practice?

Crop Sprayin

A drone spraying mechanism is very useful in the agricultural sector as it can be used to *spray water* and spread *fertilizer* and *pesticides* in an efficient way.

By implementing this system, farmers can access land that is either too wet or otherwise inaccessible by humans. Another benefit of this application is the reduced involvement of humans in the pesticide spraying operation, which greatly reduces the risk of chemical contamination. Also, the spraying heights by this means are usually higher than conventional ground sprayers, where fragile crops might experience some damage if the spraying height is too low. The major downsides of this approach are the limited flying time and amount of liquid (spraying content) that the drone can carry. Drone spraying systems typically consist of a spray tank to store the liquid and nozzle for spraying. A pressure pump is usually applied in pesticide spraying but not in fertiliser spraying.

Crop Monitoring

Monitoring the crop condition especially during the growth stages is essential to farmers. The information obtained will influence the decision-making on the timely interventions from the farmers to ensure optimal yield at the end of the season. The camera plays an important role in providing the required information on the crop condition. The widely used cameras are *digital*, *thermal*, *and*

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multispectral types. Thermal cameras are equipped with an infrared sensor which can develop a thermal map containing temperature data of the crop.

Example: The farmer can quickly have a general view about the situation of the field only by looking at *orthomosaics*[1]. The farmer may know that there are weeds in the parcel; however, the visual analysis of orthomosaics can allow detecting more detailed information about problems, like infestations, and comparing the perspective from ground level. Thus, the farmer can plan possible plant protection tasks and their timings based on the orthomosaics.

Source: www.ijetae.com

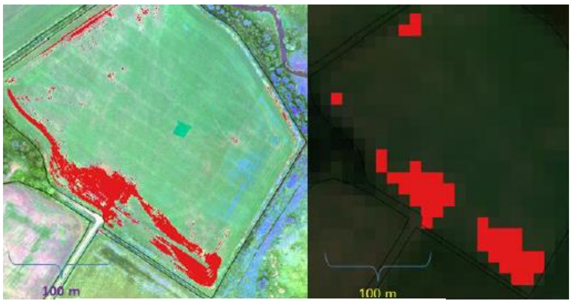
Digital images from digital cameras can be processed to extract red-green-blue (RGB) colour information whereas multispectral cameras can capture visible and invisible photos of the crop by employing different wavelengths of light to develop a set of photos for that wavelength, which is then combined to produce an accurate mosaic. After analysing the images, the physical inspection by farmers on the concerned area is recommended.

Mapping and Soil Analysis

Mapping and soil analysis are closely related in a way that the results from aerial mapping can be used to further analyse the soil condition and estimate the crop yield. Mapping can be conducted manually or automatically via drones according to a predefined route. Following this route, land images are automatically taken by the onboard camera which later are processed through specific software.

Example: The difference between detecting drone and satellite data can be seen in the analysis of anomaly detection. The aim of anomaly detection is to detect areas which are not developing in the same way as most parts of the area. The anomalous areas (marked in red) are quite similar in both data sets.

The drone dataset (left) has indicated more anomalies than the Sentinel dataset (right).



Source: www.ijetae.com

Livestock Monitoring

Monitoring livestock using drones has drawn considerable attention from farmers. The livestock images captured by the drone can be analysed to determine the *number and behaviour of the livestock*, which are later transmitted to the monitoring devices in real-time so that farmers can act accordingly. This approach is very efficient especially when it comes to monitoring livestock on a large agricultural land, as well as tracking human poachers.

How much does a drone cost?

[1] Orthomosaics: A large, map-quality image with high detail and resolution made by combining many smaller images called "orthophotos".

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These range from €1.500 to over €25.000 for a commercial grade spraying drone. To this, one must add the equipment for the acquisition of monitoring technology and corresponding SW equipment. The total price can thus reach up to €40,000.

Spending roughly €40.000 for a drone may seem like a lot. But these drones are robust and durable, so they will continue providing cost-saving benefits for years to come. The return on investment will depend on the size of the agribusiness, the number of crops or stock the farmer is working with, and the frequency of planting and spraying. When the drone works on a larger area for a longer period of time, it will obviously mean a sooner return on investment.

How drones manifest themselves in different areas of agricultural production (data from IJETAE Journal, Issue 04, April 2022):

	Drone Application				
	Crop spraying	Crop monitoring	Mapping and soil analytics	Livestock farming	Planting
Flight time	High	High	High	High	High
Altitude	Medium	High	High	High	Medium
Distance	High	High	High	High	High
Camera	Low	High	High	High	Low
Payload	High	Low	Low	Low	Medium

There is no simple answer, there are many factors that will determine *what type of drone farmers should invest in.* One key factor will be the size of the fields to be mapped; farmers who own small-to-medium sized farms should probably invest in a multi-copter drone, whilst mapping large fields is more suitable with fixed-wing drones. Both multi-copter and fixed-wing drones have their advantages, multi-copter drones are usually less expensive and easier to operate. They have better manoeuvrability which will allow farmers to carry out close up high-resolution inspections of plants from low altitudes, fixed-wing drones are not capable of flying at really low altitudes.

Another benefit of multi-copter drones is that they only need a small area to take off and land, whilst fixed-wing drones require a much larger area. The one major disadvantage with multi-copters is their flight time (when compared to fixed-wing drones).

Summary

A drone is equipped with a global positioning system (GPS), propellers, brushless motors, a flight controller, and an electronic speed controller (ESC), and it is controlled by the radio channel transmitter and receiver. A drone can be distinguished into two groups: a) fixed wing drone and b) multi-rotor drone. Drones that are equipped with multispectral or thermal cameras will help identify a wide range of issues related to plant and soil health. They can show early signs of pest infestation, stress and disease which will allow farmers to take quick action and mitigate the issue before they become a serious problem. Drone spraying mechanisms are very useful as they can be applied to spray water, fertilisers, and pesticides in an efficient way. This enables the farmer access to land that

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is either too wet or otherwise inaccessible by humans. No involvement of humans into pesticide spraying operations reduce the risk of chemical contamination. Monitoring the crop condition influences the decision-making on the timely interventions to ensure optimal yield at the end of the season. Mapping and soil analysis are closely related to analysis of the soil condition and estimation of the crop yield. Mapping can be conducted manually or automatically via drone according to predefined route. Following this route, land images are automatically taken by the onboard camera which later are processed through specific software. Monitoring the livestock using drones is used to determine the number and behaviour of the livestock. This approach is very efficient especially when it comes to monitoring livestock on a large agricultural land, as well as tracking human poachers. The price of a drone with cameras and other monitoring equipment ranges from €25,000 to €40,000.

Links to relevant topics

1) Udit Debangshi: Drone -Applications in Agriculture, DOI: 10.5281/zenodo.5554734, DOI: 10.5281/zenodo.5554734

2) Roope NÄSI, Eija HONKAVAARA, at all. 2017 "Surveying the world of tomorrow - From digitalisation to augmented reality", Conference *FIG Working Week*, https://www.fig.net/resources/proceedings/fig_proceedings/fig2017/

3) International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (E-ISSN 2250-2459, Scopus Indexed, ISO 9001:2008, Volume 12, Issue 04, April 2022

Key words

drone
artificial intelligence
sensors
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speed controller (ESC)
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fixed wing drone
multi-rotor drone
multispectral cameras
thermal cameras
spray water
digital camera
thermal camera
multispectral camera
orthomosaics

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