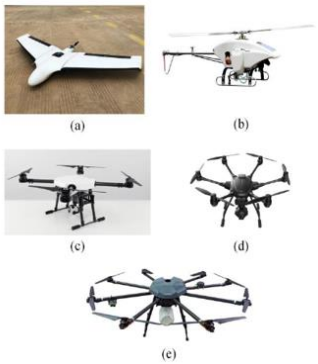
B8. Precision agriculture mapping – drones

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.

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

What makes 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 fertilizer distribution, which is very difficult to be achieved by manual labour, especially for thousands of hectares of land. Compared to the remote sensing using satellites, employing drones in precision agriculture provides a higher functionality, and enables a better spectral and spatial resolution.



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

Different types of drones currently available in the market which can be applied in precision agriculture. Drone can be distinguished into two groups: a) *fixed wing drone* and b) *multi-rotor drone*.

Fixed wing drone consists of a pair of wings which passively generates lift for the drone as it cut through the air at a specific angle whereas multi-rotor utilizes the speed and direction of the motors to move.

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

Example: 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	Quadcopter	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	Quadcopter	38 min	22.5 m/s	8 km	–	Camera comes separately

Drone	Commercial drone suitable for crop spraying task				
	Type	Flight time	Flowrate	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

Sensors. Sensors on drones are an important part of the technology. Technical equipment also contributes significantly to the price of the drone. How 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 Spraying. Drone spraying mechanism is very useful in agriculture sector as it can be applied to *spray water, fertilizers, and pesticides* in an efficient way. By implementing this system, farmers can access land that is either too wet or otherwise inaccessible by humans. Other benefit of this application is the involvement of humans from pesticide spraying operation, which greatly reduce the risk of chemical contamination. Also, the spraying heights by this mean 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 system typically consists of spray tank to store the liquid and nozzle for spraying. Pressure pump is usually applied in pesticide spraying but not in fertilizer 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. Camera plays an important role in providing the required information on crop condition and the widely used cameras are *digital, thermal, and multispectral* types. Thermal camera equipped with infrared sensor can develop a thermal map which contains temperature data of the crop.

Okomentoval(a): [HJ1]:

Example: The farmer can quickly have a general view about the situation of the field only by looking *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, comparing the perspective from ground level. Thus, the farmer can plan possible plant protection tasks and their timing based on the orthomosaics.

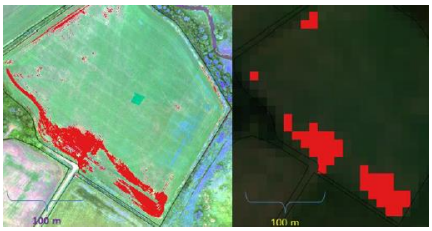
Digital images from digital camera can be processed to extract red-green-blue (RGB) colour information whereas multispectral camera can capture visible and invisible photos of the crop by employing different wavelengths of light to develop a set of photos for that wavelength, which is then combined to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

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

defined 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 of 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 of the most parts of the area. The anomalous areas (marked on red) are quite similar in both data sets.
The drone dataset (left) has indicated more anomalies than Sentinel dataset (right).



Livestock Monitoring. Monitoring the livestock using drones has drawn considerable attention from the farmers. The livestock images captured by the drone can be analysed to determine the *number and behaviour of the livestock*, which 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 do drone cost? These range from 1.500 EUR to over 25.000 EUR for a commercial grade spraying drone. To this, one must add the mood for the acquisition of monitoring technology and corresponding SW equipment. The total price can thus reach up to 40,000 EUR.

Spending roughly 40.000 EUR for a drone may seem like a lot. But these drones are robust and durable though, so they'll 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 working with, and the frequency of planting and spraying. When the drone will work on a larger area and for a longer period of time these will obviously mean the 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 really 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:

Drone is equipped with global positioning system (GPS), propellers, brushless motors, flight controller, and electronic speed controller (ESC), and it is controlled by the radio channel transmitter and receiver. 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 mechanism is very useful as it can be applied to spray water, fertilizers, and pesticides in an efficient way. This enables the farmer access to land that 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 pre-defined 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 EUR.

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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

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Key words:

drone
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