

Unmanned aerial vehicle

and its application in Indian Agriculture: A perspective

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In India, crop failures are common, unpredictable and difficult to deal due to the sheer scale. Food and nutritional security is a question that needs to be addressed in the context of environmental pollution, water scarcity and climate change, and a viable solution is crucial. Unmanned aerial vehicle (UAV)/drone can assure a sustainable solution to agriculture through its application in soil fertility assessment and mapping; monitoring of plant health, stress identification and mapping, crop insurance, irrigation and drainage planning, resource mapping, natural hazards damage assessment, and plant protection spray. The next revolution in agricultural will be driven by data, which will help to increase agricultural production with minimum harm to the environment and increase profits of farmers. Overall, UAV/drone technology has enormous opportunities to apply it in the field of agriculture with few challenges which need to be addressed before its actual application in the large field scale.

Key words: Drone, India, Unmanned aerial vehicle, UAV sensors

UNMANNED aerial vehicles (UAVs), popularly known as drones is an aircraft with no human pilot on-board. The UAV refers to the unmanned aircraft. Drones are operated remotely by a human operator or autonomously using the embedded autopilot. UAV is a tool to lift a camera/payload to generate data, the UAV itself is not the product. The term unmanned aerial system (UAS) denotes the larger portion of the UAV, the pilot located elsewhere controlling the aircraft via a ground control station (GCS) through wireless connections plus the sensor mounted on the UAV and the software that is used to process and analyse the data collected by the sensor.

UAV use in agriculture to help increase crop production and monitor plant growth. UAV let farmers see their fields from the sky. This bird's-eye view can reveal several issues such as moisture stress, soil fertility variation, and insect pest and disease infestations. The drone can inspect the crops for the farmer regularly to

their liking. Weekly, or even daily, pictures can show the changes in the crops over time, thus showing possible “trouble spots”. Having identified these problematic spots, the farmer can try to improve crop management and production.

Why Drones? Why not remote sensing?

Satellites offer expensive services and do not satisfy the increasing need for high spatial and temporal (repeated controllable measurements) resolution. For example, monitoring of crop health and soil properties. UAVs have been proposed for repetitive tasks that are considered long and monotonous for humans or even dangerous.

Types of UAV/Drones

Based on the type of aerial platform used, there are 4 major types of drones namely Multi-Rotor, Fixed Wing, Single Rotor Helicopter and Fixed Wing Hybrid VTOL (Fig. 1).

Out of all the 4 drone types, multi-

rotor drones are the easiest to manufacture and cheapest option available as well.

Multi-Rotor Drones

These are the most common types of drones and commonly used for aerial photography and video surveillance. Based on the number of rotors on UAV, it further classified as Tricopter (3 rotors), Quadcopter (4 rotors), Hexacopter (6 rotors) and Octocopter (8 rotors). Out of these, Quadcopters are the most famous and commonly used. In multi rotor drones, the majority of its energy (possibly from a battery) is spends to fight gravity and stabilize themselves in the air. Due to this, it has limited flying time (20 to 30 minutes), limited endurance, minimal payload and speed. In general, quadcopters are more stable than octocopters. In aerodynamics, the lower the count of rotors the lesser will be the spin of the object. That's the big reason why quadcopters are more stable than octocopters. In that sense, single

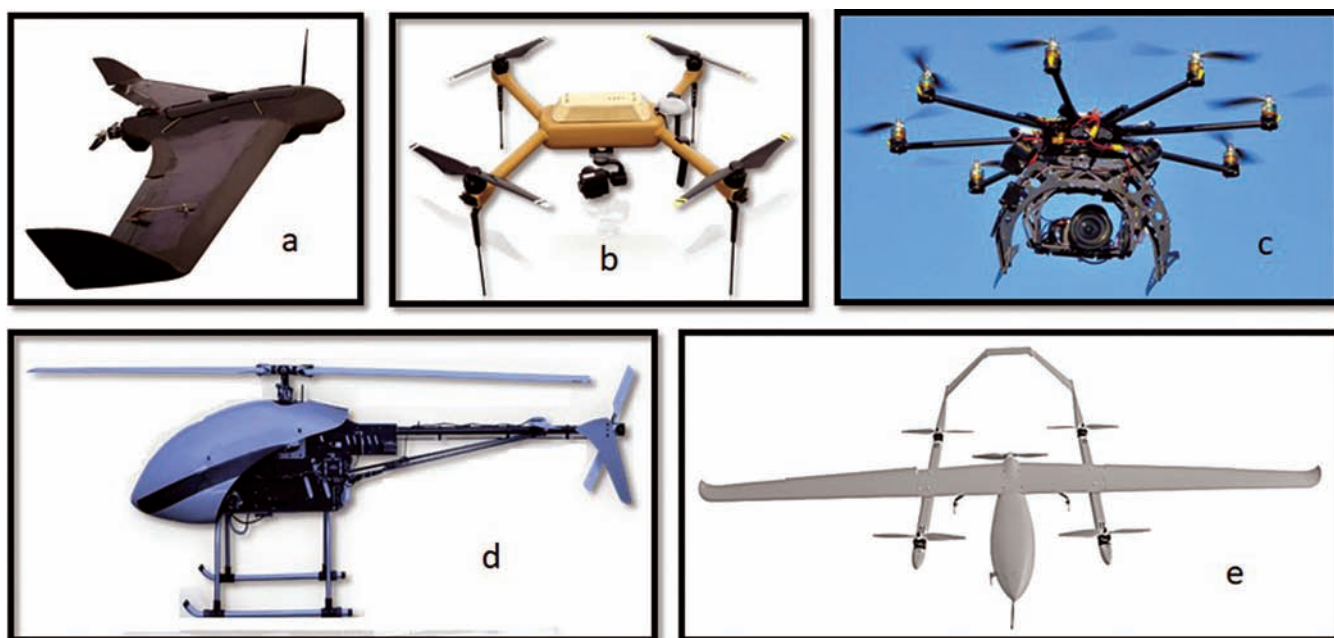


Fig. 1. a) Fixed-wing drone b) Multi-rotor drone – Quadcopter c) Multi-rotor drone – Octocopter d) Single rotor drone e) Vertical Take-Off and Landing

rotor drones are much efficient than multi-rotor drones.

Fixed Wing Drones

It uses a ‘fixed wing’ like the normal aeroplanes and uses minimal energy to stay afloat on-air and fighting gravity. It cannot stand still on the air instead, move forward on their set course (flying path) as long as their energy source permits. It has an average flying time of a couple of hours. Fixed-wing drones are mostly used for long distance operations like aerial mapping and surveillance due to their higher flying time and fuel efficiency. However, it is not used for aerial photography as it cannot be kept still on the air for a while. The cost of fixed-wing drones are higher and it requires skill to fly. Take-off and landing of the fixed-wing drone are not easy. It needs either a ‘runway’ or a catapult to launch and a runway or a parachute or a net is again needed to land them back in ground safely.

Single Rotor Drones

It looks very similar to actual helicopters in design and structure. It has just one big-sized rotor plus a small-sized one on the tail of the drone to control its heading. It has higher flying times since it is much efficient than multi-rotor versions. However, these machines come with

much higher complexity and operational risks and high cost. It needs special training to fly them properly. The large-sized rotor blades often pose a risk (deadly wounds) if the drone is involved in an accident.

VTOL (Vertical Take-Off and Landing)

These are hybrid versions combining the benefits of fixed-wing (higher flying time) with that of rotor based models (hover). A vertical lift is

used to lift the drone into the air from the ground. Gyros and accelerometers work in automated mode (autopilot concept) to keep the drone stabilized in the air.

The different types of camera/sensors used for imaging in a UAV system are RGB camera, Thermal/ Near IR camera, Multispectral camera and Hyperspectral camera.

Different types of sensors and its application in agriculture is given in Fig 2.

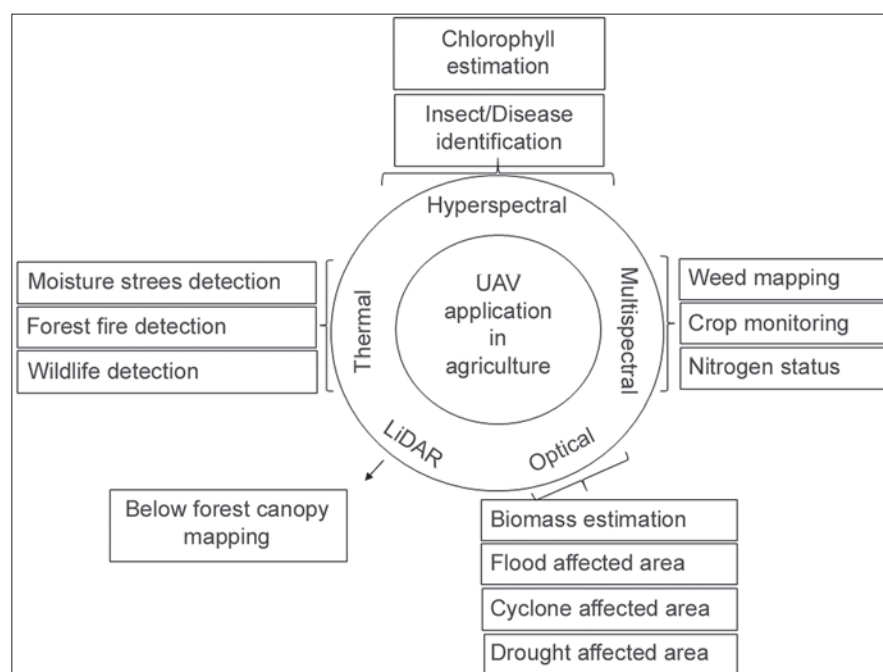


Fig. 2. Sensors and its application in agriculture

Drones applications in agriculture

Soil fertility assessment

Drone imagery is useful to extract soil characteristics viz. slope, moisture, problem soil identification and mapping. It helps the farmers to apply just the right rate of fertilizer, reduce wastage, and maximize production. The Digital Surface Model (DSM) of bare soil and crop and multispectral orthophotos were processed using various software like Agisoft Photoscan, OpenDroneMap, Pix4D Mapper photogrammetry, DroneDeploy Enterprise 3D Map, Maps Made Easy orthophoto and 3D models, PrecisionHawk 3D map. Multispectral and multi-temporal orthomosaics imagery are useful to delineate homogeneous zones for the management of agricultural inputs with optimal ground resolution.

Plant emergence and crop health monitoring

Using drone imagery user can drive plant population, days to emerge, and spacing information to take decisions on replanting, thinning, gap filling and pruning activity. UAV imagery provides more efficient crop insights and helps to plan field operations more accurately to increase input efficiency. Multispectral sensors mounted on UAV can collect images that are stitched to produce spectral reflectance bands. These bands permit users to derive indexes such as a Normalized Difference Vegetation Index (NDVI), Photochemical Reflectance Index (PRI) and Leaf Area Index (LAI), allowing farmers to identify crop stress before it becomes much severe and invisible to the human eyes. It also used to predict harvest date and estimation of yield well in advance.

Crop protection: Target or location-specific spraying of chemicals

Pesticide footprint on agriculture field and food produce can be reduced through use of drone/UAV for spraying of crop protectants to control insect pest/disease infection. In conventional methods, pesticides are sprayed entire field, while site specific treatment using UAV allow site

specific spraying of crop protectants and thereby reduce the pesticides load in agroecosystem. Approximately use of UAV drone can save upto 20% of the pesticides. Use of drone for spraying also helps in covering a large area in a short period. Digital outputs produced through drones can guide the proper and efficient application of crop protection products. A 'smart agricopter' has been developed by the students of the prestigious Indian Institute of Technology (IIT) Madras to eradicate manual spraying of pesticides in agricultural fields and help recognize crop health through an imaging camera. It allows spraying pesticides 10 times faster and with 100% precision at the same price as manual spraying.

Irrigation and drainage

UAV equipped with RGB and/or thermal infrared sensors can be used to plan and troubleshoot drip irrigation system. Using UAV signatures, user can easily identify clogged emitters and repair it immediately for efficient irrigation supply. This, in turn, helps to manage the water flow and usage across an operation.

Tree/plant species identification and classification

UAV imagery is highly effective in distinguishing tree/plant species. It is also used in weed mapping and new species identification. The multispectral ortho-mosaic image derived from UAV was classified into 'weed'/'no weed' classes through various machine learning algorithms (unsupervised and supervise classification) and geo-referenced observations. Many others have reported the overall accuracy (OA) of 75 to 90% in weed mapping.

Resource mapping:

One of the foremost applications of the drone in agriculture is for mapping of the resources and crop area.

Reaching the unreachable

Information about the area which is difficult to access to human such as difficult terrain, waterlogged area etc. are easily collected through drones. Similarly, timely monitoring and early

detection of any infection in tall and large orchard crops are easily collected through drones.

Crop insurance

On-demand basis, rapid high-resolution UAV data is collected to derive accurate area affected by natural disasters such as flood, drought, insect and disease damage. UAV data also facilitate cross-checking of data at any time which is not possible in case of manual assessment. The accuracy of UAV data is very high and less erroneous. Use of UAV sequential data in forecasting crop yields could help farmers in financial planning and for the government to announce relief packages or subsidies pre-emptively.

Data acquisition and processing

Before data acquisition, the user should have clear knowledge about the mission. Avoid data acquisition on extreme weather. User should confirm that the overlap (frontal and side overlap), and camera angle are correct to meet the mission. Regular monitoring of power supply is very important during the mission. Immediately after data acquisition is over, the user should check for the blurred image. In case of presence of the blurred image, the mission should be repeated immediately to acquire a quality image. Pre-processing and post-processing steps are involved in UAV data acquisition. The detailed processes of obtaining UAV data and its processing is explained in Fig 3.

Advantage of using a drone in agriculture

- Use of drone ensures the process decision that is quick and accurate. High-intensity data collection with high spatial resolution.
- UAV permit farmers to distinguish subtle changes that cannot be readily identified by "crop scouts" at ground level.
- UAV data used to speed up the meticulous process of conducting crop inventories and yield estimation.
- It makes possible to practice precision farming in small landholdings.
- Improve agricultural input use

efficiency to a great extent through site-specific application of agro-inputs like fertilizers, insecticides, herbicides and irrigation.

- Drones are alternative to heavy machinery, tools and lack of skilled labours.
- Low-cost way to perform agricultural operation like spraying and to manage farming to a great extent.
- Improving insect pest and disease detection and plant protection
- Prevent the exposure of spraying personals to hazardous chemicals

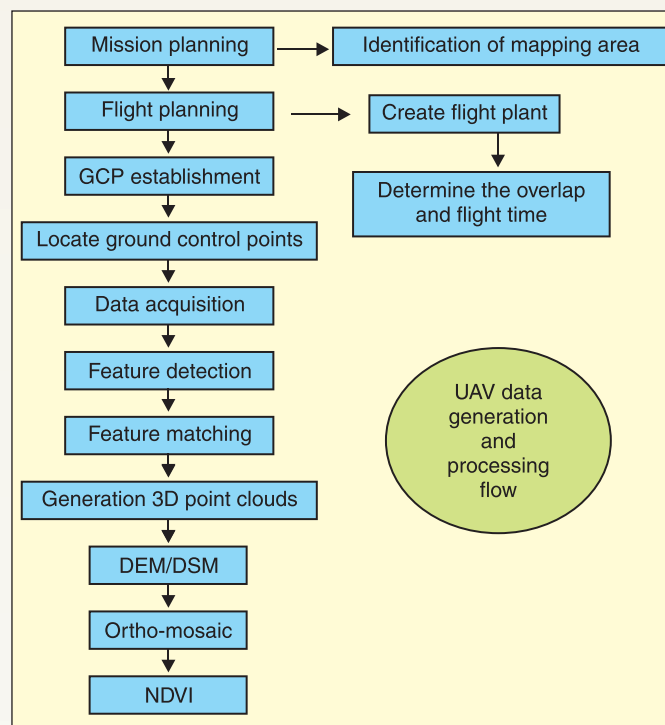


Fig. 3. UAV data generation and processing flow

Constraints

- It needs minimal knowledge about computer and software to operate a drone and process the data collected from UAV sensors.
- A single drone may not be suitable for all kind of work. A specific drone is needed for specific work.
- Lack of massive data processing capability: The data acquired from UAVs per hectare of surface surveyed can reach thousands of gigabytes due to its high spatial resolution. So users must develop large data processing capabilities. Most of the rapid data processing tools are available freely to the user. Even in case of paid software, early renewal charges are again very high.
- Limited endurance: Lack of powerful batteries to support long time flying/endurance is the supreme limiting factors to the rapid intrusion of UAV technology. The steep development in electric batteries technology will likely lead to a consistent increase in the endurance of the UAV.
- Limited payload capacity: Most of the UAV available in the markets are having very limited payload capacity (< 2 kg). For extensive and large scale application of UAV technology demands large payload capacity.
- Initial high cost: Cost: Benefit analysis shows limited economic benefits from the use of UAV. Long term use and rental service through custom hiring centres may provide financial benefits.
- Need licence and skill: Farmers need a licence to operate and use drones in agriculture. Digital Sky Platform was launched by DGCA (Directorate General of Civil Aviation) on 1 December 2018 to issues and monitor drone licencing in India. Getting drone licence and doing drone registration in the digital platform is not easy for Indian farmers.
- Less area coverage: Most of the UAVs available in the markets are not appropriate for large area data acquisition because of their limited flight endurance. The real-time data acquisition of a complete area of interest as with satellite platforms is not possible using the drone.
- Cannot be operated during adverse weather like rain/strong wind.
- Lack of clear and common rules for operating drones prevent research mobility and exchange opportunities.
- Need multiple sensors for multiple purposes and the cost of sensors are high. Less weight and low-cost sensors are crucial to satisfy specific needs and goal.

Challenges ahead

Like any other potential innovation, UAV/drone technology has few challenges in both science-technology front and also operational-administrative front. The imagery collected by UAV is processed and analysed through specially developed software and sophisticated algorithm. Heavy computational systems (minimum 4 gb RAM and 500 gb storage) is required for this purpose. Development of easy to work open-source software solutions remains the key for application at the field scale. Most of the drone available in the market is having very limited pay load carrying capacity. There is a

need to improve software and hardware system of the drone for stable flight under different weather conditions, capturing quality imagery and easy data processing. Reach of drone technology in India may be delayed by techno-economical feasibility to small farmers (having fragmented landholding of < 2 ha). Taking prior permission to use drone every time may not be possible from farmer's point of view. For rapid and spatially extensive spread of UAV technology needs appropriate DGCA guidelines and its ratification is essential.

SUMMARY

Application of drone in agriculture enables farmers/service providers to quickly and precisely identify problems. Multiyear drone data allows the user to compare his/her new practise with old practices in terms of improvement in soil fertility, crop productivity and impact on the environment. UAV has enormous application and potential in Indian agriculture, however, to utilize its full potential government should come up with user and farmers friendly action plan in terms of law, policy and establishment of infrastructure and human resource training centres.

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