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UAVs in Orchard Management: Need, Challenges, and Applications

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Introduction

Feeding the burgeoning population, eradicating rural poverty, and managing natural resources have emerged as the three primary concerns for agriculture around the world. Precision agriculture can help to manage these natural resources sustainably. Precision agriculture (PA), as the term implies, is a farm management method that employs information technology (IT) to ensure that crops and soil receive exactly what they require for optimal health and productivity. Remote sensing, Artificial Intelligence (AI), sensors, handheld Global Positioning System, Unmanned Aerial Vehicles (UAV), and manual field sampling are employed as input in PA to provide sustainable agriculture and horticulture. UAVs, often known as Drones, have been utilized in agriculture to modernize farming in recent years. UAVs contain sensors that can provide real-time information regarding plant, nutrient, and water status in the orchard, allowing for more efficient and precise cultural operation and management decisions. UAVs are employed for management in numerous orchards, including oil palm orchards, chestnut orchards, olive orchards, peach orchards, lychee orchards, citrus orchards, and mango orchards. Even the Government of India recognizes the usefulness of drones in achieving *Atmanirbar* Bharat in agriculture and allied sectors. The latest *Kisan* Drone scheme introduced by the Government of India would increase the usage of drones in agricultural and other industrial sectors. Keeping in mind drone schemes and theses potential application in agriculture and related industries, the study highlighted opportunities in orchard and tree plantation management employing UAVs with high-resolution imagery.

Components of UAVs

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Drones/UAVs are guided by propellers, wings, or both (depending on availability). Drones with propellers have two types of propellers onboard for direction and thrust.The chassisis the primary body of the quad copter that houses all of the other components.The power supply to the electronic speed controller is controlled by the flight controller. And also utilized to detect changes in the orientation of the drone. Besides, it helps to control the motors and keeps the drone in the air. The transmitter sends signals from the controller to the drone to create direction and thrust commands. The receiver receives signals from the transmitter and transmits them to the Flight Controller PCB. Sensors/cameras are mounted fixed to the chassis to capture the images/ sense the remote signals. Primary sensors are flight control, stability, remote communication, and tasking sensor. Which are Necessary for operating and controlling the UAV. Secondary sensors may or may not be associated with its functioning such as imaging sensors, sensing, tracking, and measuring sensors fixed to the UAVs.

Fig 01: Components of UAV

Need forUAVs in Orchard management

Fruit orchards necessitate site-specific or even individual-tree management throughout the growing season, from flowers to fruitlet development, ripening, and harvesting to tree dormancy. Earlier, growers made orchard management decisions primarily based on visual inspection of color, shape, size, and other information of fruits or fruit trees based on their own experience (Srivastava et al. 2017), which has professional experience

requirements for observers, and the observation results were frequently inaccurate. Furthermore, the application of pesticides to manage pests and diseases is challenging due to higher plant height, requiring more labor, and being less efficient in controlling diseases and pests. Manual inspection of fruit ripening and maturity can be easily replaced by the use of UAVs and machine learning approaches for better decision-making. UAVs can readily monitor irrigation and variations in nutrient status in the field, which aids in reducing water and nutrient stress in trees. All the above operations are labor-intensive, have a high cost of operation, are inefficient, and are time-consuming, soICT and manpower are utilized concurrently to conduct various orchard management tasks.

Application of UAV in orchard management

- **Spraying chemicals/pesticides:** The application of UAV in spraying chemicals and pesticides in the field helps in less exposure of workers to harmful chemicals, in spatial variable spraying, and improves the spray efficiency. The UAV can be pre-programmed or remotely controlled by a drone operator to spray the chemicals. Payload is the governing factor for the design of UAVs for spraying applications. The main parts of a UAV for spraying system are the pump and its controlling system, Accelerometer, a gyroscope, and GPS which is used for controlling the drone. Before spraying operation, the optimization of spraying parameters, such as flight height, velocity, nozzle flow rate, and application rate, is needed to achieve the best performance from UAVs. However, the UAV pesticide/chemical spraying is associated with certain disadvantages also which include the requirement of sound technical knowledge, payload limitations, effects on the environment, and high cost.
- **Crop growth monitoring:** The UAV captures images of farm fields from a camera fixed on the UAVs, which are subsequently processed by a field extractor, which extracts the fields using an object detector. The extracted fields are then sent to a field growth grader here it is divided into different grades like grade 1, and grade 2 based on the growth stage using machine learning or neural network. It is extremely important to keep the height of the UAVs constant to get uniformity and higher accuracy. Finally, all of the data from the field extraction and field growth grader is combined to provide correct visualization.

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- **Ripening and pruning assessment:** The assessment of the ripening stage of fruit was also done by use of UAVs and Machine learning algorithms. Once UAVs captured the images or video from the orchard, then these images are Orth-mosaiced, and preprocessing were done (Sabzi*et al.*, 2019). In the ripening stage identification process, the first step is to separate the object of interest (Apple) from the background, then a set of color features is extracted from each segmented object based on a prior study. Further, extract the color feature from the Apple then feed this information to machine learning/ ANN or genetic algorithms to classify the apple as unripe, half-ripe, ripe, or over-ripe.
- **Diseases identification/ detection:** Diseases in orchard crops can be detected early through some indicators with the help of a UAV. By analyzing the datasets obtained from the thermal, multispectral, and hyperspectral sensors mounted on UAVs with the help of machine learning algorithms it is possible to detect the disease and adopt preventive or control measures (Zhang *et al.*, 2021). RGB sensors also can be used for the same purpose based on visual traits. Hence UAV provides a quick, accurate, large area coverage, and low-cost tool for disease assessment.

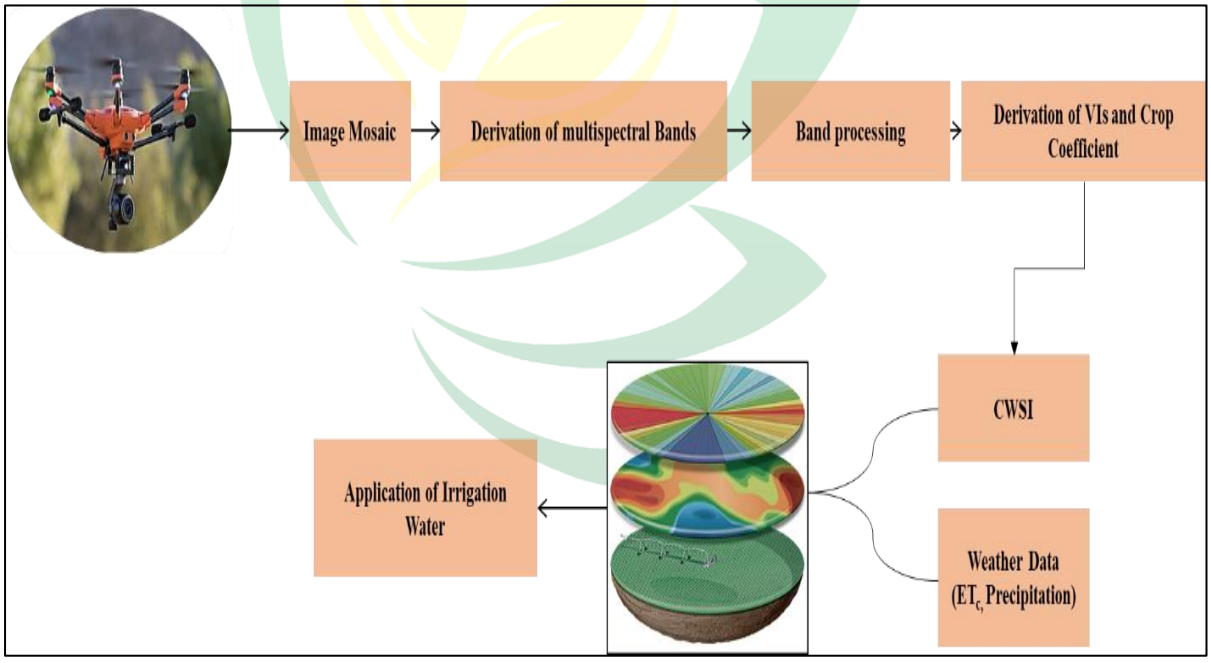

Fig 02: Steps in irrigation variability map using UAVs

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- **Irrigation management**: In irrigation management, UAVs are run over the orchard to capture the through multispectral remote sensing imageries (Ex. Red edge camera). Captured imageries are mosaicked with the help of software, then derived from the multispectral bands and processed in the laboratory using image processing software (Shi *et al*., 2019). Further, it was processed for extracting the information to derive the vegetation indices (VIs)such as NDVI, GNDVI, SAVI, etc. It helps in the derivation of crop coefficient and ultimately helps in the derivation of the crop water stress index. Plant water deficit was calculated using Crop Water Stress Index. In combination with CWSI, weather data help in the derivation of variability maps in the field. Eventually based on the crop water, soil, and climate data information provided to the software to calculate crop water requirement in the field. Even UVAs are also used to locate the water bodies and calculation the volume of water that can be stored within that water body.
- **Health and nutrient status of soil:** The health of a plant is interpreted through the availability or unavailability of nutrients to the plant. The abundance or deficiency of a particular nutrient induces some disorder in the plant which eventually affects the health of the plant. Hence to monitor the health status of the plant, nutrient status must be monitored.
- **Area assessment and crop identification:** UAVs are used to assess the area of the orchard, and the fruit growing in the orchard can be easily identified using the camera mounted on the UAVs. Such information is necessary for the Horticulture department in analyzing the area under horticulture crops and their yield. Furthermore, some research was undertaken to identify two different trees in an orchard using photos captured by UAV cameras. During image capture, the flight height remained constant above the ground surface. Structure from Motion (SFM) and Multi-View Stereo (MVS) approaches are employed in this method to generate a Digital orthophoto mosaic (DOM), Digital terrain model (DTM), and digital surface model (DSM) based on UAV photos (Dong *et al*., 2019). The impact of the soil and weed is then removed from the image background using algorithms. Following that, a local maxima filter approach and a marker control watershed segmentation model are used to detect individual trees and delineate individual tree crowns.

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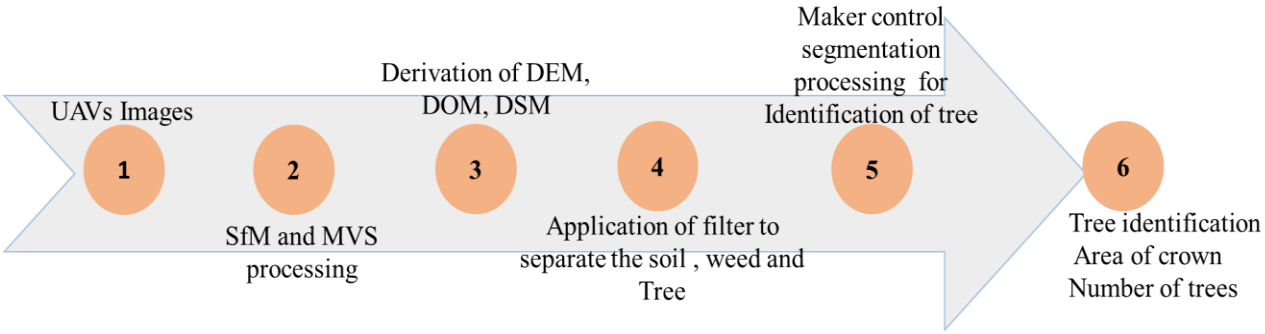

Fig.4: Steps in tree identification and number of tree

Problems in using UAVs

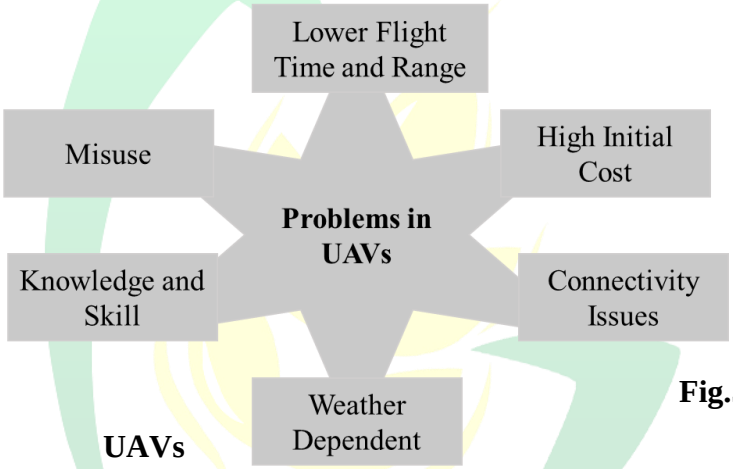

Fig.5: Problems in UAVs

Conclusion:

Drone and satellite imaging can provide significant benefits in agricultural applications such as water management, fertigation, monitoring, and orchard harvesting decisions. Advances in ICT and electronics will aid in orchard management. These management tactics include pesticide spraying, tree identification, growth assessment, and pruning planning in the orchard, as well as assisting with fruit harvesting and ripening decisions. The system's ultimate goal is to enable an appropriate plan to use the available resources sustainably and also help in increasing the productivity of crops, reducing labor and time, and improvement in resource efficiency.

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