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Unmanned Aerial Vehicle: Step towards Precision Agriculture

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A UAV is a remotely controlled aircraft that can fly without a human pilot (Rajput et al., 2021). Unmanned aerial vehicle (UAV) also known as remotely operated aircraft**.** In 1916, the United States began developing this technology and developed the first pilotless aeroplane (Mudaliar and Sorate, 2018). The unmanned aerial system, which includes the UAV, communication link, and ground control station, is incomplete without it. In terms of accessibility, speed, and dependability, the UAV overcomes the limitations of the terrestrial system (Tice, 1991)**.** UAVs have cameras and sensors for agricultural monitoring, as well as sprayers for pesticide spraying. UAV can provide cloud-free and high-resolution images to serve the commercial applications such as agriculture, mining and monitoring. Previously, a wide range of UAV models were used for military and civilian purposes (Van, 1999). In agriculture, Yamaha creates the first UAV, RMAX model for pest control and crop monitoring applications (Giles and Billing, 2015). A technical analysis of UAVs in precision agriculture explores their suitability for tasks such as crop monitoring (Bendig et al., 2012), crop height estimation (Anthony et al., 2014), pesticide spraying (Huang et al., 2009), and soil and field analysis (Primicerio et al., 2012), forestry, fisheries, and wildlife protection (Watts et al., 2012 and Zajkowski 2003).

The Unmanned Air Vehicle can stay in the air for up to 30 hours, completing the same activities, such as performing an accurate, repeating raster scan of the region, day after day, night after night, in full darkness or fog, and under computer control (Ahirwar et al., 2019).

In light of the current situation, a crop monitoring and pesticide spraying UAV comprised of an automated drone system and a sprinkling system with a multi-spectrum camera has been created. The sprinkling system is attached to the UAV's lower section, with a nozzle beneath the pesticide tank that sprays the pesticide downstream. The multi-spectral camera scans the entire crop field and provides a spatial map as the first method of monitoring. This map shows the crop's status using normalized difference vegetation index (NDVI), and the farmer then decides which herbicides and fertilizers to use on the crop.

A) **Fixed-wing:** Fixed-wing UAV have a stiff wing (non-movable wing), a fuselage (the primary body of the aircraft), and tails that are propelled by a motor and propeller. They have the advantage of being able to fly at higher speeds for longer periods of time, which allows them to cover a wider range of scenarios (ex: jungle, desert, mountains, maritime etc.).

B) **A multi rotor includes:** These UAV are known as rotatory wing UAV because they have rotary blades or propeller-based systems. These UAV, unlike fixed-wing models, can fly in all directions, horizontally and vertically, as well as hover and have high manoeuvrability. These UAV are classified based on number of rotor as follows.

a) **Single rotor:** A helicopter is a type with only one large rotor on top and one little rotor on the UAV's tail. Two separate components make up a single-rotor system. The first is the helicopter, and the second is the ground control of the helicopter (Xinyu *et al.*, 2016)

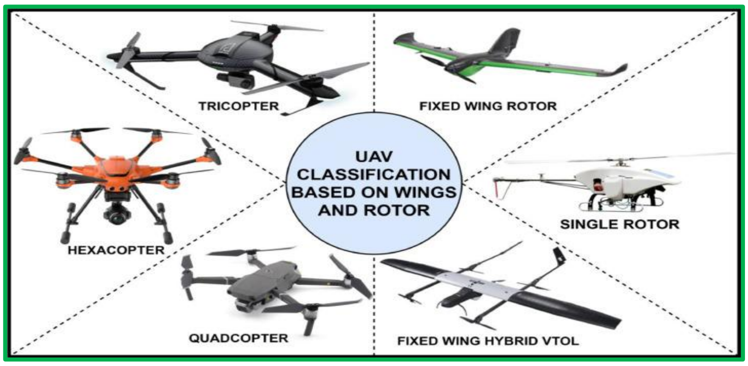

Fig. 1: Types of UAV

b) **Tri Copter:** The tricopter's general structure includes three rotors, which aid in balancing the tricopter's weight while in flight. The rotors are arranged so that the right rotor moves clockwise. The other two rotors will spin backwards.

c) **Quadcopter:** A quadcopter is a type of UAV with four rotors. These rotors provide lift for the quadcopter. The two opposite rotors rotate clockwise, while the other two rotate counterclockwise. Pitch (backward and forward), roll (left and right), and yaw are the movements of the quadcopter around the axis (clockwise and counterclockwise).

d) **Hexa Copter:** It's a six-armed UAV with a single high-speed BLDC motor linked to each of them. The airframe plate serves as a support structure for the drone's other components, such as batteries and motors, as well as a flight-controlled GPS antenna and a high-speed capacity tube. FPV cameras, ESCs, circuit boards, and sensors are also included. Spray nozzles are attached to the spray motor's outlet.

e) **Octocopter:** It has eight rotors and is used for agricultural spraying in a similar way to the Hexa UAV. It has a total of six nozzles. The mobility of the sprayed droplets and their deposition were measured using the Time-resolved particle image velocimetry (TR-PIV) method.

f) **HTOL (horizontal takeoff and landing) and VTOL (vertical takeoff and landing):** HTOL can be thought of as a fixed-wing aircraft extension. They fly fast and land smoothly. Although VTOL drones are excellent at flying, landing, and hovering vertically (Hassanalian and Abdelkefi, 2017), their cruise speed is limited due to the slowing of retreating propellers (Austin, 2011).

Components of UAV

1) **Frame:** The UAV's frame is critical in sustaining all of the components. It is vital to examine the weight of the frame because a heavy frame will make lifting the UAV's harder. We opted to build the UAV's using a light-weight hardwood frame after considering all of the factors. The components and their arrangements on UAV is shown in Figure 2.

2) **BLDC Motor:** Brushless DC motors, also known as commutated motors or synchronous DC motors, are powered by a battery and driven by an inverter or an Electronic Speed Controller that generates an AC current to drive each phase of the motor. The controller sends current pulses to the motor winding, controlling the motor's torque and speed. The payload estimation affects the rating of BLDC motors.

3) **LiPo Battery:** The working current of BLDC motors was extremely high. The battery's discharge rate determines this high current flow capability. As a result, we used a LiPo battery because it has a high discharging current rating.

4) **Electronic Speed Controller (ESC):** An electronic speed controller is a circuit that controls the speed, direction, and dynamic braking of BLDC motors.
5) **Propeller:** The propeller size is determined by the frame size and motor rating.
6) **Flight Controller:** The flight controller helps in controlling the drone by considering stability, speed, acceleration, and gyro.
7) **Radio Controller:** To begin with, calibrate the transmitter with the flight controller using the receiver. The transmitter will interface with the UAV after calibration, and the UAV will operate according to the transmitter.
8) **Multi-Rotor Flight controller unit:** The unique All-in-One design makes installation simple while also saving space and weight. It can measure altitude and attitude and hence be used for autopilot and automatic control.
9) **Remote LED module:** Now that the M-Lite LED Module has USB connectivity, changing the firmware on the M-Lite module is a straight forward process. A USB port is utilized in the PC connection for parameter setup and firmware updating, and a connector is used to connect to the main controller LED port.
10) **GPS Anteena:** A quadcopter's rough position, height, and ground speed can be determined using a GPS antenna. On-screen displays can also show GPS information (OSD).
11) **FPV cameras:** These are cheap, portable, and small. A video transmitter is used to transmit real-time video from the FPV camera to the ground from a drone. With the help of the FPV camera, you can observe how the drone is flying and what it is observing in real time.
12) **Power Module:** Through a 6-pos cable, the Power Module makes it easy to supply clean power from a LiPo battery to a Smart AP while also monitoring current usage and battery voltage.

Types of Agricultural Sensor

Sensors suited for smart farming are discussed as follows.

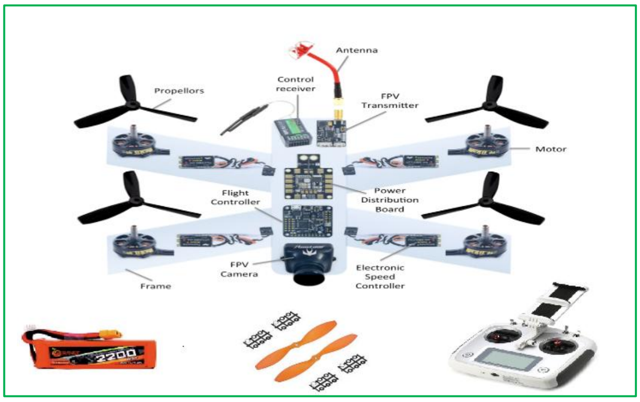

Fig. 2: Arrangement of components of UAV

1. **Location-based Sensors:** In agriculture, location sensors are utilized to locate various places and spots (Lee and Mase, 2002, and Bayrakdar, 2020). Farmers use a variety of location sensors to assist them at various phases of the crop's life cycle. GPS receivers are typically used to determine the longitude and latitude of a specific spot on the earth's surface using a GPS satellite network.
2. **Electrochemical Sensors:** These sensors extract a composition from a biological sample such as plants, soil, and so on. These sensors are commonly used in smart agriculture to measure pH levels and soil nutrient levels, with sensor electrodes detecting specific ions inside a soil (Salam, 2020).
3. **Temperature and humidity sensors:** Temperature and humidity are two of the most essential meteorological variables that have a direct impact on the health and growth of all crops. The farmer can modify the amount of fertilizer and water used by measuring these environmental parameters correctly (Singh et al., 2020).

4. **Optical sensor:** Sensors that transform light rays into electrical signals. Several optical sensors have been utilised in UAVs for precision agriculture applications, including RGB cameras, converted near-infrared cameras, six-band multispectral cameras, and high spectral resolution spectrometers. These are as follows:
a. **Visible Light Sensors (RGB):** UAVs most commonly utilise visible light sensors (RGB) in precision agriculture and related smart agro applications. It is well known that the human eye is sensitive to red, green, and blue light bands. The RGB sensor in the UAV camera records the image in such a way that it replicates the effect observed with the naked eye.
b. **Multi-spectral sensors:** These are ideal for agricultural analytics using UAVs. These sensors have a high spatial resolution and can detect near-infrared reflectance (Nhamo et al., 2020).
5. **Thermal infrared sensors:** These sensors help to capture the temperature of objects, produce images, and display them based on the data collected. Thermal cameras capture thermal energy with the use of infrared sensors and optical lenses.

Application of UAV

Because UAVs outperform traditional remote sensing technologies in terms of power consumption, human life risk, data collection convenience, hovering, and ultra-high spatial resolution, they are a great alternative for surveying and mapping.

Agriculture: Precision agriculture's main goal is to apply the proper amount of input at the right time and place to get superior results. Data collection and variability mapping of agriculture fields are common precision farming procedures, as are data analysis, making farming management decisions based on the outcomes of the study, and lastly, controlled application of pesticides and fertilizers. Mainly UAV is used in agriculture for following purposes.

[1] **Soil and field analysis:**UAV can be used to analyse soil and fields. They can be used to create precise 3-D maps for early soil investigation of soil property, moisture content, and erosion. This is critical when it comes to seed planting patterns. UAV -driven soil analysis gives data for irrigation and nitrogen-level management in the soil even after planting (Primicerio et al., 2012).
[2] **Planting:** While not yet widely used, some manufacturers have developed systems that can shoot pods containing seeds and plant nutrients into already prepared soil. These drone-planting devices will save 85 percent on planting expenses (Ahirwar et al., 2019).
[3] Crop spraying: UAV equipped with distance-measuring devices such as ultrasonic echoes and lasers can modify altitude in response to changes in topography and geography. Spraying with drones is expected to be 5 times faster than traditional methods, according to experts (Huang et al., 2009).
[4] Crop monitoring: Inadequate crop monitoring of large fields is one of the most significant challenges in farming. UAV with surveillance technology are now able to create time series animations that depict the precise development of a crop and highlight production inefficiencies, allowing for better crop management (Bendig et al., 2012).
[5] **Irrigation:** UAV equipped with hyper spectral, multispectral, or thermal sensors may identify which sections of a field are dry, allowing water resources to be distributed more efficiently, with more water going to the dry areas and less going to the moist areas.
[6] **Health assessment:** Assessment of crop health and detection of bacterial or fungal infestations on trees is critical.
[7] **Weed detection in the middle of the field:** We can construct weed maps using NDVI sensor data and post-flight picture data to help farmers distinguish between high weed intensity areas and healthy crop areas growing alongside them (Ahirwar et al., 2019).

[8] **Cattle herd monitoring**: UAV with thermal sensors are an excellent alternative for monitoring cattle herds from above, as they may see animals that are missing, injured, or giving birth.
[9] **Crop insurance:** Aerial imaging can be used to swiftly classify scanned areas as cultivated or uncultivated land, as well as to assess the extent of natural catastrophe damage. Drone data could also be valuable for early detection and prediction of pest infestations, with insurance firms sharing the information with farmers (Ahirwar et al., 2019).

Benefits of UAV in Agriculture

1. Automatic piloting and operations.
2. Automatic analysis for real-time decisions.
3. Increase of precision in remote sensing.
4. It can be deployed quickly and repeatedly thus it saves the time.
5. Highest economic benefit (improve the yield and profitability).
6. Reduces waste of water, chemicals other inputs.
7. They could limit the amount of pesticide sprayed.
8. Environmentally friendly.

Limitations of UAV

Weather dependencies: weather is constantly changing and drones are vulnerable to these conditions. Severe weather interrupts drones.

1. Wind speed-they may cause turbulence.
2. Very low and very high temperatures affect the sensors.
3. Precipitation-heavy rain intercepts radio signals

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