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An Overview on Drones Design and Development

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(Research Scholar)

Abstract: The drone also knows as unmanned aerial vehicle (UAV) is a most powerful and popular technology now a days. The drone industry is very challenging and requires synergy with multiple technologies to make it successful. Today , Drones technology is most popular technology amongst researchers and product development companies this is due to fact that since now we have wide range of controller and processors sensors, motors etc. available which can be best suited as per the military or commercial need of the application. Also the rise in demand for the application such as remote monitoring and also performing remote operations such as delivery of food, medicines etc are increasing day to day. Despite these appealing benefits, UAVs face limitations in operability due to several critical concerns in terms of flight autonomy, path planning, battery endurance, flight time and limited payload carrying capability, as intuitively it is not recommended to load heavy objects such as batteries. As a result, the primary goal of this research is to provide insights into the potentials of UAVs, as well as their characteristics and functionality issues.

The present article discuss about drones and their uses in military and commercial applications.
Also highlights on the latest technology for military and commercial application not limited to search and rescue, surveillance, traffic monitoring, weather monitoring and firefighting, personal tasks, security and news reporting.

Keywords: Drone, Technology, Unmanned Aerial Vehicle (UAV), GPS, Robot Operating System (ROS)

1) INTRODUCTION

A drone is a type of aircraft also knows as unmanned aerial vehicle (UAV) since it does not needed a pilot on board to fly it. As per the history of drone usage it was earlier developed and targeted for soldiers and for military purpose. Since due to advancement in technologies and raise in commercial demands of drone have become most popular, nowadays drone can be used in industrial parks, surveying, firefighting, disaster relief, commercial use, delivering a courier, scientific research, in mining industry, etc.

Furthermore, drone technology is attracting quite significant research interest. In addition to the security and military applications, typically involving tracking or surveillance, the Earth Sciences present challenges entailing the coordination of air and ocean vehicles. Examples include studies of air-sea fluxes or of coastal fronts.

Drones gained a negative image with their recent military use, but the stigma of the world "drone" has largely worn off over the past few years with the proliferation of hobby and commercial models.

Drone also can be used in military purpose, video-making, film making, inspection, agriculture, news gathering, spraying of pesticides, for security purposes, oil spill monitoring, shipping emission monitoring; further uses include target monitoring and designation, as well as the elimination of designated targets. The main limitation of using a drone is the fall of a drone from a great height, which can be caused by battery discharge, damage due to weather conditions (low air temperature, rain), or hitting an obstacle (trees, buildings, high-voltage lines).

2) DEFINITION

A ‘Drone’ is defined by the Merriam Webster dictionary as “An unmanned aircraft or ship guided by remote control or onboard computers”.
A UAS, unmanned aerial system, is defined as “an aircraft and its associated elements which are operated with no pilot on board”.

The RPAS definition is more detailed and refers to “a remotely piloted aircraft system, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design”.
The technical difference between the two is that RPAS can only be piloted from a remote pilot station (RPS) whereas UAS may be piloted from an RPS or a ground control station (GCS).

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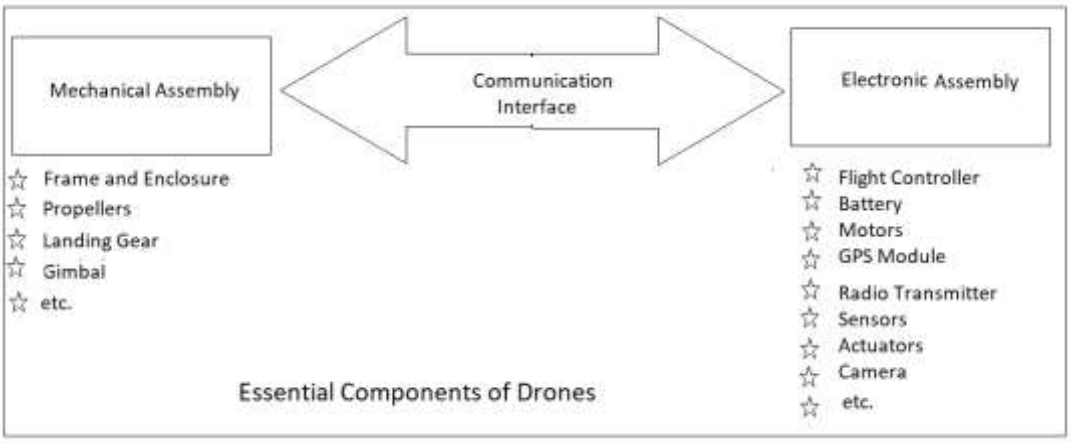
3) ESSENTIAL COMPONENTS OF DRONES

Drones use a combination of hardware and software for its operation and functioning. They have propellers or rotors that generate thrust, and a flight controller that manages the drone's stability. A pilot uses a remote control to direct the drone's flight.



3.A) Mechanical Assembly
3.B) Electronic Assembly
3.C) Communication Interface
3.D) Safety Mechanism

3.A) Mechanical Assembly

It consist of both fixed and moving mechanical parts, the mechanical assembly serves multiple purpose. Firstly, it acts as a housing for electronic and communication interface secondly it provide safety against wear and tear occurs during flight.

Propellers

Drones typically feature multiple propellers, each connected to a motor or engine. These propellers serve as the drone's wings and generate the necessary lift to keep it airborne. When the motors spin these propellers at high speeds, they create thrust, effectively counteracting the force of gravity.

Mechanical Frame and Body

It is a structure (frame) into which all other drone parts fit. The frame of a drone provides structural integrity and houses all its essential components. Usually constructed from lightweight materials such as carbon fiber or plastic, the frame keeps the drone agile while minimizing overall weight.

Landing gear

It is used to land the drone safely to the ground surface.

3.B) Electronic Assembly

Motor: Motors are essential in making drones as they generate the force to rotate the propellers and propel the drone

Electronic Speed Controller (ESC): It is an electronic control board that varies the speed of the motor. It also works as a dynamic brake.

Flight Control: Flight control creates a log of the takeoff location that guides the drone and thereby the need to return to the takeoff location. Flight control systems that ensure stability, responsiveness, and safety during flight. This has become known as the 'back home' feature.

Sensors: Gyroscope and Accelerometer

Embedded sensors, including gyroscopes and accelerometers, play crucial roles in maintaining drone stability. Gyroscopes measure the drone's orientation in space, ensuring level flight, while accelerometers detect changes in speed and direction.

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The Brain: Flight Controller
The drone's central processing unit, known as the flight controller, receives data from sensors and adjusts motor speeds accordingly. This precise control system ensures the drone remains stable and responds accurately to pilot commands.

Battery, electronics, and power distribution cables: This battery acts as the power source for the drone. It supplies power to all electronics through power distribution cables. We can also do the battery charging via Wireless Power Transfer(WPT) system or solar panels.

Camera: For video footage, a camera is attached to the drone and used to shoot, save and send video. Leveraging Drone Cameras Aerial photography and videography are among the most popular applications of drones.

Camera Stabilization: The Gimbal
Drones equipped with cameras frequently employ a gimbal—a specialized device that stabilizes the camera. This ensures that the captured images and videos remain steady and smooth, even during maneuvers or in windy conditions.

Real-Time Monitoring: Remote Viewing
Drone operators can view the live feed from the drone's camera on a remote control or dedicated screen. This live feed allows operators to frame shots, monitor the surroundings, and capture captivating visuals from lofty heights.

3.C) Communication Interface
Radio transmitter: It is used as a channelized transmitter and communicator with drones.

Navigation with GPS
Many drones incorporate GPS technology, allowing them to determine their precise location and altitude. GPS facilitates features like automated navigation, return-to-home functions, and geofencing to restrict drone movement within predefined boundaries.

3.D) Safety
Ensuring safe drone operation is paramount, both for the drone itself and for the well-being of people and property on the ground.

Obstacle Detection and Avoidance
Advanced drones are equipped with obstacle detection sensors, often utilizing technologies such as ultrasonic sensors or LiDAR (Light Detection and Ranging). These sensors continuously scan the surroundings and can automatically adjust the drone's flight path to avoid collisions.

Fail-Safe Mechanisms
In case of communication loss or critical issues, drones often employ fail-safe mechanisms. For instance, they may initiate a return-to-home procedure, guiding the drone back to its takeoff point, or they may hover in place until the issue is trouble shoot.

4) IMPORTANT CHARACTERISTICS OF DRONES

Payload capacity: These types of drones are designed to carry heavy payloads. Therefore, a key feature is their payload capacity, which can vary from a few to hundreds of kilograms, depending on their size.
Flying range: To fulfil their cargo carrying purpose, they must have high-capacity drone batteries or even hybrid propulsion systems.

Advanced navigation systems: These drones need sophisticated navigation systems to fly autonomously and safely.
Stability and endurance: Due to the heavy loads they carry, these drones need to be stable and sturdy.
Communication and connectivity: Cargo drones often require reliable communication and connectivity for their operation. This may involve the ability to connect to mobile networks, satellite networks or remotecontrol systems.

5) DRONES TYPES

We can categorized drone as follows

A) Based on type of Wings

a. Fixed Wing Drones
b. Single Router Drones
c. Multi Router Drones
d. Hybrid CTOL Drones

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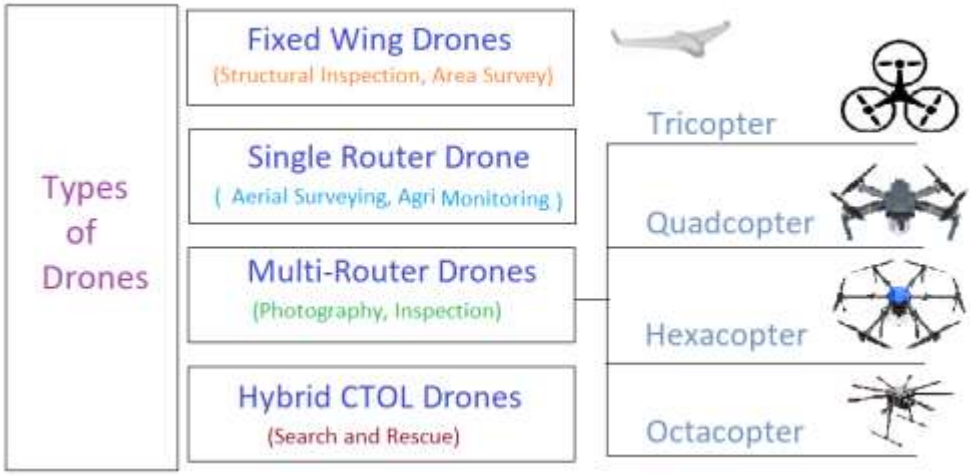
B) Based on Application

a. Personal drones
b. Professional drones
c. Cargo drones
d. Passenger drones

A) Based on type of Wings

Depending upon the type of wings drones can be categories as



Fixed Wing Drones

These drones are similar to traditional aeroplanes with wings. They are efficient in flight and cover long distances. Fixed-wing drones are generally used for aerial mapping, surveillance, and agriculture.

First off, as the name suggests, fixed wing drones have wings that do not move, they are bound to the body of the drone. They may have control surfaces that turn and rotate, such as ailerons and rudder, but the wings themselves are fixed. Unlike other drones, they cannot hover or land at specific points, requiring a runway or a net for landing.

Pros of fixed wing drones are that their aerodynamic shape allows them to remain airborne for long periods of time, so they can cover large areas and are energy efficient. This is ideal for missions that require the drone to be airborne for hours or days, such as surveillance and climate monitoring.

Most fixed-wing machines have a normal flying time of a few hours. Gas-fired UAVs can fly up to 16 hours or more. Given the longer flight time and higher fuel consumption, fixed-wing machines are in an ideal world for long-separation tasks (whether for mapping or observation). In any case, they can not be used for the elevated photography when the automaton has to remain motionless for a certain time.

Different disadvantages of fixed-wing UAVs are larger expenses and prepare the required capabilities in flight. It is difficult to place a fixed-wing UAV visible all around.

Rotary-Wing Drones

For rotary-wing drones, the rotor-blades rotate around a central mast, forcing air downwards and creating the vertical lift required for the aircraft to become airborne. All vertical take-off and landing (VTOL) aircraft fall into this category, including small and large helicopters and multicopters. Rotary-wing drones may have a single rotor or even up to 16+ rotors generating thrust.

Pros of rotary-wing drones are that they are simpler to operate initially and can hover in place, allowing them to fulfill a wide variety of roles. Basic models are also relatively inexpensive, so small rotary drones are a great place to start for those wanting to get into the industry.

The main cons relate to their short flight time, as generating upward and forward thrust requires a lot of energy, thus restricting the range and endurance of the vehicle.

Single Rotor Drones

These drones consist of a single rotor and tail rotor for better stability and control. Single-rotor drones are less popular as compared to multi-rotor drones due to their high cost and complex design.

They have longer flight times and can even be powered by gasoline engines. In simplified functions, the smaller the number of rotors, the lower the rotation of the article. In addition, it is the integral motivation that explains why

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quadricopters are more stable than octocopters. In this sense, single rotor UAVs are significantly more productive than the different rotor UAVs.

Multi Rotor Drones

Multi-rotor drones include quadcopters, hexacopters, and octacopters. These drones have multiple drones arranged in symmetrical patterns. They are highly efficient and capable of vertical takeoff and landing. These drones are used for aerial photography, videography, and inspection. Quadcopter motors are specially designed to deliver optimal thrust and stability, ensuring smooth flight and precise manoeuvrability in these drones.

Multi-rotor automats are the most widely recognized types of automata used by experts and novices. They are used for most normal applications, such as in-flight photography, aeronautical video observation, etc.

Limitations: The main ones are limited flying time, continuity and speed. They are not reasonable for very large-scale activities, such as long-range airborne mapping or reconnaissance. The fundamental problem with multicopters is that they have to spend a lot of their vitality (perhaps a battery) to fight gravity and find a remarkable balance. At present, most multi-rotor controllers are only equipped with 20 to 30 minutes of flight (with a basic payload, for example, a camera).

Hybrid VTOL or Powered-lift drones

Hybrid VTOL drones are a combination of fixed-wing drones and multi-rotor drones. They have vertical take-off and landing capabilities along with efficient forward flight. They are suitable for aerial mapping, surveillance, and cargo delivery.

They occupy a fascinating middle ground between fixed wing and rotary drones, using elements of both to complete a flight.

These are half-breed shapes that link the advantages of fixed wing models (longer flight times) to those of rotor (stationary) models.

There are several types of powered-lift drones, namely tiltrotors, tiltwings, and drones with two perpendicular sets of rotors.

Half and half of the VTOLs are a series of computerization and manual flutter. A vertical lift is used to lift the automaton into the air from the first stage. Whirligig and accelerometers work in mechanized mode (autopilot idea) so that the drone is perceptibly installed all around. The manual (or even customized) remote control is used to direct the controller to the ideal heading.

B) Based on Application

As per the usage or applications drones can be broadly categorized into following types

Personal drones

Personal drones are usually the simplest drones, as they have no specific requirements.

They can be used solely for the purpose of the flying experience, so they have no additional elements. Many models usually have a camera for simple aerial photography and filming, allowing the user to observe their surroundings from a different point of view.

Professional drone

Professional drones are usually larger or have more parts to perform a specific activity.

These drones are used to perform multiple types of activities, and there are more and more tasks that a professional drone can be used for.

Some of the elements that characterise professional drones are high definition cameras, stabilisers, proximity sensors, among many others.

Passenger drones

The characteristics of a passenger drone are different from most UAS, as they are aircraft designed to hold a passenger and his or her luggage inside, with the capacity to rise and land vertically.

Cargo drones

The main function of the cargo drone is to transport items from one place to another, so its main feature is a winch that is placed on the body of the drone to lift loads of different weights.

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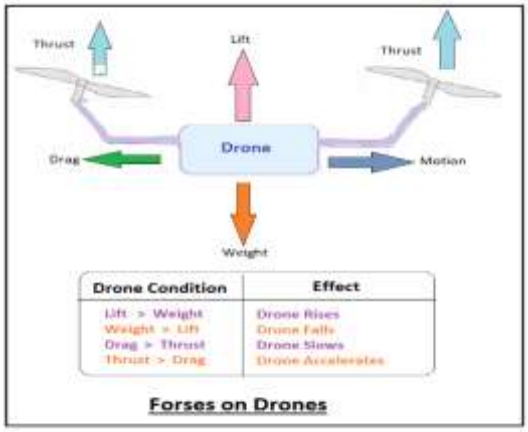
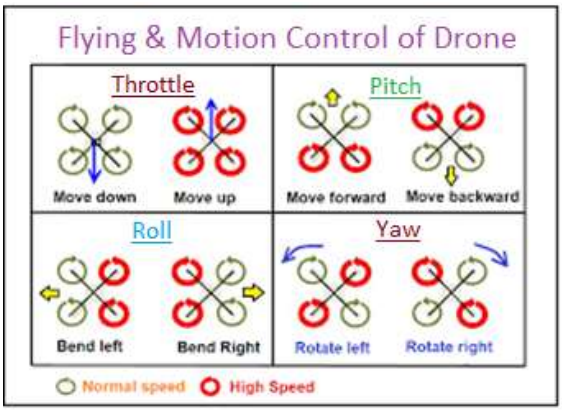
6) FORCE STUDY ON DRONES AND MOTION CONTROL





Throttle Control
The throttle control on the remote or flight controller governs the drone's altitude. Increasing the throttle results in higher motor speeds, generating more lift for ascent. Decreasing the throttle reduces lift, leading to a descent

Pitch, Roll, and Yaw To change direction, drones manipulate their orientation using three main movements:
Pitch: Tilting the drone forward or backward.
Roll: Tilting the drone left or right.
Yaw: Rotating the drone horizontally, akin to spinning a top.

These movements are achieved by varying motor speeds on different sides of the drone. For example, to roll to the left, the motors on the left side spin faster, tilting the drone in that direction.

7) HIGH LEVEL ARCHITECTURE

Working of Drones
Drones are working through a combination of hardware components and software algorithms. The drone operation starts with the flight controller which manages the drone's movement, stability, and orientation in the air. The flight controller provides power to the drone motors, propellers, and other components of drones.

The basic components of a drone include drone motors, propellers, flight controllers, batteries, and remote control systems. The motor and propeller are necessary to provide thrust to lift the drone from the ground, while the flight controller is like the brain of a drone, it is responsible for processing data and controlling the movement of drones.

The battery powers the electronic components of the drone and remote control systems allow the operator to control the movement of the drone. The drone operates through a combination of electrical components and software algorithms.

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Power on: The drone's engine starts, and the propellers begin to rotate. They usually have long battery life, so they are able to stay in the air for quite a long time before requiring a battery change or recharge.

Flight controller manages stability: The flight controller receives information from sensors and GPS, and uses algorithms to adjust the drone's position. After gaining altitude in the sky, the flight controller detects the flight level and GPS provides information about the drone's position, and allows the pilot to control the directions and movements of the drone.

Electric Motors: Drones work by means of a set of electric motors that propel the device through a multi-propeller system that provides great stability when taking off, flying and landing.

Propellers generate thrust: The propellers rotate to create an upward force that counteracts gravity.

Pilot controls the drone: The pilot uses a remote control to move the drone forward, backward, left, and right.

Algorithms adjust the drone's position: The flight controller uses algorithms to adjust the drone's position and keep it stable.

Data links allow communication: Data links allow the drone to communicate with the pilot and ground control station. In the case of RPAs, they are operated from a remote ground station via a communications link, which sends signals to the drone to perform the manoeuvres the pilot wants it to perform.
On the other hand, those that are not remotely controlled are linked to software that uses GPS to programme controlled flights, and these operate autonomously.

Safety: Real time Obstacle & Collusion Detection: Some of them have multiple sensors that allow them to detect obstacles on the route, capture images, make drone filming or additional accessories, such as lights that allow drones to fly at night. Safety features such as return-to-home functions, automatic landing, and fail-safe mechanisms to ensure the safe operation of drones and prevent accidents or malfunctions.

8) CHALLENGES OF DRONE TECHNOLOGY

- Weather : Drone cannot fly during rain and windy
- Battery : Normally last around 30 minutes in flight
- Payload :Total interface including camera, LiDAR and thermal sensor normally below than 20kg
- Data misuse: Data collected by drones, such as crop yield data, can be misused if it falls into the hands of a third party.
- Privacy issues: While using drone for surveillance it may cause privacy issues
- Compliance issues: As per the regulation the drone manufacturer has to follow the stringent laws. The Government of India has mandated that all drones or (UAs) must register through the Digital Sky Platform to receive a UIN and UAOL license.

9) APPLICATION OF DRONES

• Scientific research
• Remote sensing
• Commercial aerial surveillance
• Domestic policing and patrolling
• Search and rescue operation
• Forest fire detection
• Transport of goods
• Oil, gas and mineral exploration and production
• Drones Can be used in irrigation land mapping, watershed mapping.

10) CONCLUSION

Drones has wider range of applications and increasing its utility day by day. Another advantage of drones due to its compact size and extensive capabilities to carry more payload, long flight duration etc. Additionally, they serve as an efficient means of transporting medical supplies to remote areas, particularly in cases where the road infrastructure is hindered by challenging topography, rendering conventional modes of transportation impractical.
Drones are challenging technologies and become more and more powerful due to advancement technological synergy. After a few decade the drone technology become enough mature and sustainable with lawful of its implemented application in almost all the areas.

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