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Problems and Prospects of Flying Rotor Drones Particularly Quadcopters

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Abstract

Rotor type drones are used as a source for acquiring intelligence from areas which are remotely located. This intelligence can be used for ensuring crop insurance, knowing post-disaster assessments, knowing information of restricted security zones, etc. Apart from various advantages, rotor type drones, like quadcopters, have certain drawbacks also. These drawbacks need to be researched and addressed in detail so that the information can be acquired in a manner which is deliberate and very effective, while obtaining information from various sensors attached to the drones. These drawbacks are the problems pertaining to sound of propellers, selection of flight controller, power management issues, flying in non-conducive weather, collision avoidance, videography during night and extended communication ranges, which have been discussed in this paper.

1. INTRODUCTION

Rotor type drones are used for multifarious activities that include gathering intelligent information from far flung places which are not accessible by humans, post damage disaster assessments, agricultural insurance (Hartanto et al, 2019; Jun et al, 2017), civil applications (Hayat et al, 2016), air quality measurements (Villa et al, 2016), etc. The rotor type drones are easy to build and requires very less resources for manufacturing. On the other hand, the satellite, and fixed-wind UAVs (unmanned aerial vehicles), which are also used for similar roles, require large amount of funds for manufacturing purpose. In addition, rotor type drones have an exclusive facility of hovering over a place, which is not there with fixed-wing UAV or aircraft. The large number of sensors in the form of various cameras can also be mounted which can provide live feed of scenarios which are as such out of reach from human beings. The satellites were used earlier for transmitting live pictures and videos. The operating cost of using the satellite was, however, very high. Aircraft was used in place of them. The operating cost of using them for relaying, surveying was moderate but costly in nature. The degree of availability was moderate for aircraft in comparison to satellite, though. A rotor drone, on the other hand, bridges the gap and provides high spectral imagery at a very low cost. Rotor drones are being used in majorly two broad areas viz., civil applications and military applications.

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1.1. Civil Applications and Military Applications

Various civil applications in which rotor drones being used are elucidated below.

(A) Providing wireless coverage
(B) Remote sensing applications
(C) Inspection of power lines
(D) Counting wildlife
(E) Delivering medical supplies to inaccessible regions
(F) Forest fire detection and monitoring
(G) Humanitarian aid
(H) Landslide measurement
(J) Illegal landfill detection
(K) Construction
(L) Crowd monitoring
(M) Crop surveying
(N) Agriculture insurance
(O) Soil examination
(P) Irrigation monitoring
(Q) Inspection of airport

1.2. Military applications

Various military applications (throughout the globe) in which rotor drones being used are elucidated below.

(A) Real-time monitoring
(B) Surveillance
(C) Patrolling
(D) Demining
(E) Natural Disaster Management
(F) Convoy Protection
(G) Landslide investigation
(H) Aerial photography

Instead of the various applications (as per specific advantage), no drone has been manufactured till now which doesn't have any basic drawback. The reason behind the same is drone(s) are manufactured without paying adequate heed to the basic inherent drawbacks. They are manufactured as per specific application only. It is therefore of paramount significance to understand the drawbacks in detail. These basic drawbacks further need to be researched and addressed in detail so that the information can be acquired in a manner which is deliberate and very affective, while obtaining information from various sensors attached to the rotor drones.

2. AN IDEAL QUADCOPTER

An ideal quadcopter may have the following characteristics, which are very important for providing intelligent information to managers, seating at the hinterland, so that the orient, observe, decide, act (OODA) loop for them, may be shortened to a great extent (Chen and Liu, 2016).

- Light in weight
- Best microcontroller
- Correct usage of Lithium Polymer (LiPo) battery in comparison of weight
- Higher sustenance in air
- Automatic collision avoidance mechanism
- Extended communication ranges

All the above aspects are basically the drawbacks or research gaps, which are still being researched in detail to home on to an ideal quadcopter.

3. PLANNING PARAMETERS OF ROTOR DRONE OR QUADCOPTOR

The planning parameters based upon which a quadcopter should be manufactured are very important, as based upon them the genesis of an ideal quadcopter (free from major limitations) can be built upon. Characteristics of a quadcopter incorporating some salient planning parameters are discussed below.

1. Quadcopter should provide best pictures and videos using the multispectral, hyperspectral and thermal sensors.
2. Quadcopter planned to be used should have maximum stay time in air by employing appropriate LiPo battery. The additional details may be found in Vohra et al (2021).
3. Quadcopter should create less noise through rotors, by designing the propellers and using material at a safe distance from propellers of the drone.
4. Quadcopter should easily relay the pictures/videos through communication medium to rearward- maximum distance.
5. Quadcopter must have a collision avoidance mechanism. The novel artificial algorithm needs to be incorporated in the flight controller of the drone.
6. Quadcopter should have the best flight controller, with the capability of taking various sensors and making the drone as efficient for intended task as possible.
7. Quadcopter, so used should have the capability of performing with its best capability even in harsh terrains and non-conducive weather conditions.

All the above objectives which are research gaps still existing in the industry, are covered below in greater details.

4. RESEARCH GAPS REQUIRED TO BE ADDRESSED

The various drawbacks associated with drones, which are still being researched and where study gap still exists, are enunciated below in succeeding paragraphs.

4.1. Acoustic Signature of Quadcopter

The acoustic signature made by the propeller gives advance warning that someone is nearing by (Kloet et al, 2017). It gives the security personnel the time cushion to react so that the drone can be put down. This acoustic signature can be muffled by use of following techniques.

(A) Using shrouds

Shrouds around propeller is a way of putting the noise of drones down to many decibels. These shrouds can be in the form of rubber, foam or aluminum foil. The solution, however, reduces the sound of drones, increases the weight, thereby decreasing the overall flight time of drone. The concept is to surround the drone with an anechoic chamber type environment. It was found that the quadcopter with light high-quality foam can dampen the noise of the quadcopter to a great extent in comparison of aluminum foils or a combination of foam and aluminum foils.

(B) Using specially designed propellers

The propellers can be designed in a manner which are large in number but specifically designed which reflect the air with propellers in a manner that the sound gets muffled (Abdelwahid et al, 2019). The DJI Mavic Air 2 is an example of such a rotor with blades which are specially designed so that the propeller emits less sound. Propellers, which are larger in size, can even with less speed, produce the same pressure against air to lift the drones as against smaller propellers, which produce a lot of noise.

(C) Using brushless motors

Motors on which propeller run are available in varying forms, which by virtue of their continuous rotation, also produce sound. It is found that using good quality brushless motors for propeller also reduces the sound of propeller to a great extent.

4.2. Choosing Appropriate Flight Controller

Flight controller is the brain of drone, which controls the altitude, and helps in achieving stable flight for drones even in stormy conditions. All the sensors are controlled using flight controller which is controlled by the transmitter at ground (Baris et al, 2019). The flight controllers are available in varying forms depending upon the nature of drone to be flown (Glock and Meyer, 2020). The varying forms of flight controllers make them a subject to study, as it becomes very confusing sometimes, to select the appropriate flight controller that fulfills the requirement.

4.3. Cost comparison of various flight controllers

The cost comparison of various flight controllers is given below in table 1. The user as per his requirement can use various flight controllers after detailed scrutiny of the technical details.

Table 1. Cost comparison of flight controllers

Name	Cost	Remarks
CC 3 D	Rs*.1200.00	Programming possible with PC
KK 2.1 (Red switches)	Rs. 1500.00	No PC required for programming
K2K 1.5 (Black switches)	Rs. 1800.00	PC required for programming
APM 2.8	Rs. 3000.00	PC required for programming
Pixhawk	Rs. 6000.00	PC required for programming
APM + GPS	Rs 7000.00	PC required for programming
DJI Naza M Lite	Rs. 8000.00	PC required for programming
DJI Naza M Lite + GPS	Rs. 18000.00	PC required for programming
DJI Naza M V2	Rs. 15000.00	PC required for programming
DJI Naza M V2 with GPS	Rs. 25000.00	PC required for programming

Note: * Rs. is equivalent to Asian Rupees

4.4. Power Management of Drones

The drones are used for diverse activities right from surveillance, express shipping, precision crop monitoring, geographic mapping of inaccessible terrain and locations etc. To perform affectively in ibid actions, the drones must keep flying for some time in air. Remaining in air for a longer duration is therefore a necessity for drones, but their stay duration is totally dependent upon the batteries used. The batteries which are normally used in drones are LiPo batteries which are rechargeable. The options are now available to recharge them once the drone comes back to ground or to recharge them using Poles/ Recharging Stations (Huang and Savkin, 2020). In addition, there are methods through which they can be recharged using other drones also while in flight (Jain and Mueller, 2020). Further details can be found in Vohra et al (2021).

4.5. Collision Avoidance

The sensors are installed in drone at front and back, right, and left, above and below, which alert the drone that the obstacle is near-by. The drone can be formed with two sensor/side-guarded, four sensor/ side-guarded, six sensor/ side-guarded. Once the obstacle comes in front of a drone, it must decide whether to take a turn from side with some radius, or it is flown above the obstacle (Devos et al, 2021). Although multiple algorithms have been developed written in this regard but the problem is still under research and a lot more is to be done. The decision to maneuver around the target is taken autonomously by the drone following an algorithm which is programmed in the flight controller of the drone (Singh and Dhuheir, 2020).

4.6. Extension in Communication Ranges

The drones need to transfer information to the receiver, where the pilot based upon the information received, diverts the drone to a different path to obviate any collision or further instruct it to perform some tasks which is to be notified to the drone through instructions. There are instances where the drones move out of the range and further communication is, therefore, not possible. In such cases, the need to increase the communication ranges of drones becomes quite prevalent. Same can be achieved by two methods. The drone which is in air passes the information to the receiver which is present on the ground. The communication network which is already deployed in ground is used in such cases. In other method, there are instances where the ground communication is not enough to provide seamless communication to drone. Drones are at some places used in relay roles where for some time of the day, they act as a small relay for extending communication ranges (Arribas and Mancuso, 2019).

4.7. Weather Conditions

The weather conditions also play a pivotal role in determining the correct flight of drones. Weather conditions can be classified as given in Table 2. The drones need to be flown, only when the weather supports them. The weather on an average remains conducive for drones to fly, except in situations as described in Table 2. The drones must not be flown during severe conditions where there are very high chances of drones to get damaged (Luers, 2003). The propellers, flight controllers will get seriously damaged in weather conditions which come under the category of adverse and severe weather (Ranquist et al, 2016).

Table 2. Severity of weather (Gao and Hugenholtz, 2021)

Severity	Hazards	Weather Types	Flying drone
Moderate	Reduced visibility	Fog, Haze, Glare , Cloud cover	Not advisable
Adverse	Loss of communication, Loss of control, Loss of command, Diminished aerodynamic performance, Reduced operator	Wind and turbulence, Rain, Solar storms, Temperature and humidity, Snow and ice	Not to be flown, Only for proving some facts of experiments
Severe	Severe damage to or loss of aircraft, Unacceptable risk to operator and person	Lightning, Hail, Tornadoes, Hurricanes	Strict No

4.8. Videography during Unfavourable Conditions

The drones are required to be used for videography even at unfavourable weather conditions. Video from drones can only be transmitted at night if drone has requisite thermal sensors, which can pick the heat signature of various bodies (Bürkle, 2009). Normal cameras do not have facility of picking the heat signatures and therefore will not be able to record anything at night-time (Dilshad et al, 2020; Nalamati et al, 2007). Moving vehicles can also be tracked by drones even at night using heat signatures emitted by the vehicles (Yeom and Nam, 2021). As the drones are not able to sustain in rains, so, videography is also not possible during rains. Research is being done for drones to sustain in rainy conditions. Similarly, the drones generally do not sustain in stormy weather conditions, affecting videography in such situations (Jeon and Lee, 2020). Good flight controllers with multiple sensors are used in such cases to make drones sustain in such conditions.

5. PROPOSED METHODS TO BRIDGE THE GAPS

(A) Reduction of Noise
For reducing the noise of propellers, foam will be used at a safe distance from the propellers (Vijayanandh et al, 2019). The frame will accordingly be used by the drone to give adequate spacing from propellers.

(B) Collision Avoidance
For taking care of the collision avoidance aspect, telemetry method is to be planned, which will provide command to the drone to return to home (Chen et al, 2016). In addition, the drone will be fitted with sensors from all six directions. Obstacle sensing techniques using artificial intelligence (AI) may be used (Aswini et al, 2018).

(C) Videography in Extreme Weather Condition
For facilitating videography in extreme weather conditions, good flight controller with proper gimbal positioning is to be used with the drone frame. Camera will be adjusted in such a manner, in case the drone moves in a random direction, the camera remains at the same position, so that focus of the camera is not affected.

(D) Extended Ranges of Providing Video and Pictures
To facilitate longer ranges of communication, a second drone may be used as a relay so that video/ pictures are made available through maximum ranges. The placing of type of antenna with polarization aspects need to be considered.

(E) Power Management
The LiPO battery to be used in a manner, keeping the voltage, capacity, and discharge rate etc. parameters, under consideration so that maximum sustenance by drone in air is made possible.

(F) Flight Controller
For selection of flight, different flight controllers can be used and programmed through hardwired switches or through laptop/PC (Ding et al, 2014). The best flight controller decision will be taken once all the flight controllers need to be checked in practicality, so that their theoretical aspects can be matched with their ground results (Ebeid et al, 2017).

6. IMPRESSIONS OF A QUADCOPTER

The impressions from a quadcopter affected by the above drawbacks are tabulated in Table 3, to to better assimilate, how a quadcopter provide false readings when being affected by the drawbacks covered above.

Table 3. Impressions of a quadcopter

Serial No.	Type of rotor drone	Type of drawback	Disadvantage of drawback	Remarks
1.	Quadcopter	High acoustic signature	The audio and videos transmitted have a humming effect	This drawback may be minimized using shrouds or using specially designed propellers.
2.	Quadcopter	Wrong use of flight controller	The sensors were not giving the requisite details as per requirement	The flight controller is the brain of the quadcopter, therefore, need to be properly chosen as per the function envisaged.
3.	Quadcopter	Power management of drones	The rotor drone stayed in air for only 45 minutes	For a rotor drone to stay in air for a longer duration, high end Lithium Polymer (LiPO) battery to be used but the caveat is weight. So, we need to strike a balance whether we want more sensors or more duration in air.
4.	Quadcopter	Collision avoidance	The rotor drone got engaged between high trees and was not able to understand the obstacle	Collision avoidance cameras to be put so that necessary indications from right, left, top and below may be given by the sensor to flight controller which can subsequently guide the rotor drone in terms of collision avoidance.
5.	Quadcopter	Extension in communication ranges	Absence of long-range video/ audio transmitting aerials led to shorter communication ranges	There are aerials which provide higher ranges. In addition, rotor drone (in air) ca also acts as a relay for extending communication viz. audio and video.
6.	Quadcopter	Weather conditions	The drone did not fly during rains and heavy wind conditions	Some changes in the physical attributes especially by shielding flight controller, GPS antenna and other sensors from the water droplets of rain will help in sustenance during rains also.

7. CONCLUSION

Rotor drones, right from the nano to huge ones, have varied usages depending upon the task for which they are specifically made. As they, being complex systems, the drawbacks or research gaps in either of these terms viz., power management, flight time, communication relay limitation, sustenance in unconducive weather etc., will still prevail. These basic research gaps are therefore identified in this paper and various prospects/ solutions for solving them, up to great extent, are also discussed in brief. The drone, so developed, devoid of all such basic drawbacks, will avoid collision, automatically adjust its power, and will re-energize itself so that longer sustenance in air is possible. In addition, with some minor changes in the physical attribute, if a rotor drone, performs effectively in rains and high-altitude terrains, then the same rotor drone will be able to give data in real time from far-flung places which are almost impossible for humans to reach. It is therefore the need of the hour to make an ideal quadcopter which proves as single point of contact (SPOC) for any task irrespective of its application. This will only be possible if creation of one such ideal quadcopter is made possible. Out of all the drawbacks mentioned above, the drawback in relation with acoustic signature and collision avoidance mechanism are of great interest to the researchers in present era as it will involve innovative thinking in the paradigm of supervised learning which is part of machine learning or artificial intelligence. On the contrary instead of making an ideal quadcopter, if all kinds of rotor drone are aimed to be studied, then that exercise will be futile as the number of different kinds of rotor drones (as per application) existing are mind-boggling and are in the figures of billions.

Author contributions

All authors have contributed with maximum contribution. All authors have contributed with maximum contribution.

Conflicts of interest

There are no conflicts of interest in any part of the research paper.

Statement of Research and Publication Ethics

For this type of study formal consent is not required.

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