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Design and Development of a Multi-Application Hexacopter

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Abstract: ***The technology of the fixed wing and the rotary wing unmanned aerial vehicles have been emerging and the applications have been focused widely to numerous regions. This paper focuses on some applications where we have tested our multicopter and in future the further improvement shall incorporate. Our main focus was to build an aerial Covid warrior considering mainly three different and useful applications particularly for remote village areas where many facilities are not always available. First application is the delivery of the medical supplies to the people in need. Second, use of the onboard speaker, which can relay valuable information during emergency or the valuable health related awareness remotely by respective department. And the third application is use of the sanitizer spray arrangement for the larger area disinfection. The prototype has been tested in a typical village area in different conditions and has provided required performance due to optimized design. This paper is to facilitate other users to explore the capabilities of the multicopters for any situations like we suggested with this project considering this pandemic.***

Keywords: Multicopter, Aerial Covid Warrior, Multi-applications, Sanitization, Public Awareness.

I. INTRODUCTION

As of increasing population and advancement of technology the system of air travel and air delivery has been touching remarkable heights thanks to multicopter which do not require any space for taxing. The multicopter can take flight anywhere if the suitable amount of space is available and similarly can land anywhere. Nowadays these multicopter are widely used for surveying [1] delivery of goods, in agriculture sector [2], environment monitoring [3], mapping forest areas [4], entertainment purposes [5] and rescue operations [6]. Military as well as civilians are using this platform for different purpose because of several advantages it offers as this platform is simple and easily can go through maintenance. Because of their varying size and capabilities these UAVs are the future for the medicine and other utilities delivery and much more. Since we are approaching to the possible best future the more outcome of the UAV platform is yet to come in terms of performance, security, accuracy etc. Similarly, we also tried to develop and explore the capabilities with available materials in this COVID19 crisis area to develop a UAV which could even command people to wear masks through remotely piloted by means of speaker and can deliver masks, medicines, and other needed utilities to those people in need, and spray sanitizer for a large area disinfection. The multicopter we build is of custom -made design to accommodate the several things we decided to use practically. The result discussed here will be of the environment based on a typical village area. Our team has done their best to find possible solution from a low cost-based platform and improving other several components will surely make this multicopter more endurable, strong, and agile and its performance character.

II. DESIGNING OF THE HEXACOPTER

A. Frame of the Hexacopter

Hexacopter generates thrust with six motors attached within six arms and to achieve stability three motors are made to rotate in clockwise and three in anticlockwise directions. with this setup it is able to cancel the net moment about the drone's yaw axis. The set speed of rotation of the motors is maintained with the help of ESC.

Lightweight yet strong enough materials has to be used for the frame to support its operational weight and structural load. The design of the frame is Hexagram with six equal long arms attached to the centre of a double hexagonal plate. [7]

Materials used in the frame are shown as below in Table 1.

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TABLE I

MATERIALS USED IN FRAME

S.No.	Component	Material	Properties
1.	Base	Plywood	High strength and Dimensional Stability, High Impact resistance, Light weight, easy availability, and affordable cost.
2.	Arms Undercarriage	Hollow Aluminium pipes	Light weight, strength and stability, easy availability, and affordable cost.

B. Electronic Components used

1) Batteries: "The Orange 5200maH 4S 40C (14.8V) LiPo" battery pack with XT60 connector which is equipped with heavy-duty discharge which leads to minimize resistance and sustain high current loads. It has high performance, reliability with optimum price.

2) BLDC Motor: "A2212 1000KV BLDC Brushless DC Motor", with an equipped shaft of 3.7mm. This motor is equipped with a solid metal case which makes it reliable and durable in crash.

3) Propellers: "The orange HD Propellers 1045(10*4.5) ABS DJI BLACK" which are high quality propellers specially designed for multi-copters. These propellers are light in weight and high strength propellers and has a 15degree angle design at the end of the propeller to avoid whirlpool while the multicopter is flying.

4) Electronic Speed Controller: "30A BLDC ESC with 5V, 3A BEC" It can drive motors with continuous 30Amp load current.

C. Software Component used

The software used here is called ArduPilot Mission Planner which is full-featured ground station application for the ArduPilot open-source autopilot project. Mission planner is a free, open source, community-supported application developed by Michael Osborne for the open source APM autopilot project. Mission Planner is a ground control station for Plane, Copter and Rover. It is compatible with Windows only. Mission Planner can be used as a configuration utility or as a dynamic control supplement for your autonomous vehicle.

The assembly is shown in Fig.1

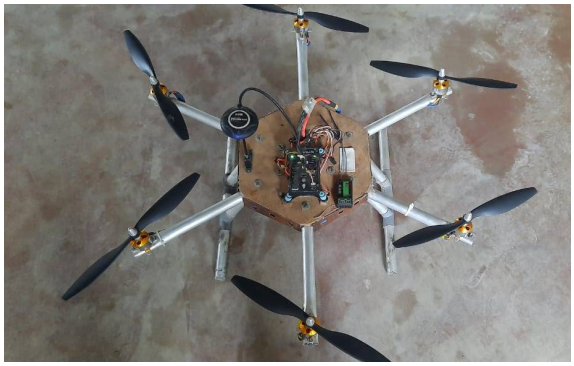


Fig.1 Assembly of the Hexacopter

III. THRUST CALCULATION

While using a 3s i.e., 11.1v battery with a 10*4.5inch propeller a A2212 BLDC motor generates 750grams of thrust.

So, 750*6=4500grams (total thrust provided by six motors)

Total weight of multicopter is around 2000grams

So, we still have 4500-2000=2500 grams of take-off payload.

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But all of this payload cannot be utilized because the multicopter will not fly if thrust will become equal to the weight to be lifted. The thrust has to be more than weight to be lifted off.
Therefore, the take-off payload weight has to be less than the 2500 grams.

IV. APPLICATIONS

A. Payload Delivery

To this solution we designed our own 13cm*6cm*7.5cm delivery box of strong cardboard (which is light in weight and holds required strength) for equipping up to 500 to 700grams of payload. Since the compartment of the delivery box is servo operated a similar kind of parachute can be deployed with the help of the RC transmitter. And as the delivery box is custom made and made by local available material, the associated compartment size can be increased with the payload capacity by increasing the thrust requirement thus adapting a good Brushless DC motor of high thrust. The compartment is located beneath the battery holder giving an adequate clearance from the ground as well.
This can easily be used for the delivery of the medical supplies such as medicines and masks to the people in need in remote areas. [8]

B. Speaker Module

Different law enforcement agencies and organizations of Sierra Leone, Rwanda, USA, Spain, Italy, China, France, UK, India and other are deploying drones in order to survey the public spaces and to get a better perspective of lockdown thus sending messages over a loudspeaker to generate awareness among people as in [9].
The broadcasting of voice messages will reduce the possibility of false news from being spread.
We used a pre-recorded audio file with a mini speaker. The size of the audio file can be varying depending on the requirement of the situation which was operated between normally 4volts. The awareness among a certain group was effective as well tested in the village. The characteristics can be enhanced further by adding an extra feature of microphone to broadcast live messages from a distance.

C. Sanitiser Spray Arrangement

Worldwide from government to local people are taking necessary measures to overcome the effects caused by COVID-19 outbreak. The public health care officials of India proposed that it is necessary to frequently sanitise one's own self and the surroundings. In this aspect, disinfecting large halls, shops, malls, parks, houses, and streets is a challenging task. Incorporating drones to do such a task is cost efficient and reliable as drones can sanitise tall building, houses etc, whereas human force will take much longer time to do such thing [10]. An ISO-9001 company Garuda aerospace designed an automated disinfecting unmanned aerial vehicle that can sanitize public places, hospitals, tall buildings and therefore came to be known as corona killer.
These drones based can spray disinfectants on infrastructure up to 450 feet. The drone based swacch bharat campaign to clean India is already started in Chandigarh and Varanasi.[11]
Now, we fitted a 12Volt DC motor in combination with compressor for the low-pressure suction from the tank. The tank can be filled with disinfectants around 500 millilitres, the capacity can be increased by increasing thrust or by changing the BLDC motor of higher capacity. A small 500ml bottle was attached, filled with disinfectant which then connected to the compressor motor attached to a small sprinkler spray mechanism. Hence when operated the disinfectant gets pressurized with the help of compressor motor and then to the spray mechanism.

V. ADVANTAGES AND LIMITATIONS

A. Advantages

1) The exemplary model of this Multicopter offers discrete solutions to typical problems in these unprecedented COVID times.
2) The hexacopter offers a significant advantage of all due to its six propellers. Even if one of those propellers fail, the other five can keep the machine flying.
3) A hexacopter have higher speeds and more power with which it can elevate to higher altitudes due to increase in number of motors included than a basic quadcopter.
4) It offers more stability and great control due to increase in number of motors, hence decided to carry out such applications as delivering payloads and disinfection over a larger area.

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5) Also, more importantly spraying will reduced the risks workers face compared with ground-based applications. Workers will have less exposure to the virus, both because they spend less time in contaminated areas and because they do not physically cover all the ground-based equipment.

B. Limitations

1) Can be larger in size, making the copter harder to fly and manoeuvre in tight spaces.
2) Priced higher than a quadcopter due to increase in number of motors.
3) If two propellers fail, the copter would not be able to fly but it will remain stable enough to reach the ground safely. If more than two motor fails, then it might crash to the ground.
4) The motor parts or other parts to be replaced due to damage can be expensive.

VI. CONCLUSION

The hexacopter is preferably a great option to use for so many applications such as surveying, carrying payloads (higher than a typical quadcopter), shipping and delivery, difficult mapping and atmosphere studying at higher altitudes and helping to optimize agricultural operations.

But they are used typically for one application at a time only. Customized drones can be available by private companies which offers customization according to the customer needs offering more than 2-3 applications all in one multirotor.

Sanitiser spray drones are also available at some places across the country utilizing to disinfect roads and other public places. And delivery of medical aids is also one of the common applications carry out mostly in the time of crisis. Speaker is also use for mainly search and rescue operations, crowd control, and broadcasting.

No multicopter is available in the market which offers all these applications at once, it can be made via private organizations with customizations, but it would make it extremely expensive. Which would not be the ideal requirement of ours.

We developed this multicopter integrated with all these applications to help the people in need in remote village areas considering the unprecedent COVID situations. Hence, we tried to make it as agile, strong, and feasible as possible along with not making it expensive at all compared to the drones available in the market. Choosing materials which were easily available locally rather than going for expensive carbon fibre ones helped with keeping the cost low. And as it is just a prototype no sensors were required to install in it as it will be working within visual range only.

Reviewing others work surely helped us designing the frame of the hexacopter and installing the electric and software components on the base in such a manner that it would not increase the weight and do not cause any additional drag. Which results in stable flight and control of the multicopter. It also helped us in understanding how it can be used for certain applications and what applications can be suitable to demonstrate with the help of this multicopter.

VII. SCOPE OF FUTURE WORK

With the present design of the multicopter it uses a battery of 5200mah which provides it the following characteristics:

A payload capacity of about 1kg.

A visual flight range within 700 meters.

And an Endurance of about 10 minutes.

This capacity can however be increased by simply increasing the battery power and increasing the size of the whole multicopter. It can also be modified with certain accessories like a good HD camera for surveying, and some sensors like GPS or motion sensors for anti-collision control.

Main objective of this is to provide the help to the needy people in village area during this difficult COVID time. If the government approves its usage, then it can be made even bigger with higher capacity and more endurance and range by double or high-capacity batteries, and motors with more power.

This multicopter will be of great use even after culmination of this COVID crisis. Payload delivery system can be used to deliver anything within certain capacity. The speakers can be used to deliver or broadcast any message by the government or any organisation in the village. And spray system can be used either to spray sanitiser to maintain the hygiene of any place or it can be introduced to help in the agricultural sector.

Therefore, this multicopter will be of significant use not just from present needs point of view but also from future point of view. It can be of versatile use for the people needs.

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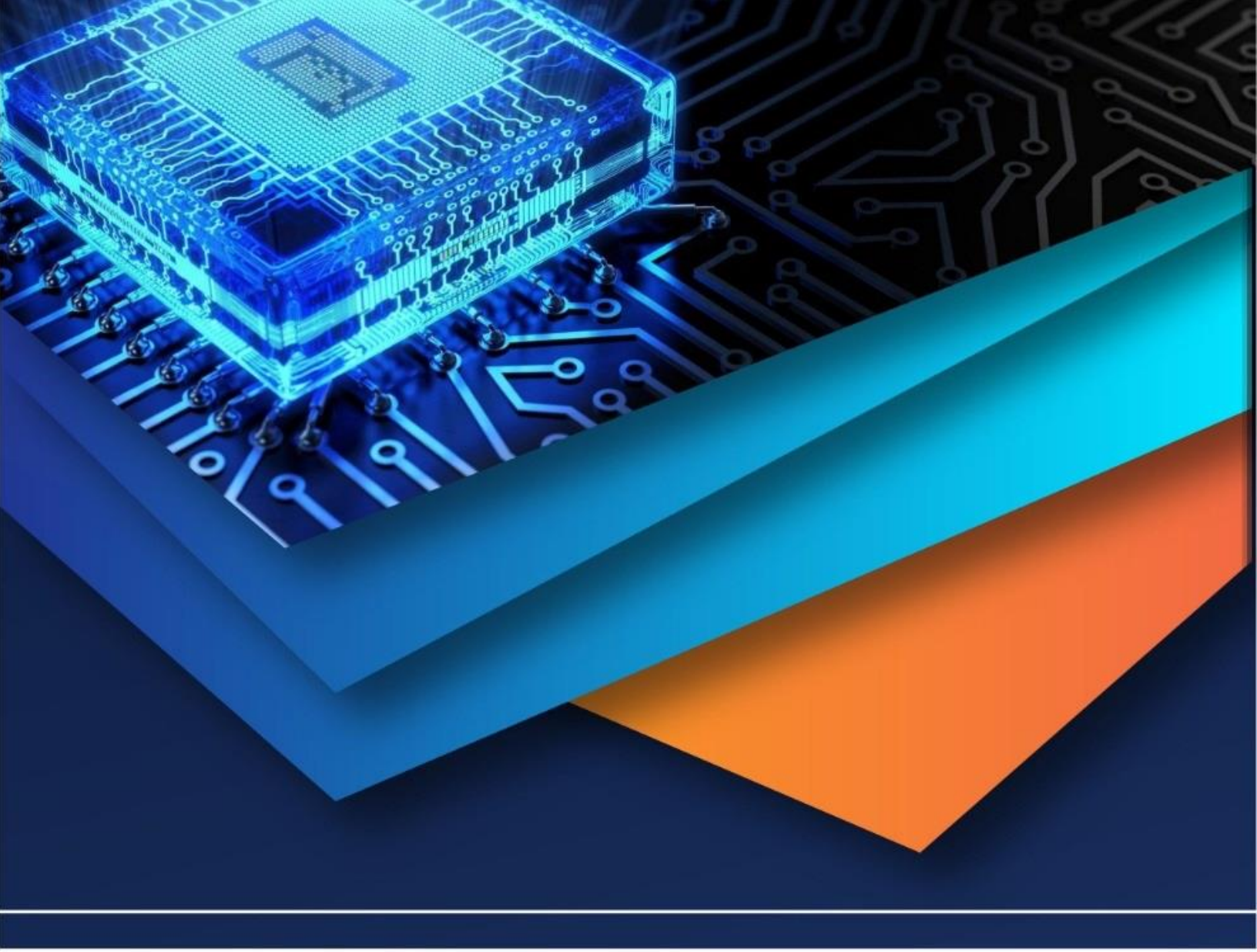
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