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Human-Centered Drone Design for Medical Supply Delivery

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Abstract: Drone, due to their flexible applications to facilitate human life, is currently used at great demand. They perform tasks repetitively at reasonable cost and quality levels. The main objective of this work is to design and develop healthcare delivery drone. The delivery drone has the potential to have the same effect on traditional transportation infrastructure. Due to poor transportation infrastructure, or roads blocked by severe weather, disasters or traffic congestion, the delivery of small items like medicines, blood and vaccines or other healthcare items that is needed in locations with difficult access becomes critical in healthcare.

To overcome this problem, autonomous drone is design for the rapid delivery of medicines at places required. The delivery drone with an ardupilot is built through both manual and autopilot mode which drives the drone to the position necessary. It can supply up to 2 kg of medicine with flight time of 7 min.

Keywords: Autonomous vehicle, Healthcare drone, Path planning, Global positioning system, Electrical speed controller

I. INTRODUCTION

Drones are unmanned aerial vehicles (UAVs) that have vertical take-off and landing capabilities. They can be personalized and built to reduce weight and have four rotors arranged in a specific direction. These drones are made of lightweight composite materials for weight reduction and maneuverability enhancement. They are equipped with advanced technologies like infrared cameras, GPS, and lasers and are operated by remote ground control systems (GSC). UAVs are divided into fixed wing and rotary wing models, each with its own strengths and weaknesses.

Drones have become cheaper due to software-based control functions and the ability to use multiple UAVs for a single application. Advances in hardware, technology, and networks have made drones more efficient and cost-effective. They can monitor and navigate using cell phones or tablets, and their operating system can control the network through weather data and optimizing drone paths.

Useful drone functions include the distribution of medicines, blood, and vaccines in hard-to-reach areas, such as India. The project aims to eliminate difficulties and complications in existing medicine transmission methods and design a drone for delivering medicines with a short time span using a perfect navigation system

Drawbacks of existing method are:

1) Not possible to deliver the necessary things within the time
2) To deliver the healthcare items in rural areas is more difficult
3) The road blocked for transmitting healthcare items, from one place to another place
4) Most people lose life because of the lag in time of treatment to patients.

II. MATERIALS AND METHODS

A. *Frame Selection*

The material for the Chassis or Body Frame used in this project is Acrylic sheet shown in Fig 1. The properties of the acrylic sheet are, relative Density of 1.19 g/cm^3, rockwell Hardness of M102, tensile strength of 75 MPa, operating temperature of 40ºC.

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Fig. 1 *Acrylic sheet*

Fig. 2 *RS 2212-920kV Brushless Motor*

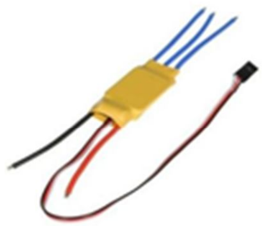

Fig. 4 *Electric Speed Controller*

Fig. 3 *Internal structure of BLDC motor*

Fig. 5 *LiPo Battery*

Fig. 6 *APM Controller Board*

B. Brushless DC motor

In order to control the quadcopter, high quality, reliable engines with rapid response are needed. If one or more of the engines are experiencing any problems at some point during a flight, it would be devastating for the quadcopter, as it can be dangerous for the quadcopter itself, property and people. It is also critical that the motors are sufficiently powerful to be able to lift the quadcopter and perform various aerial movements. This project also requires the engines to respond quickly to ensure a stable flight and a vibration-free flight. Based on these criteria the Ready to sky RS 2212-920kV Brushless Motor is acquired through this model. Fig 2 shows Ready to sky RS 2212-920kV Brushless Motor. It is designed for both remote and quadcopter aircraft and is considered highly reliable. Fig. 3 shows the internal structure of BLDC motor. Ready to sky have extensive experience with RC aircraft and quadcopter engines, and their engines are proven to be vibration-free. Based on the ESC and propellers, each engine can give a thrust of 0.5 kg at 920 kilowatts, according to the specifications. This is sufficient to meet the requirements, and if required, it can perform quick moves, which will simplify the control sequence.

C. Electric Speed Controller

An electrical speed controller (ESC) is an electrical circuit designed to adjust the speed of an electrical motor. For the same reasons as mentioned for the engines, the ESC should be fast and reliable. HW series 30A ESC produced by Hobby wing is used in this venture, which comes with a limited range of programming functions. Fig 4 shows ESC used to control the speed of the DC motor and to supply three-phase electrical power from the source of the DC battery. Signals that are sent to the three-phase brushless motor control the speed of the DC motor. This ESC's rating is of maximum current 30A with 3S Li-PO battery, and its weight is mainly lower.

D. Lipo Battery

The quad copter and motors and sensors are powered by using a battery pack. Lithium polymer battery is a rechargeable battery with low voltage weight and height similar to other batteries. There are three types of rechargeable batteries: nickel-cadmium, nickel- metal hydride and lithium polymer batteries. Nickel-cadmium battery has low internal resistance allows high power output, can operate a wide temperature range but suffers from loss of energy that can be retained by the battery after each discharge. The NiCad battery's overall capacity will decrease over time. NiMH batteries are identical to NiCad batteries with the exception that they can store 30% more power capacity but suffer from a large discharge]. Li-Po battery can hold 30% more capacity and are much lighter than the NiMH battery. Li- Po also suffers from a lower discharge compared to NiMH battery. The disadvantage of NiMh battery is including a high self-discharge (around 50% greater than NiCd) and a degradation of performance if stored at elevated temperatures. Due to this reason Li-Po battery is been chosen A battery that stays within the input voltage limits of the microcontroller, and that the battery provides enough power to be able to sustain a flight for at least 10 minutes. Hence, Tec leads 2200mAh 3S 25C Li-Po Pack delivered by Hobby wing is used. Figure 5 shows 2200mAh battery, which should allow a normal flight for an estimate of 15 minutes, although the battery voltage needs to

E. APM Controller Board

KK board 2.1.5 would not be sufficient for this project, because the KK board lacked the necessary stability to lift the weight and also lacks autonomous fly. This project requires a controller board which having high stability to lift a box above a particular distance from the ground for transport of medicines. For this reason, a more powerful board needed to ease of development, to allow future upgrades and to make the drone fly autonomously. The specifications of KK board and the APM board are compared. APM have far superior specifications considering high stability, number of Digital I/O pins, GPS portability and navigation along with ground control software (Mission Planner). Figure 6 shows APM Controller Board ARDUPILOT APM 2.8with 8 input ports and 16 output ports.

F. Transmitter

A radio transmitter is a device that allows the pilots to control the aircraft wirelessly. The signals/commands are then received by a radio receiver (RX) connected to a flight controller. During selecting a transmitter the following terminologies is considered,

1) Frequency and Technology

Most RC Transmitter come with 2.4GHz, it’s the most popular frequency currently lower frequencies are also available for longer range such as 433MHz and 900MHz. The 2.4GHz system is the standard for radio control after new protocols were creates that introduces frequency-hopping technology. The Higher frequency of 2.4GHz has the advantage of smaller antenna which is much more portable. However, the range is shorter than the lower frequencies.

2) Channels

Each control or switch requires a channel to send the signal to the receiver. Fig. 7 shows Transmitter Channels. The two gimbals take up 4 channels, throttle, yaw, pitch and roll. The extra channels namely AUX channels have auxiliary controls with switches. In general, it is recommended to have at least 6 channels for a quad copter.

3) Mode

*M*ode one configuration has left joystick elevator control and right throttle control. Mode two is the most popular quad copter since the stick is your quad copter's motion. It has the right joystick for elevator control and the left motor for throttle. Fig 8 shows the Transmitter Mode.

G. Global Positioning System (GPS)

Each drone's control is always with the pilot who uses visual tracking to decide their location and orientation for lower cost drones. Beginner drones normally do not have GPS, but The reason for choosing solid works over AutoCAD is the fact

The global positioning system is a satellite navigation device, which gathers signals from orbiting satellites using a radio receiver to determine location, velocity and time. This navigation system is more precise than navigation methods and offers knowledge of location within a few meters. Within a few centimeters, advanced GPS systems can provide even better accuracies. Integrated circuit miniaturization has enabled GPS receivers to be highly economical and be checked in software. The battery is quite heavy. The weight of the battery is around250g.

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More advanced drones use GPS receivers in the navigation and control system, allowing some smart GPS drone navigation features like Position Hold. Fig 9 shows GPS. GPS allowing the drone to remain at a set altitude and location Return to Home. The drone knows the position it took off from and will automatically return to this location by pressing the return to home button.

H. Autonomous flight

The drone's flight path can be pre-determined by setting the trajectory-defining GPS way points. The drone will then use the autopilot to follow this path after execution. All these features require the use of a GPS drone system, so having a basic understanding of how GPS works is important for a drone pilot accessible to all.

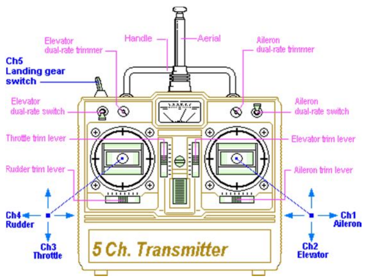

Fig. 7 Transmitter channels   Fig. 8 Transmitter Mode

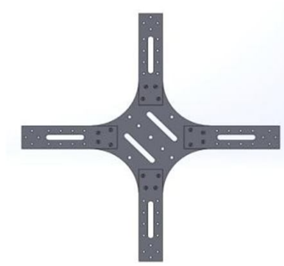

Fig 9 GPS   *Fig 10.Front View*   *Fig 11.Orthogonal View*

III. DESIGN AND DEVELOPMENT

Designing is the most important stage of any product. This machine is designed using solid works software. Initially the part drawings are made to the dimension specified and then the parts are assembled as shown in fig 10. that the ease with working in the former one. The front view and orthogonal view of the frame is shown in the figure given below. The frame of the drone was designed by Solid work software and then fabricated in acrylic sheet. The thickness of the frame is 4mm. The required shape of the frame was cut in the Acrylic Sheet and assembled by bolts and nuts. The assembled frame is shown in the fig. 12.

Fig 12 Frame assembly

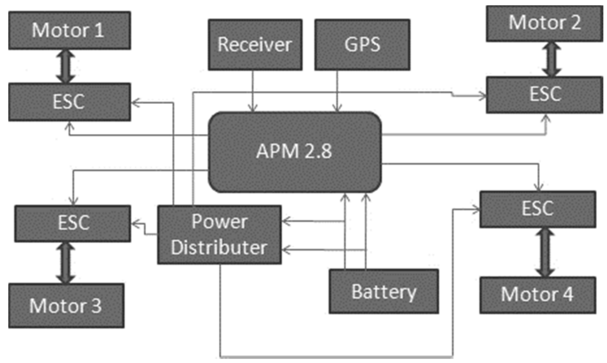

Fig 13 Electrical connection

A. *Electrical Section*

The electrical section consists of APM 2.8 circuit, Lipo- Battery, GPS Module, ESCs, Motors and receiver. Battery power is distributed to APM controller board and four ESCs. Each ESC is connected to separate brushless Dc motors. GPS and Receiver are connected to the APM controller board. When the receiver receives the signal from the transmitter, it will send that signal in to the APM controller board. Then control board provides the control signal to all the ESCs. GPS is used for path navigation. Each ESC will control the speed of their respective brushless motors. Fig 13 shows the electrical connection of the drone.

B. *Path Planning*

Path planning was done in the mission planner software by GPS

Step 1: Configuring the Ardupilot is to load the firmware for the type of vehicle.

Step 2: Make sure the correct COM port is selected at the top right and that the baud rate is set to115200.

Step 3: After setting the baud rate then click the connect on top right side

Step 4: Verify the sensors are working or not by tilting and moving the quad copter and watching the heads up display in Mission Planner.

Step 5: Then lock the GPS points shown in the Fig 14. Step 6: And then Motor, ESC, Transmitter Calibration is done by using Mission Planner Software

Fig.14 Path planning

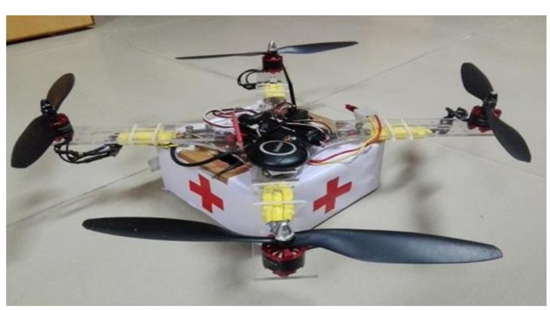

Fig 15 Entire health care drone set-up

Fig. 15 shows the entire setup of this project. It comprises the drone mounted on a medical kit and then fixed. Each motor providing 0.5 kg thrust force, enables the entire drone setup to lift and fly stable in the air with a maximum payload capacity up to 2 kg. It can fly at maximum altitude of about 50 meters from the ground level and with a GPS detection range with the APM controller is around 1-2 kilometers. Each component is tested and verified to be working as intended. Test flights have been conducted and the results confirm that the quadcopter can fly in a stable manner.

IV. DESIGN CALCULATION

A. *Mass of the Components*

Material used = Acrylic sheet
Density = 1.18 gm/cm^3
Frame = 0.35 Kg
Motor mass (1*4) = 240 gm
GPS = 12 gm
APM controller = 50 gm
ESC (1*4) = 128 gm
Battery = 250 gm
Total mass (W) = 1.05 Kg

B. *Motor Specifications*

Motor Type = DC brushless Motor
Power = 2×3.14×nT/60
Torque T = F*R*sin 90
Force F = 7*9.81 = 68.67 N
Torque T = 68.67*0.125
= 8.58 Nm

C. *Speed of Motor*

Velocity = 3.20 m/s
Diameter of the shaft = 0.006m
V = π D n/60
= π *0.006*n/60
Speed = 10,200 RPM

V. CONCLUSION

Health care drone is design and developed with implementation of navigation system to deliver the health care items. It has high stability because of the APM Control Board. It can travel, deliver and came back to its home position autonomously by GPS locations. With an autonomous drone the healthcare items like medicines, blood are easily transported to rural areas and during high traffic areas that reduces the time taken for the delivery.

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