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Design and control of electronics based medical emergency system using a Quadcopter

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***Abstract*—**Thesedays, there are many incidents that lead to road accidents, some being very severe. These accidents sometimes even result in loss of many lives. One of the major reasons for this loss is the lack of timely first aid. In fact, we observed from our survey conducted at an RTO that most deaths during accidents occur, due to delay or lack of first aid. The project focuses on developing a prototype of the system which would cater to the need of medical emergencies that arise during road accidents. This will be accomplished by use of a quadcopter which will deliver the required first aid. With this project, we are attempting to bring about faster accessibility to the patient, than other present means of medical emergency system. In order to achieve this goal, various means of communication will be utilized. The use of a camera will help to view the accident site. This will help to considerably bring down the death rates caused due to lack of timely first aid during accidents.

Keywords*—road accidents, quadcopter, first-aid, quadcopter components, traffic congestion.*

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I. INTRODUCTION

Nowadays newspapers are brimming with the headlines of innumerable accidents resulting in uncountable loss of lives. The absence of timely medical emergency and immediate treatment is one of the main reasons for this loss. Hence we will device a system that will provide timely first aid, thereby saving lives, considerably. The current medical emergency systems inclusive of ambulances are of great help in saving numeral lives, but a mode which constitutes faster accessibility to the accident site will help in reducing the number of immediate deaths. Our system will help in implementing this idea of faster site accessibility to a large extent, by providing timely first aid and serving the society through means of a quadcopter.The objective of our project is to devise a prototype of the system that would cater to the need of providing timely first aid to the victims of road accidents and thus help reduce loss of lives considerably. The above aim can be achieved by building a quadcopter which will help deliver the first aid kit using the necessary communication technology.

II. LITERATURE REVIEW

A. Theory

Emergencies typically occur in cases like road accidents, cardiac problems, convulsions, and so on. Trained technicians or paramedics provide first aid to the patient, i.e., pre-hospital care, and then shift the patient to an appropriate facility. Emergency Medical Service (EMS) is thus provided in two forms, pre-hospital services and treatment to inpatients. EMS is an essential part of the overall healthcare system as it saves lives by providing care immediately. Whenever there is medical and surgical emergency including the emergencies caused due to accidents, the patient is usually referred to the nearest city hospital after providing first-aid treatment. Problems are worse in rural areas where even the most basic emergency obstetric care has been found to be lacking.

B. Statistics

The EMS system has been ignored to a large extent in India. If the system is not being able to save the lives of its citizens, then it amounts to the collective failure of society and a system as a whole. [9][1] India is a country of paradoxes. On one hand, it has new corporate hospitals for attracting medical tourism and on the other hand, it has not been able to provide the basic primary health and necessary emergency services to the masses.

The following statistics support the above mentioned points. [10]

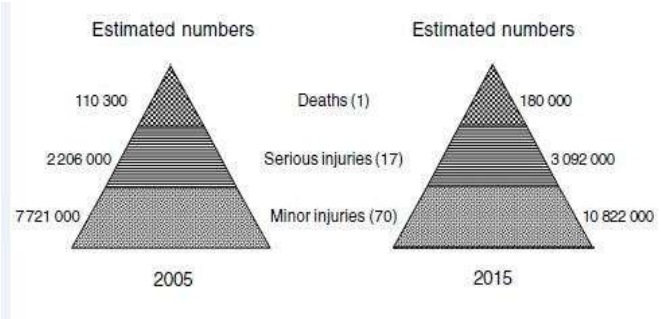

Fig. 1.Estimates of death and injuries due to road traffic injuries in India in 2005 and 2015 [10]

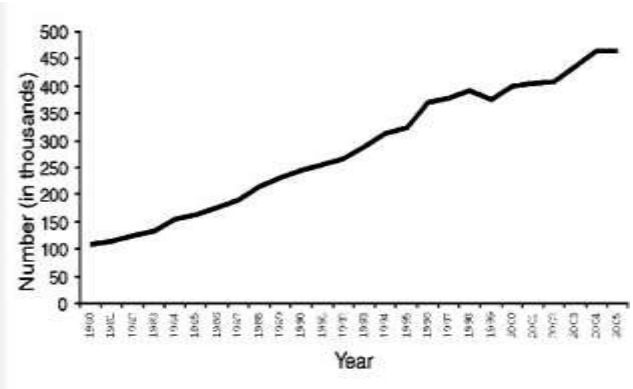

Fig. 2.Road traffic injuries in India,1980-2005 [10]

TABLE I. State-wise distribution of road traffic deaths in India in 2005. The national average is 90 per million population

State	Death rate per million
Tamil Nadu	216
Goa	178
Haryana	143
Andhra Pradesh	137
Sikkim	135
Himachal Pradesh	134
Delhi	130
Chandigarh	128
Karnataka	124
Rajasthan	111
Chhattisgarh	105
Maharashtra	103
Gujarat	97
Kerala	96
Uttaranchal	96
Madhya Pradesh	82
Jammu and Kashmir	80
Arunachal Pradesh	77
Orissa	75
Punjab	63
Tripura	61
Manipur	61
Mizoram	56
Uttar Pradesh	55
West Bengal	52
Assam	52
Meghalaya	50
Jharkhand	44
Bihar	24
Nagaland	20

Source: National Crime Records Bureau, 2005

Fig. 3.State wise distribution of road traffic deaths in India in 2005.The National Average is 90 per million population [10]

C. Use of Quadcopters in Medical Emergencies – Current enario[11]

- DHL PARCELCOPTER: THE NORTH SEA
  Its payload consists of medicines like painkillers or anticoagulants.
- MATTERNET QUADCOPTER: BHUTAN
  Its payload consists of antibiotics. It flies from the hospital in the Himalayan capital of Thimphu. The tests ran in August 2014 and a rollout was planned for 2015.
- GOOGLE X SELF-FLYING VEHICLE: QUEENSLAND, AUSTRALIA
  Its payload consists of Dog treats, cattle vaccines, and a first-aid kit for farmers.

D.On-field Data Collection

On 7th December 2015, we had visited the R.T.O office at Andheri (west), Mumbai. The purpose of the visit was to get detailed information about the various medical emergency services currently available.The visit constituted of meeting the higher officials at the office. The first session dealt with meeting the Public Relations Officer of the R.TO. The second session was concerned with meeting the transport officer, Assistant R.T.O.From the conversations, the most significant information collected are as follows. Currently, there is an ambulance service available which reaches the accident site after dialing 102. Apart from the government maintained ambulances, there are many private organizations which provide the ambulance facilities. These ambulances may take a span of approximately 15-30 minutes to reach the required site to attend the victim. This span of time is further delayed sometimes, due to the unavoidable traffic congestion. Also, most deaths occur due to delay in provision of timely first aid.If any conclusions may be drawn from the data, they are, perhaps, as follows. The current medical emergency systems inclusive of ambulances are of great help in saving numeral lives, but a mode which constitutes faster accessibility to the accident site will help in reducing the number of immediate deaths. Our system will help in implementing this idea of faster site accessibility to a large extent, by providing timely first aid and serving the society through means of a flying robot. This system will prove highly beneficial, as indicated by these higher officials of the R.T.O, whom we met.

E.Review of Quadcopter Characteristics:

Various characteristics of a quadcopter have been compared and illustrated graphically as follows:

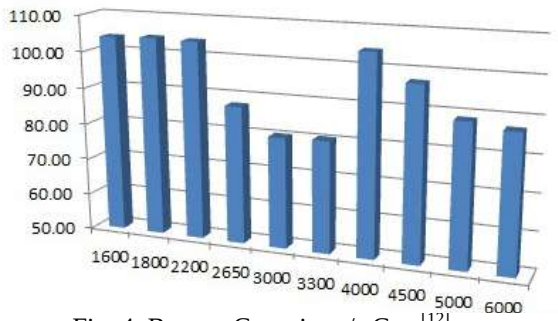

Fig. 4. Battery Capacity v/s Cost[12]

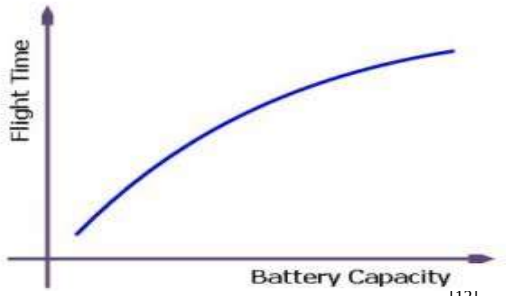

Fig. 5. Battery Capacity v/s Flight Time [12]

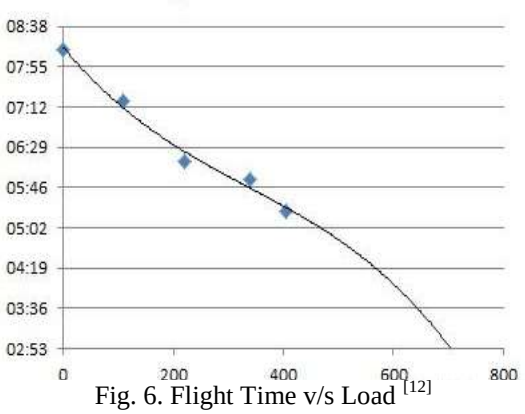

Fig. 6. Flight Time v/s Load [12]

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III. DESIGN OF THE SYSTEM

A. System Design

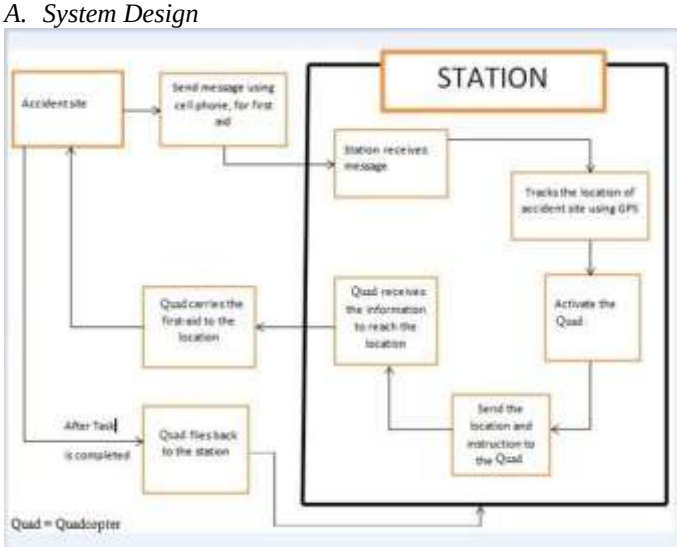

Fig. 7.Block diagram of the system

The figure above depicts the proposed design of the system. From the site where first-aid is required, a message (or signal) will be sent to the Station. The station will receive the signal and by using a tracking system (GPS), the location from which the signal was sent, is tracked. The station then takes the necessary steps to facilitate a quadcopter. The quadcopter will then be activated and an instruction is given to it to fly to the site alongwiththe required first-aid. During its flight, it will constantly be tracked and monitored. It may also capture images of the site (it could be helpful if there was an accident at the site) and perhaps even facilitate live streaming of its path, if required.After the task of delivering the first-aid to the site is completed, the quadcopter will fly back to the station.
It is to be considered that there are certain government constraints with respect to issuing the licence of a number, exclusively assigned for a specific purpose. So here we assume that we already have the location informed to the station. Also due to our budget and weightconstraints, we have used an android phone with in built GPS system and camera instead of using a GPS board and camera separately.The functions of this phone can be monitored with suitable means of communication. This will help bring down our costs considerably.

B. Flowchart of the System

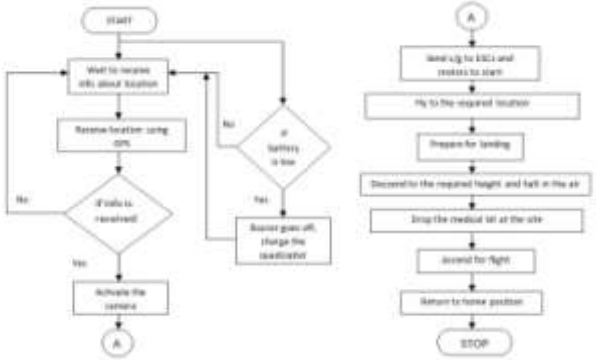

Fig. 8.Flow chart of the project

C. Design of the Quadcopter

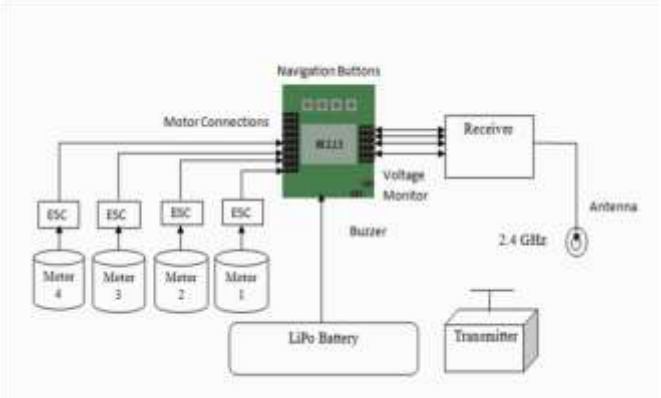

Fig. 9.The design of the system

The following components are used in this layout: [4] [5][13]

- The Quadcopter Frame:

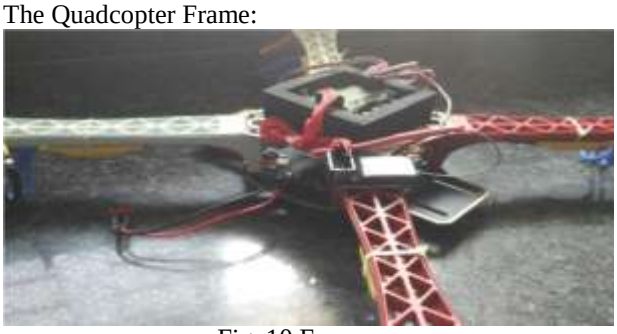

Fig. 10.Frame

The frame should be light as well as rigid to hold a LIPO battery, 4 BLDC motors, four ESCs. The frame arms are made of ultra strength material to survive any crash and the frame boards are high strength compound PCB frames, which makes wiring of ESCs and battery safer and easier. The frame must be large enough to allow all four propellers to spin without collision, but must not be too large and therefore too heavy for the motors.

- BLDC Motors:

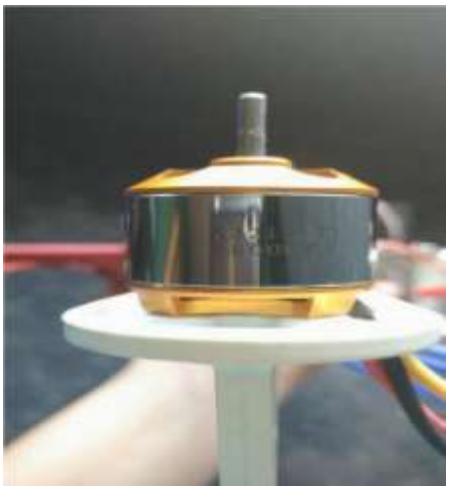

Fig. 11.BLDC Motors

BLDC (Brushless DC) motors are electronically commutated and the advantages include better speed vs torque characteristics,high efficiency with noiseless operation and

very high speed range with longer life. The disadvantage of a brushless motor is its higher initial cost.
Four BLDC Motors are needed for the copter.The motors spin the propellers to provide the quadcopter with lifting thrust. However, they require more complex speed controllers.

- Electronic Speed Controllers:

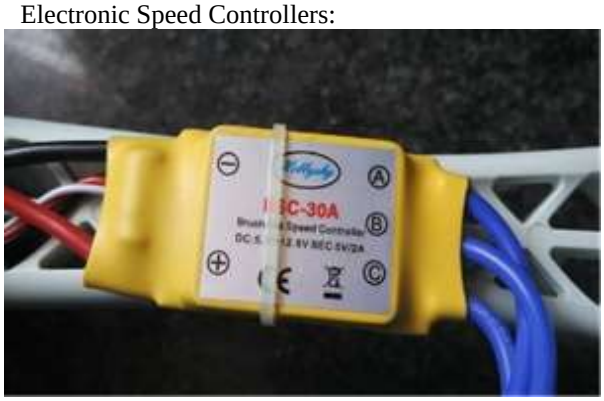

Fig. 12.Electronic Speed Controllers

The ESC performs two primary functions. The first is to act as a Battery Elimination Circuit (BEC) allowing both the motors and the receiver to be powered by a single battery. The second (and primary) function is to take the receivers and/or flight controllers signals and apply the right current to the motors. Every motor needs an individual electronic speed controller. These speed controllers accept commands in the form of PWM signals and output the appropriate motor speed accordingly.

- Transmitter-Receiver:


Fig. 13.Transmitter


Fig. 14.Receiver

A RC Transmitter (2.4 GHz RC radio transmitter) is required to direct the quadcopters direction and position. A 2.4 GHz RC radio receiver on the quadcopter receives commands from the RC transmitter on the ground. The transmitters have two sticks, two trim buttons or a slider per stick, a number of switches, and a power button. We are using 6-channel RC 2.4GHz transmitter (FS-CT6B) which needs to be programmed using T6config application and receiver (R6-B).

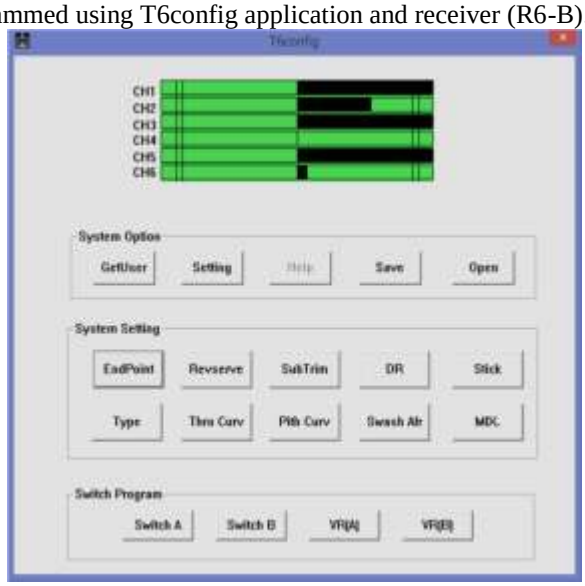

Fig. 15.T6congig window

Transmitter Controls: [12]

1. Roll: Roll moves the quadcopter left or right. It is done by pushing the right stick on the transmitter to the left or to the right.
2. Pitch: Pitch is done by pushing the right stick on your transmitter forwards or backwards. This will tilt the quadcopter, resulting in forwards or backwards movement.
3. Yaw: Yaw rotates the quadcopter clockwise or counter-clockwise. This is done by pushing the left stick to the left or to the right
4. Throttle: Throttle gives the propellers on the quadcopter enough power to get airborne. When flying, the throttle is engaged constantly.

- Development Board: [15][17]


Fig. 16.Flight Control Board

The flight controller, the brain of the quadcopter, performs the necessary operations to keep the quadcopter stable and

controllable. It accepts user control commands and calculates the necessary motor output. At the heart of the KK2.1.5, that we have used, is an Atmel Mega644PA 8-bit AVR RISC-based microcontroller with 64k of memory. A handy piezo buzzer is also included for audio warning when activating and deactivating the board.

- Electromagnet:

An electromagnet is a type of magnet in which the magnetic field is produced by an electric current. The magnetic field disappears when the current is turned off. Electromagnets usually consist of a large number of closely spaced turns of wire that create the magnetic field. It would be used for the attachment and detachment of the medical kit.

- LiPo Battery:

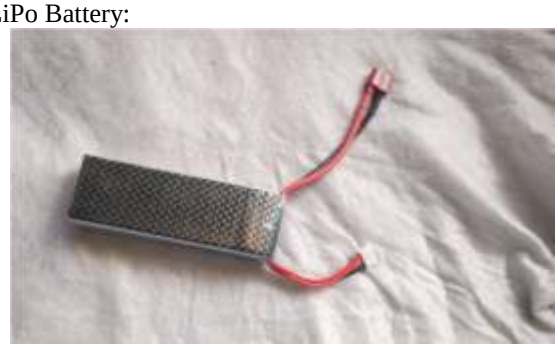

Fig. 17.LiPo Battery

Lithium Polymer battery is a type of rechargeable battery, light in weight and hold huge power in a small package. They have high discharge rates to meet the need of powering quadcopters. Special care to be taken to charge, discharge or store the LiPos because of the volatile electrolyte used in LiPos which can burst or catch fire easily when mishandled. RC LiPo battery packs will have at least two or more cells hooked up in series to provide higher voltages. So a 11.1V battery (which we have used), and is widely used, has 3 cells x 3.7 volts (3S). But there are few disadvantages of LiPo Battery such as these batteries are still expensive compared to NiCad and NiMH. They last only 300500 charge cycles

- Charger:

A 11.1 volt RC LiPo battery cell is 100 percent charged when it reaches 12.6 volts. Charging it past that will cause it to catch fire. A good charger should have certain specifications such as Reverse polarity protection, its Charge temperature must not be charged when temperature is lower than 0C or above 45C. It should have discharge current protection to prevent damage due to short circuits.

- Propellers:

Fig. 18.Propellers

On each of the four brushless motors, a propeller is mounted. By making the propeller pairs spin in each direction, but also having opposite tilting, all of them will provide lifting thrust without spinning in the same direction. This makes it possible for the Quadcopter to stabilize the yaw rotation, which is the rotation around itself.

- GPS and Camera:

Global Positioning System is a space-based navigation system gives information about location and time using signals from four or more GPS satellites and can be used to track the quadcopter. A camera can be used to capture pictures of the accident site or even facilitate live streaming. Due to budget constraints, we would be using an android phone consisting of an in-built camera and GPS by installing an Android application, 'Real Time GPS Tracker 2' which would help in tracking the quadcopter.

- Medical Kit: It can consist of first-aid requirements.

No.	NAME OF COMPONENT	SPECIFICATION	QUANTITY (in pieces)
1	BLDC Motors	1800 kilo volt	4
2	Electronic Speed Controllers	30 Amperes	4
3	Transmitter	FS-CT6B	1
4	Receiver	R6-B	1
5	LiPo Battery	11.1 volt, 2200 mah	1
6	Charger	100-240 volt AC	1
7	Propellers	(9x4.5)"	4
8	Android phone	In built GPS, camera	1

Fig. 19.Specifications of Components used

IV. CONSTRUCTION

The steps for the construction of the quadcopter, using the above enlisted components are as follows

A. Soldering the Electronic Speed Controllers:

All the four ESCs must be soldered to the base plate of the Quadcopter one by one as per the respective terminals.

B. Soldering the Battery Connector:

A suitable battery connector must be soldered to the base plate of the Quadcopter as per the respective terminals so that later on the battery can be connected to it.

C. Fixing the motors:

The four brushless DC Motors must be fixed on the respective four frames using screws as per the size of the motors.

D. Connecting the ESC and the Motors:

The three wires of each ESC must be connected to the three wires of each motor respectively.

E. Fixing the frame:

The four arms of the Quadcopter must be fixed to the base and upper plates using suitable screws.

F. Connecting the flight control board and the receiver:

The flight control board and the receiver must be placed on the quadcopter and thereafter they are connected to each other using female to female wires.

G. Calibrating the Flight Control Board:

The flight control board must be calibrated as per the requirements. Some of these calibrations include selecting

the type of the quadcopter to be used, setting the direction of rotation of the motors and the self-level settings.

H. Synchronizing the transmitter with the receiver:

The transmitter can be synchronized with the receiver using the T6config application. The various transmitter controls can be assigned to the transmitter using this application.

I. Testing the rotation of the motors:

Out of the four motors, two should rotate clockwise and the other two should rotate anticlockwise. By connecting the battery, the direction of rotation of the motors must be tested and rectified if the direction of diagonally opposite motors is not the same.

J. Fixing the propellers on the motors:

Four suitable propellers must be fixed on the motors keeping the direction of rotation of motors in mind.

V. TESTING AND RESULTS

There are various testing parameters that are to be considered for a quadcopter. Some of them are listed below:

A. Sensor Test:

The gyroscope and accelerometer must be tested. On testing, it was found that when the quadcopter is tilted, the values of sensors change with the change in the angle of tilt.

B. PI Settings: [12]

The PI settings determine the quadcopter's sensitivity and precision with respect to angular change. If the Proportional gain value is too high, the quadcopter will be more sensitive to even a slight angular change. In contrast, if it is too low, it will be difficult to keep the quadcopter steady. If the Integral gain value is too high, the quadcopter may start oscillating. When the quadcopter is instructed to go in a direction and then forced to stop, it gives an opposition as a counteraction. If the Integral gain value is too low, this counteraction may not last for long.

C. Receiver Test:

The receiver signal inputs must be tested as per the following steps:

1. The transmitter trims must be used to set roll, pitch and yaw values to "zero".
2. At throttle zero, the flight control board must display "idle" and at throttle greater than 90, it must display "full".
3. The transmitter end points must be adjusted so that roll, pitch and yaw read between -100 to -90 and 90 to 100 at maximum stick travel.
4. The roll, pitch and yaw commands must be set so that they correctly appear as left, right, forward and back in T6config application.
5. Arm-Disarm test: At throttle zero and full left yaw, it must display "arm" with a beep from the buzzer. At throttle zero and full right yaw, it must display "disarm" with a beep.
6. If other errors occur, check connections of the flight control board with the receiver.

The above tests were conducted successfully.

D. Electronic Speed Controller (ESC) Test:

The ESCs must be tested to ensure a smooth flight. Following are the steps for ESC test which we conducted:

1. Full throttle must be applied on the transmitter and the first and fourth button on the flight control board must be pressed.
2. After connecting the battery, two short beeps from each ESC must be heard.
3. One short beep must be heard from each ESC after bringing the throttle to idle position.
4. The buttons must then be released and the motors must be spun. It is important that all motors start at the same time.

The ESCs were found to be functioning efficiently, providing the required power to the motors to spin.

E. Pre-flight Test:

If any errors are displayed on the flight control board, they must be corrected before the flight of quadcopter.

VI. CONCLUSION

Our project which will act as a 'first aid air ambulance' serving accident victims, has advantages such as it will help in reducing death rates considerably due to unavailability of timely first-aid. It would have faster accessibility to the accident site since it provides easy transport facility devoid of traffic congestion thereby making it eco-friendly. No system is perfect, so our system also has limitations like there may be functional difficulties in the quadcopter when exposed to various climatic conditions. The government restrictions for no-fly zones, the limited payload capacity of the quadcopter and the quick discharge of the battery hinders it from achieving its full potential. Thus, the implementation of this system prototype itself is highly expensive. Having listed the limitations, few of these can be overcome if we use more enhanced technology. Since our project is a prototype of the actual system, we have few budget constraints. But with proper financial investment, a fast and an accessible first aid medical emergency system can be further developed more efficiently which might incur an initial high cost but, in the long run, would serve victims and reduce the number of death rates caused due to road accidents.

ACKNOWLEDGMENT

On the outset of this technical paper, we would like to extend our sincere & heartfelt obligation towards all those who have helped us in this endeavour. We are ineffably indebted to our guide Prof. Vilas Kharat for his conscientious guidance and encouragement to accomplish this technical paper. He has taken efforts to go through this paper and make necessary corrections as and when needed.

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