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Design and Fabrication of Four Way Controlled Autonomous Quadcopter with Real Time Anti Collision Feature

Uday Dhand[1], Venkat Kodde[1], Sonu Bhaskar[1], Vasanth Rao K P[2]

B. E Student, Department of Mechanical Engineering, RNS Institute of Technology, Bengaluru, Karnataka, India[1]

Assistant Professor, Department of Mechanical Engineering, RNS Institute of Technology, Bengaluru, Karnataka, India[2]

ABSTRACT:A Quadcopter is multi-rotor copter with four arms, each of which hasa motor and a propeller at its end. Quadcopters are similar to helicopters in some ways, though their lift and thrust comes from four propellers, rather than just one. Also, helicopters have a "pitch" or tail rotor that helps stabilize the craft, whereas quadcopters do not. This paper presents design and fabrication of light weight quadcopter with intelligent algorithm and robust design. Four way communications is endeavored to achieve via android phone with real time anti collision and danger avoiding features using sharp IR sensors. Self designed app has features like flight stabilization, hovering control and safe landing. Four way communications includes accelerometer movement, voice control, screen tap on app button and GPS navigation using Google Maps. It is designed for use in dynamic fields like military, pesticide sprinkling, civilian surveillance, aerial imaging and delivery of small products.

Keywords: Unmanned Aerial Vehicle (UAV), PID, Autonomous, Arduino, Quadcopter.

I. INTRODUCTION

Quadcopter also known as Quadrotor is an Unmanned Aerial Vehicle (UAV) [1], unpiloted aircraft, operated by remote control [3] or autonomous [2] control. It is lifted, propelled and controlled by rotors, where propellers are symmetrically placed. Application of quadcopter is increasing each day, like for military, agriculture, GPS navigation, ground mapping, and aerialsurveillance [1]. GPS navigation helps to deliver small commodities from one place to another. As the demand of Smartphones are escalating, it is cost efficient to combine it with external hardware components to make it compact, handy and user friendly quad copter because necessary sensors can be embedded in them. Android is the most used mobile operating system at present, therefore Android [4] based Smartphone is suitable for this operation. Android is an OS, based on Linux, made primary for touch screen mobile devices. Quadcopter consists of two sets of identical propellers. 1st set consists of two clockwise (CW) rotating rotors and the 2nd set consists of two anticlockwise (CCW) rotating rotors. These basically vary speed of revolutions (RPM) of rotors which control lift, stabilization and torque.

For balancing quad copter takes persistent measurements from the sensors [5]i.e. gyroscope, magnetometer and accelerometer and requires adjustment of each rotor for dynamic balancing. Quadcopters are mostly designed in two configurations. First configuration is Plus "+" and the second configuration is Cross "X". Ours is "+" configuration. A Quadcopter has four degrees of freedom- pitch, yaw, roll and altitude. Each of the degree is controlled by adjusting the thrust of each rotor. Quadcopter uses electronic speed controller (ESC) to stabilize [6] the aircraft while hovering. Diameter of each rotor is smaller compared to that of a helicopter rotor. Thus, each rotor needs to carry one-fourth of the total load of the quadcopteras compared to that of helicopter where a single rotor carries the entire weight of it. In this way, service life and efficacy of the motors increases. There are Quadcopters wheremounted frames safeguards the propellers from being damaged and the external environment. Although the Quadcopter can perform three types each of translational and rotational, its inputs are limited to four, being these the lift produced by each rotor, making the

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quadrotor a dynamically controlled system. The Quadcopter is a system with four inputs (to 4 rotors) with six outputs, but due to its simple structure it's almost easy to pick the four observable variables that will make the feedback of the system.

II. IMPLEMENTATION

Quadcopter/ Quadrotorhave recently attracted lot of researchers because of the ease in maneuverability in open and closed enclosures and simple control of its dynamic behavior. Quadcopter covers various engineering aspects like electrical, electronics, mechanical, aeronautical to name a few. All these helps to design, analyze, assemble, communicate, test, control and stabilize quadcopter with the incorporation of enticing features.

Fig.1: Our Designed Model of Quad copter

Our model includes design of quadcopter in Solid Edge application and fabrication of the supporting plates of acrylic material and 4 arms using aluminum. Our model is operated by our self designed app called as"Blue copter" which provides Graphics User Interface (GUI) to make it work like remote control. Android is most used mobile operating system, so an Android Smartphone is apt for this investigation (Here we have used Samsung Galaxy J5, Version 6). Additional control feature like gesture control and voice controlis accessed from the same app.GPS navigation is implemented via GPS module along with magnetometer fitted on the quadcopter and Google maps in Smartphone. GPS module is added to control quadcopter from a long distance. For GPS Navigation we have used midpoint formula, the distance between the source (quadcopter) and destination (target location) is programmed to a minimum of 10 cm in 3-Dimensional coordinates so that the Quadcopter can take decision to move if the distance is more than 10 cm. For making this Quadcopter, we have used Arduino platform to code and flash the program into the microcontroller. PID algorithm is used to calculate the output values of motor and to give flight stability. Our design is unique because of combining ArduinoNano based in ATMega 328 with flight controller board and integrating it with GPS module with sharp IR sensor in all the 4 directions. Each components and peripherals is well synchronized to operate its respective task. Low cost HC-05 Bluetooth Module mounted on quadcopter is used to communicate with mobile Bluetooth.Danger avoiding and collision control is implemented using Sharp IR Sensors.

Flight Mechanism of Quadcopter

The basic flight mechanism is shown in the figure 4 as shown:
YAW (for turning left and right) It is done by turning up speed of regular rotating rotors and reducing power from counter rotating rotors.
ROLL (for tilting left and right) It is controlled by increasing speed on one rotor and lowering the speed of opposite rotating rotor.
PITCH (for moving up and down) It is controlled in the same manner as roll, but here it uses second set of motors. But roll, pitches are determined from where the "front" of the drone.

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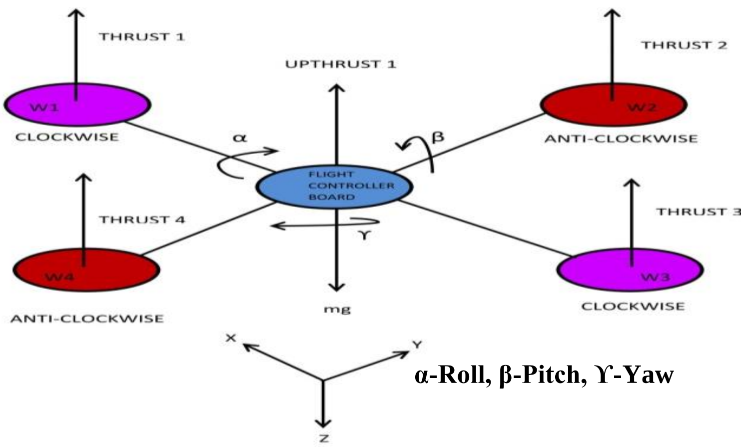

Fig 4: Diagram Showing Roll, Pitch, Yaw in Quadcopter

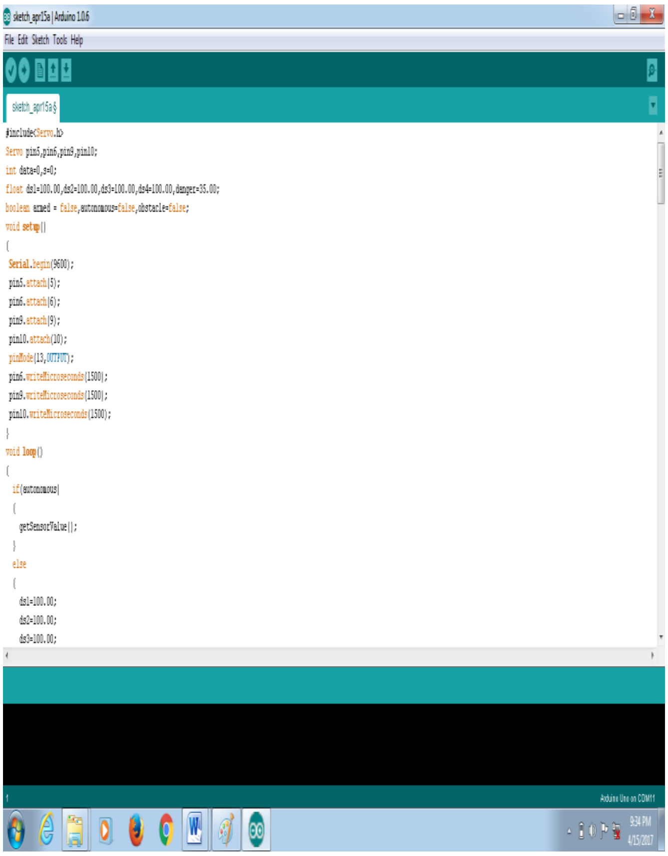

Fig. 2: Code Flashed To Run Quadcopter on Arduino

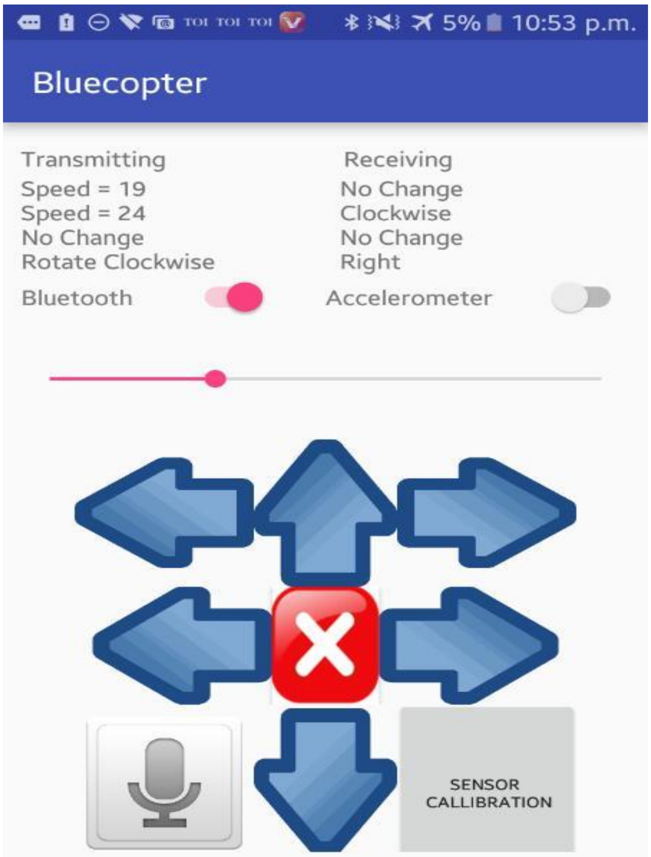

Fig. 3: Self Designed Android App Named As "Bluecopter"

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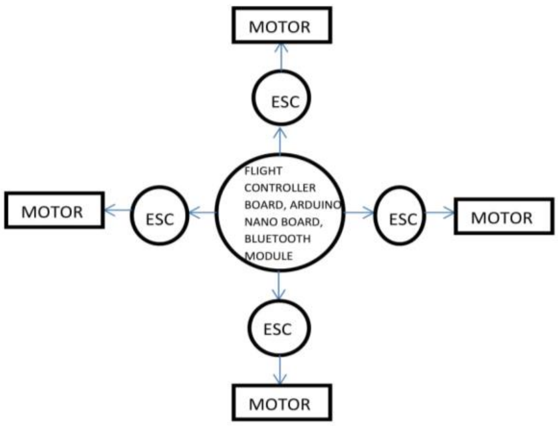
Mass of Components

SL NO.	COMPONENTS	WEIGHT
1)	Supporting Plates(2)	50
2)	Aluminum(4)	60
3)	DC Brushless Motor(4)	200
4)	Propellers(4)	60
5)	ESC (4)	100
6)	Flight Controller Board	40
7)	Battery	180
8)	IR Sensor(4)	60
9)	Wires and Glue Sticks	30
	TOTAL	**780**



Block Diagram of Quadcopter

III. LITERATURE SURVEY

Comparative Study of Various Technologies Used

Refer No.	Research Title	Merits	Demerits
[1]	Wireless Control of Quadcopter with Self Balancing System	Simple Design	High cost due to expense incurred on external remote control
[3]	Quadcopter Controlling Using Android Mobile Devices	Easy set up and portability in design	Only one type of controlling feature
[4]	Gesture Control Quadcopter	Easy to mount on circuit	Cost incurred in buying accelerometer
[5]	Face and Voice Recognition UAV	Easy to integrate on Quadcopter	Photosensitive to low light intensity and goes in vain at high illuminated area.
[6]	Stability Control of Autonomous Quadcopter	Perfect stability	Problem while calibrating to autonomous nature
[9]	Quadcopter-Obstacle Detection and Collision Avoidance	Quick and steady response	Difficult to implement for dynamic objects.

Description of Components

SL NO.	COMPONENT NAME	SPECIFICATION	FUNCTIONS
1)	Bluetooth Module	Bluetooth protocol: v2.0+EDR Frequency Range: 2.4GHz Modulation: GFSK	The bluetooth transceiver module is used as UART RS232 serial converter module. It can easily transfer the UART data through the wireless bluetooth, serial communication.
2)	Arduino Nano	Powered via Mini-B USB connection It has 14 digital pins on the nano and8 analog input pins.	The Arduino Nano is a small, complete and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.x) orATmega168 (Arduino Nano 2.x).It helps in easy storage of data and efficient processing of signals.
3)	Brushless DC Motor	Max Efficiency:80%, Max Efficiency Current: 4-10A (>75 percent),	Built with high-end magnets, a high pole count and custom mount, this motor is designed purely for multi-rotor applications.

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		Motor Dimensions: Φ27.5 x 30mm and Shaft Diameter: Φ3.17mm	
4)	Electronic Speed Controller (ESC)	Remote or radio control, Type: Rc parts and manuals Firmware: Simonk, Weight (Kgs): 25g	It is an electronic circuit to vary the speed, direction and possible to act as a dynamic brake, of a brushless motor. This particular ESC is recommended with A2212 brushless motor (1000KV, 1400Kv, 2200KV).
5)	KK Flight Controller Board	KK2.1.5 Multi-Rotor controller is a flight control board for multi-rotor aircraft (Tricopters, Quadcopters, Hexcopters etc), IC: Atmega644 PA, Signal from Receiver: 1520us (5 channels) Signal to ESC: 1520us.	Its purpose is to stabilize the aircraft during flight. To do this it takes the signal from the 6050MPU gyro/acc (roll, pitch and yaw) then passes the signal to the Atmega644PA IC. The Atmega644PA IC unit then processes these signals according the users selected firmware and passes control signals to the installed Electronic Speed Controllers (ESCs).
6)	GPS Module	Remote Control Peripherals/Devices: Remote Controller, RC Parts Antennas, Parts/Accessories: Frame , Model Number: Ublox 6MGPS, Four-wheel Drive Attributes: Assemblage	Capable of receiving information from GPS satellites and then to accurately calculate its geographical location.
7)	Magnetometer	Specification Chipset: HMC5883L. Power supply: 3~5V, Communication mode: IIC protocol. Measuring range: ±1.3-8 gauss.	Measures magnetism—either magnetization of magnetic material like a ferromagnet, Magnetometers are widely used for measuring the Earth's magnetic field
8)	Sharp IR Sensor	Distance measuring range: 10 to 80cm, Analog output type Refresh rate: 36ms, Supply voltage: 4.5 to 5.5V, Average current consumption: 33 mA.	GP2Y0A21YK0F is an Infrared distance measuring sensor capable of measuring distance from 10 to 80cm.
9)	Propellers	2 sets of carbon nylon 10X4.5;1045/R CW CCW Black Propeller	A propeller is a type of fan that transmits power by converting rotational motion into thrust. A pressure difference is produced between the forward and rear surfaces of the airfoil-shaped blade, and a fluid (such as air or water) is accelerated behind the blade. Propeller dynamics can be modeled by both Bernoulli's principle and Newton's third law.
10)	LiPo Battery	Chemistry: Li-Polymer,	3S Lipo Battery to use with RC Models such as

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		Capacity: 2200mAh, Max charging Rate: 8C, Connector: Dean Connector and Discharge Rate: 25C (Continuous)	Quadcopters, RC Planes and RC Cars. Also it powers IC's
11)	LiPo Battery Charger	Charger for 7.4V-11.1V Li-Po Battery and power source is AC & Battery	It works on 110 to 230V AC. It can be used to charge any 2 or 3 cell Lithium Polymer battery which can sustain continuous charging at 600mA to 800mA.

IV. SIMULATION AND TABULATION

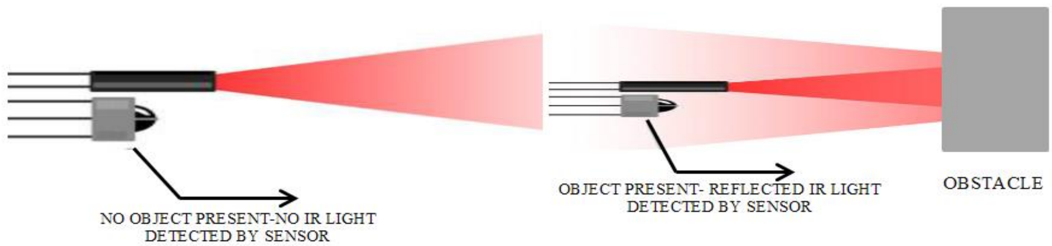

Fig. 5 IR Sensor Working Principle

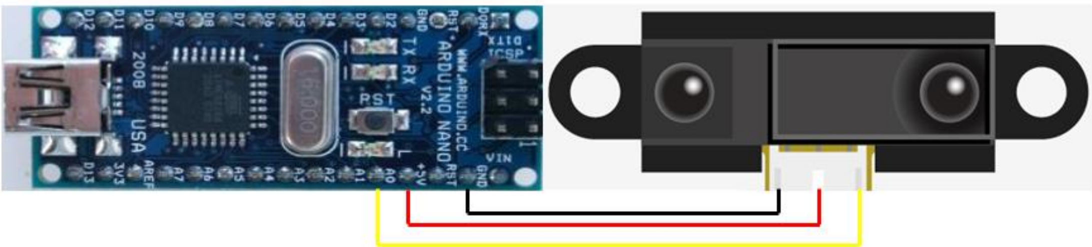

Fig. 6 Circuit Connection of IR Sensor

V. PROPOSED ALGORITHM

Step 1 : Start.
Step 2: Check if autonomous mode is ON
2:1 Call the user-defined function getSensorValue() to get the distance of object from the sensor.
2.1 Else assign all the 4 motor pins with some specific value to prevent garbage intake of values by any motor pins.
Step 3: Now , check if value obtained by getSensorValue()<= danger (danger is variable which is assigned a safe distance of 25 cm.
3.1 If above expression turns out to be true, call the user defined autonomousMode()function, to reduce the speed in particular direction and increase in the opposite direction.
3.2 Else pass a neutral pulse in the digital pins.
Step 4: Use a function called as Serial.available() for Bluetooth serial communication.
Step 5: Pass the instruction from mobile app for forward, backward, left, right, top or bottom and perform action after getting sensor value as mentioned in step 2 and comparing it withdanger as given in step 3.
Step 6: Stop.

The SHARP IR Sensor measures distance by shining a beam of infrared light and uses a phototransitor to measure the intensity of the light that bounces back. The principle of operation is very simple; whenever the IR light falls on the receiver diode, the resistance offered by the IR receiver decreases and allow more current through it. The IR receiver offers more resistance when no IR light falls on it. White color reflects more IR light than any other colour.

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The effective distance measuring range for this proximity sensor is 10-80cm. If an object is closer than the shortest distance, it reports an analog output and is consistent with the expected results. We have attached the IR sensor to an object (here we have used cardboard moving dynamically to and fro from quadcopter). With the IR sensor in place on quadcopter, we took measurements from different distances. To get values, we have used LCD of Flight Controller board by interfacing with arduino. Here we have kept safe distance of 25 cm, i.e it will detect obstacle at a distance of less than or equal to 25cm.The getSensorValue() results are tabulated as shown:

Tabulation for Sensor value with Distance

Sl. No.	getSensor Value()	Distance (cm)	Status
1)	541	10	OBSTACLE
2)	271	20	OBSTACLE
3)	217	24.99	OBSTACLE
4)	216.67	25	NO OBSTACLE
5)	181	30	NO OBSTACLE
6)	135	40	NO OBSTACLE
7)	110	50	NO OBSTACLE
8)	90	60	NO OBSTACLE
9)	78	70	NO OBSTACLE
10)	67.70	80	NO OBSTACLE
11)	55	100	NO OBSTACLE

Design Parameters With Specification

SL. No.	PARAMETERS	SPECIFICATION
1)	WEIGHT	780g
2)	FLIGHT SPEED	20 m/s
3)	FLIGHT TIME	15 minutes
4)	ANDROID APP	SELF DESIGNED
5)	BATTERY	LiPo BATTERY
6)	SENSOR	SHARP IR SENSOR
7)	TAKE OFF/LANDING AREA	$1m^2$
8)	COMMUNICATION FREQUENCY	2.4 GHz and above
9)	CONNECTIVITY	GPS
10)	COVERAGE	LARGE
11)	AUTONOMOUS	AVAILABLE
12)	OPERATIONAL VOLTAGE	8.5-13.5V DC SUPPLY

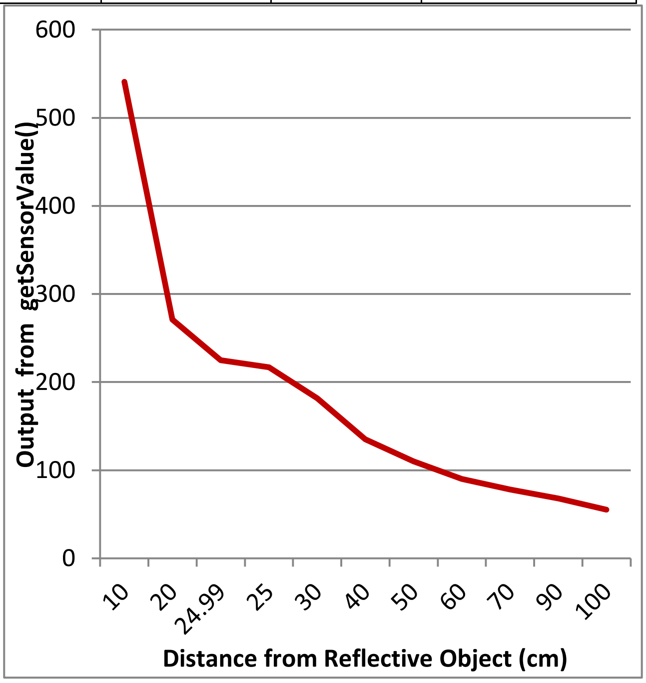

Fig. 7 Analog Value of getSensorValue() vs Distance of Sensor from Obstacle

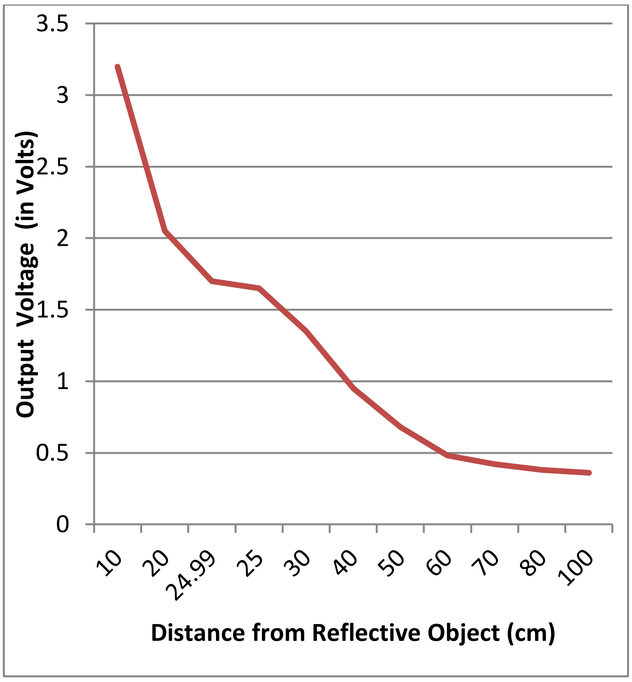

Fig. 8 Output Voltage vs Distance of Sensor from Obstacle

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VI. APPLICATIONS

- The designed drone can be used for aerial surveillance.
- GPS Navigation can be used to pick and place the object in the desired location.
- Drones are continuously being employed for disaster management and rescue missions.
- In agriculture sector too, drones are continuously employed to sprinkle pesticides, insecticides, chemical fertilizers, etc.
- Heavy drones can aid military purpose of carrying out difficult tasks which can pose danger by being physically present.
- Drones can also be used for aerial footage and recording of important events.

VII. CONCLUSION

Based on the work carried out/ implementation done in this study, the following conclusions can be drawn:

1. The designed model is light weight with low cost and is fully autonomous to fly without human intervention.
2. GPS module fixed on quadcopter also helps for location tracking. Quadcopter is easily controlled by hand gesture, voice control,GPS navigation and mobile app. An automatic system eliminates human errors and provides safe, secure and consistent flying.
3. The designed model can be an alternative option at low cost for various application like aerial survillence, ground mapping, pesticide sprinkling, etc.

The major goal of our project is to study the design and fabrication of quadcopter, flight stability, hovering control, safe landing and autonomous control all integrated into one. The significance of our model is that it is designed from the engineering perspective to create an appealing working model of UAV. Our model is working accurately for GPS navigation. Our designed app "Bluecopter" is very efficient enough to send signal to flight controller board for providing good balance and stability during hovering action. Thus adding hallmark to work in quadcopter design, science and technology. This model can be enhanced to new heights in various research works by amalgamation of various technologies, to be more appealing in terms of performance for commercial purpose.

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BIOGRAPHY

	**Uday Dhand** is an Undergraduate Student from the Department of Mechanical Engineering, RNS Institute of Technology, Bengaluru (Karnataka), INDIA. His main areas of research interests are robotics, arduino, programming, etc. He is a member of Indian Society of Mechanical Engineers (ISME).
	**Venkat Kodde** is an Undergraduate Student from the Department of Mechanical Engineering, RNS Institute of Technology, Bengaluru (Karnataka), INDIA. His main areas of research interests are communications, networking, analysis, PCB designing, etc.
	**Sonu Bhaskar** is an Undergraduate Student from the Department of Mechanical Engineering, RNS Institute of Technology, Bengaluru (Karnataka), INDIA. His main areas of research interests are design, fabrications, simulation, thermal science, etc.
	**Vasanth Rao KP** is an Assistant Professor from the Department of Mechanical Engineering, RNS Institute of Technology, Bengaluru, (Karnataka), and INDIA. His main areas of research interests are manufacturing, quality control, etc.