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Autonomous Drone Delivery System

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Abstract - Drone delivery system has been a very popular research topic. Various systems have been constructed and tested using different types of drone technologies. This work presents the construction of miniature quadcopter for delivery of goods from source position to user specified destination location. The technological evolution has reduced the cost and improved the performance of the low powered microcontrollers that made the construction of quadcopter easy. In this case the quadcopter is constructed using Electronic speed controllers, Arduino UNO, US sensors, battery, Flight controller, motors, propellers, GPS etc. The proposed system demonstrates the delivery of light weight products autonomously. This system completes its mission with minimal human intervention. However, in case of providing real time service like product delivery, it must be able to cope with the real time problems such as obstacle present on the drone's path. To deal with such problems US sensors are used to avoid the obstacles present on the drone's path and reach the destination position. The advantages of this system are mainly related to increased delivery speed especially in urban contexts with traffic, to the possibility to make deliveries in areas which are difficult to reach and the drone's ability to carry out consignments autonomously. This system has wide variety of applications in various areas such as online product delivery, postal services, agricultural field also it can be used for rescue operation in hazardous areas.

Key Words: Keywords = Quadcopter, Autonomous Flight, Artificial Intelligence, GPS.

1. INTRODUCTION

An Unmanned Aerial Vehicle (UAV) is an air-craft without a human pilot aboard. Its flight is controlled either autonomously by on-board computers or by the remote control of a pilot on the ground. The QC (Quad copter), an emerging UAV is lifted and propelled by four rotors. The basic QC design comprised of four complete rotor assemblies connected at equal distances from each other and a central hub. All the rotors are located within the same plane and oriented such that opposite motors rotate in same direction while adjacent motors rotate in opposite direction and thrust generated by each rotor id perpendicular to the vehicle. If the rotors are comprised of parts with the same specifications and expected performance, each will produce the same amount of thrust given a specific power input. It has good manoeuvrability with limitless applications. The modern quadcopters are evolving into the small agile vehicles. As they have proved their usefulness in aerial imaging, the new researches are allowing quadcopters to prove their usefulness in wide variety of areas to explore unknown environments and to maneuver in dense surroundings swiftly and precisely. Use of autonomous QC can enable faster transport of goods which can ensure on time delivery. Besides, it can improve the transportation management. Generally, home delivery of product requires a delivery person and a vehicle for transportation. Hence the lots of resources like fuel, time and human labour is spent on conventional home delivery. Considering the real time problems in conventional delivery, like traffic jam and identifying actual delivery location leads to wastage of more of the resources. The autonomous drone delivery system can overcome this problem by discarding the use of vehicle and the need of a delivery person. The autonomous drone delivery system enables user to provide the destination location to QC. The QC reaches the user specified location by avoiding the obstacle present on its path with the help of US sensors and reaches back to the initial location safely.

1.1 Related Works

In recent years the drone technology has made a huge impact on the human lives and has created its appearance in mass market. Various researches have been conducted and explored numerous application of drones in different areas.

An example of how drone can be used for film shooting or spying mission is given in [1]. In this A.R Drone is used which has sensors and frontal camera mounted on it and it is controlled by a computer via Wi-Fi. It describes methods of autonomous tracking of selected object by using tracking learning detection (TLD) approach to track an arbitrary object selected by user. There are certain drones created for military application or for any kind of search and rescue mission. [2] Presents a drone which is capable of moving through any environment that is air water and ground. This drone uses environmental data and bio information as a method of communication with environment. [3] Proposed a system that is used for mission completion of disconnected drone in urban areas. This system is designed to complete the given task even when communication between drone and the controlling entity is disconnected in urban areas. It is based on the image processing. This system consists of three modules: detecting safe landing zone, approaching object detector, return to line of control. The drones can be used for delivery of drug consignments which is presented in [4]. The drone used in this system is an autonomous pharma copter which is used for drug shipment. Both customer and pharmacist use android device to place and receive orders. As per the availability of the product in nearby area, customer

place an order which is stored in pharma copter server and this data is fed to drone and using GPS it reaches the destination and delivers the consignment. The mini drones are preferred for the application in confined spaces. Such a drone is presented in [5], where the construction of autonomous and tele operated miniature quadcopter is carried out for the applications in confined spaces such as corridors or inside a building. It has used field programmable gate array (FPGA), which is programmed to process the data received from the ground station. This tele operated drone is very useful in search and rescue mission in the areas which are difficult to reach. The above works shows the impact of drones on individuals' safety and wellness. The autonomous drone delivery system can make a great impact on human life as it is providing social benefits, such as less pollution since drones can replace delivery vehicles. Another most important factor is the delivery cost which is far less than the delivery cost of the conventional delivery. It is important and worth to shift from conventional delivery to drone delivery in the cases of urgent product delivery in the range of up to 10km.

1.2 Working of Quadcopter

Quadcopter is basically an UAV which is propelled by four rotors by using air lifting phenomena. The propellers apply vertically downwards force on the air as a result it creates an uplifting force and hence action reaction law is applied on the entire system. When the uplift force overcomes the gravitational force the drone starts levitating. Two basic concepts are used for drone levitation, thrust and torque. The rotation of propellers plays very important role in drone's flight. If all propellers rotate in clockwise direction, then the torque is applied on the whole system in that direction. Similarly, if all propellers rotate in anticlockwise direction, then torque is applied and whole system starts rotating in anticlockwise direction. Therefore, to overcome this problem two propellers are rotated clockwise and other two propellers are rotated anticlockwise. This phenomenon generates torque in opposite direction and results into balanced and stable system. Motion of quadcopter is controlled mainly by three movements which are

3.1 Pitch Rotation
Pitch is a motion, which causes the movement of quadcopter in either forward or backward direction. It tilts the quadcopter up or down from front to back.

3.2 Yaw Rotation
Yaw motion causes the movement of quadcopter either to left or right. This moves it around in clockwise/anticlockwise rotation as it stays level to ground.

3.3 Roll Rotation
Roll motion causes the movement of quadcopter about its longitudinal axis. This motion enables quadcopter to fly in left or right direction.

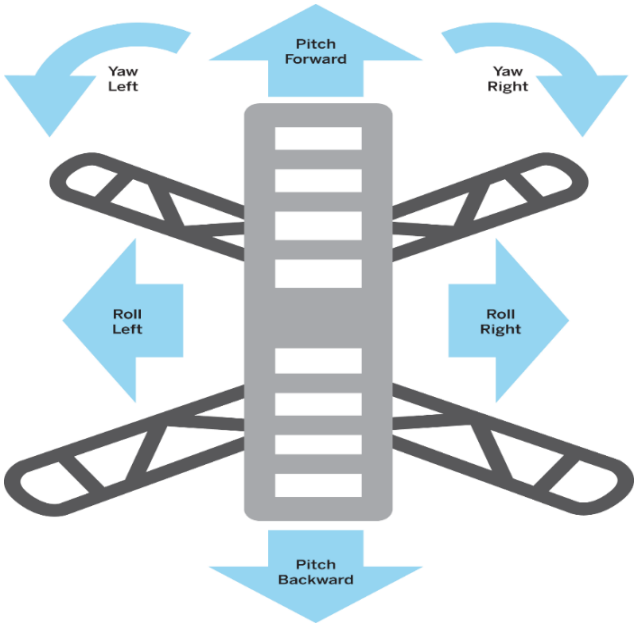

Fig-1:Working Of Quadcopter

1.3 Construction of Quadcopter

A. Frame

The frame is the basic skeleton of the quadcopter. All the other components are mounted on the frame. Frame should be selected according to its weight, size and material since this is related to selection of other components. Frames are generally made of carbon fiber which is light and stiff.

B. Motors

Four brushless DC motors are used in this QC. These motors are synchronous motor powered by direct current. These motors are rated according to spin speed at a constant voltage.1100 KV motors are used in this case.

C. Propellers

Four propellers are needed for QC. Propellers are chosen on the basis of drone's arm length and motor's speed. In this case 9 x 4.7 propellers are used.

D. Electronic Speed Controller

The ESC is the component that communicates with motors how fast to spin based on the signal received from flight controller. Each ESC controls a single motor. ESC are connected to power supply. Four 30A ESCs are used in proposed QC. It converts the PWM signal from flight controller or radio receiver and then drives brushless motor. ESC is a circuit used to control speed and direction if motor by varying the magnetic forces created by windings and magnet within motors.

E. Flight Controller

Flight controller is the most important part of the drone. It determines the spin speed of motors based on user command or sensor's signals. It is generally consisting of several sensors such as gyroscope for orientation, accelerometer for acceleration, barometer for altitude etc. In this QC open pilot flight controller is used.

F. Radio Receiver

The radio receiver is the component that allow user to send signal to drone. The number of channels is the important factor while selecting the receiver. For multirotor control at least channel must be present being each control input in the basic configuration (pitch, yaw, roll, and throttle).

G. Battery

Most QC use LiPo batteries that are lightweight and compact. Batteries are selected on the basis of required flight time and the type of motors used. The increase in battery capacity does not mean the increase in increased flight time, because of the greater battery weight. The battery used in this case is 2200MAH, 11.1V 3cells battery.

H. Arduino UNO

Arduino UNO is the open source computing platform. It is a micro controller, based on AT mega 328P which consists of 14 digital input/output pins (6 pins are used as PWM output), ^ analog inputs, a USB port, 16MHz quartz crystal, power jack and reset button. Arduino IDE is used to upload programs to Arduino boards to perform desired tasks.

I. GPS

The control of drone lies with the pilot. Generally RC drones does not have GPS but autonomous drones usually have GPS mounted on them for precise navigation purpose. Some smart GPS navigation features are: Position Hold – It enables drone to levitate at fixed altitude and location. Return to Home – This enables drone to remember the initial location and at the press of the return to home button it can return to its original location. Autonomous Flight – The route of the drone can be predetermined by creating GPS waypoints to define the trajectory. ON execution drone can follow that trajectory.

J. Ultrasonic Sensors

As the name suggests, ultrasonic sensors measures distance by using ultrasonic waves. The sensor head emits an ultrasonic wave and receive the reflected wave from the target. US sensor measure the distance to the target by measuring the time between emission and reception. The sensor used in this case is HC-SR04 US sensor.

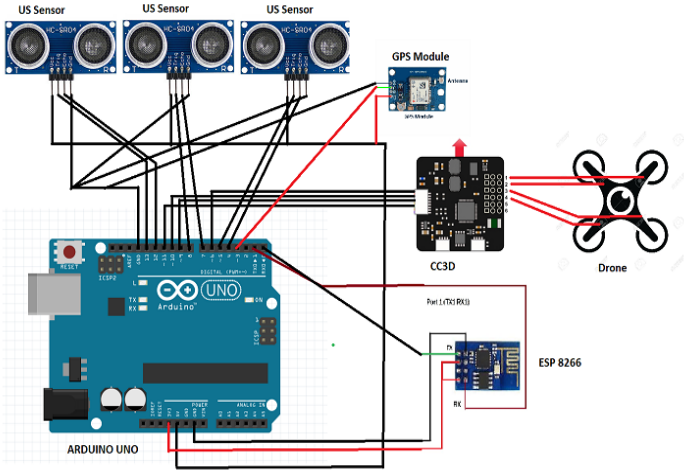

Fig-2: Circuit Diagram

1.4 Operational Overview

The proposed system is used for autonomous delivery of a parcel. In this process the user can provide the destination location to the system using an interface. By selecting the location on google map provided in an interface, the exact coordinates are fetched by GPS. After receiving the coordinates, the drone takes off and elevate up to 20m-30m altitude. The drone starts moving towards destination location and it checks the presence of any obstacle in the path of the drone using US sensors. If obstacle is detected, then it checks the input of left sensor and if it receives clear signal from left sensor then it moves in that direction otherwise it moves towards right direction. In this way by using obstacle detecting and avoiding algorithm the drone reach to the destination location. Once the drone reaches at destination location it drops the parcel and returns back to the initial location safely by tracking the same path using GPS.

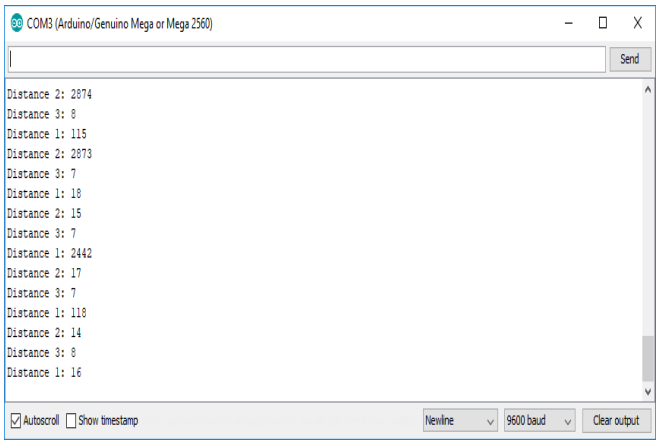

Fig-3: Serial Monitor Output for Obstacle Detection and Distance Calculation

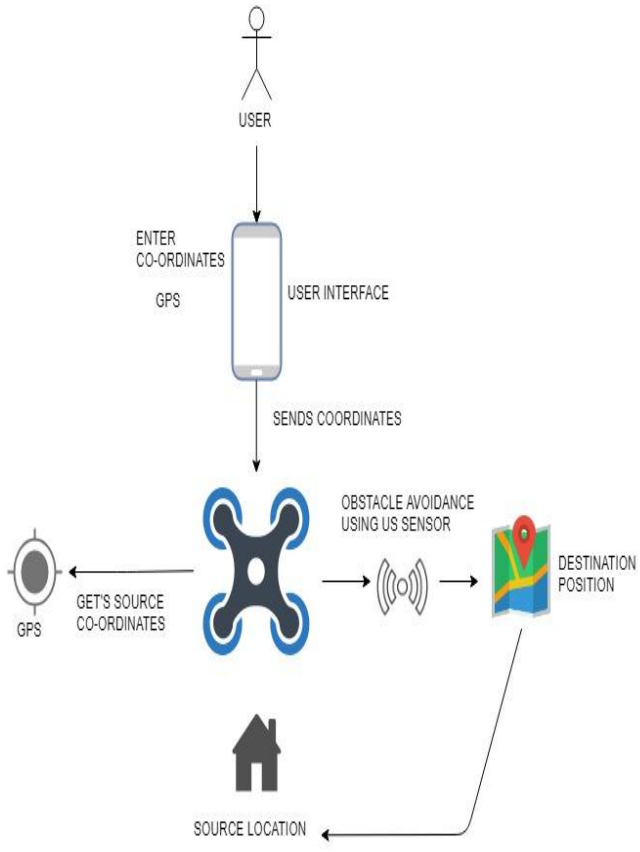

Fig-4: Architecture Diagram

ESC Calibration

ESC calibration varies with different brands of ESCs. The calibration of ESC is done using radio system for each rotor and corresponding ESC. Following steps are followed.

- Program is uploaded on controller board, transmitter is turned on and throttle stick is put to maximum.
- Battery is connected by keeping throttle stick high.
- The beeps on transmitter indicates the battery cell count and extra two beeps indicates that maximum throttle is achieved.
- Now transmitter throttle stick is set to down at its minimum.
- ESC emits long tone that indicates minimum throttle and calibration is complete.
- Fig.3 shows the values the values of different channels such as channel1-throttle, channel2-roll, channel3-pitch and channel4-yaw.

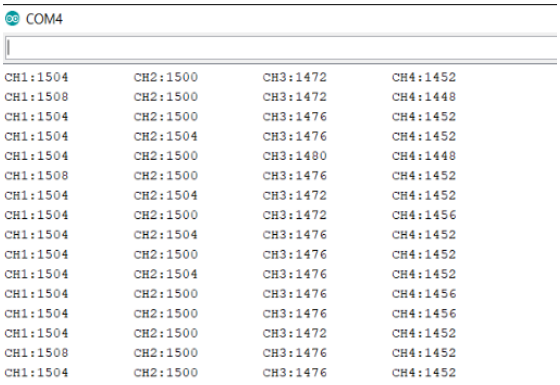

Fig-5: Serial monitor output for ESC calibration while all sticks in center.

GPS Testing

The GPS module is used to track the live location of the drone. The following fig. shows the longitude and latitude of the source location of drone in decimal degree minute and seconds format. As the drone moves towards the destination location the current position of drone changes and with the help of these changing longitude and latitude of moving drone the path of the drone is traced.

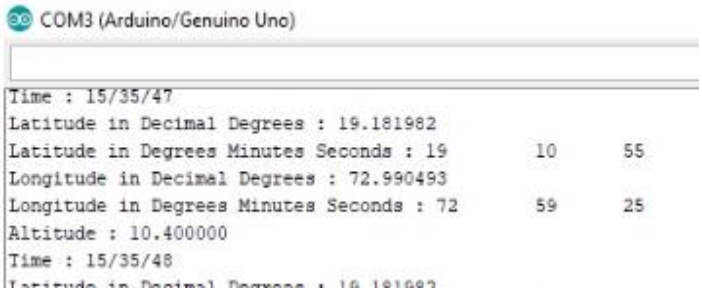

fig-6: Serial monitor output for source location tracking.

3. CONCLUSIONS

The autonomous drone delivery system focuses on delivery of a parcel to the user specified destination location by following google map and after delivery of parcel, returns back to the initial location safely. This drone delivery system overcomes the drawbacks of the conventional delivery process by saving time and reducing delivery cost. This system has social benefits like minor pollution since drone can reduce the number of vehicles used for delivery which are one of the main causes of pollution. The proposed drone is very economical as compared to other drones that are currently being used. In future development the battery power can be replaced by solar power which will optimize the cost of drone even more so that it can help more number of people extensively.

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