MAT JOURNALS

Journal of Electronic Design Engineering
Volume 2 Issue 2

Quadcopter based Automatic Spattering of Pesticides and Fertilizers

K. N. Baluprithviraj, P. Naveena, R. Palanisamy

Department of Electronics and Instrumentation Engineering,

Kongu Engineering College, Perundurai, Erode, Tamil Nadu, India

E-mail: baluprithviraj@gmail.com, naveenaeie@gmil.com, palaneie@gmail.com

Abstract

Agriculture plays a major role in Indian Economy. The crop yield depends upon the pesticides and fertilizers applied in the fields. But the manual handling of these things leads to health hazards. The World Health Organization (WHO) estimated that over 3 million cases of pesticides poison each year, which is majority in developing countries like India. This paper aims to overcome the problem by automating the spray of pesticides and fertilizers in the fields. The system is constituted by an aerial sprayer which consists of a Quadcopter and spraying mechanism. The Quadcopter is controlled by the Radio Frequency signals and the spraying of pesticides is achieved with less manual labour without any health issues. This paper is to mainly overcome the ill-effects of pesticides on human beings and also to cover larger areas with short span of time.

Keywords: *Quadcopter, pesticides, agriculture, quad rotor, variable pitch actuators, radio frequency*

INTRODUCTION

This paper aims to develop a variable-pitch quad rotor capable of aggressive aerobatic maneuvers which stretch beyond the current abilities of typical fixed-pitch quad rotors. It is to downsize the human efforts in the agricultural field and also to reduce human health issues pertaining to pesticides by using the quadcopter for spattering the pesticides and fertilizers. The power sprayer available in the markets is generally manual and the proposed method is automated, hence it can save much time for the farmers. Quadcopter is classified as rotorcraft, as opposed to fixed-wing aircraft because its lift is derived from four rotors. Figure 1 shows the Quadcopter Layout diagram.

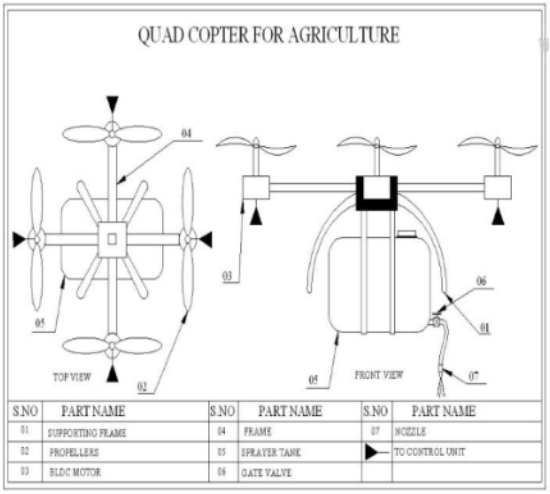

Fig. 1: *Quadcopter Layout Diagram.*

RECENT DEVELOPMENTS IN QUADCOPTER

Small scale Unmanned Aerial Vehicles (UAVs) are engaged in searching an unusal objects in the application of surveillance for the past few decades. The direction of the quadcopter can be changed by adjustment of the individual propellers speed without requirement of cyclic and collective pitch control. The main application of quadcopter includes rescue missions in military, in film making, in agriculture, coast guard maritime and rescue mission. The microcontroller and the propeller speed are controlled by Electronic Speed Controller (ESC) and Lithium polymer battery is used which provide power for longer duration more than 45 mins. In order to reduce the weight of the vehicle, the frames are made of fibres. If all of these developing qualities can be combined together, quadcopters would be capable of advanced independent missions that are currently not achievable with any other vehicle. Figure 2 shows the Flying prototype of the Parrot AR Drone.

Fig. 2: *Flying Prototype of the Parrot AR Drone.*

METHODOLOGY OF PROPOSED SYSTEM

Existing Method

Conventional method which is used to spray pesticides is normal power sprayer which is basically of three different types Hand sprayer, Electric sprayer and Petrol sprayer. Apart from that, Tractors equipped with GPS system and huge sprayers can automatically spray pesticides from the ground. Greenhouse pesticides spraying through pipelines and nozzle system is another method [1, 2]. Line following robot have also been proposed to spray pesticides and fertilizers.

Disadvantages of Existing Method

1. Spraying at semi-aquatic fields is tedious using normal power sprayer and it also leads to lot of weight bearing.
2. Tractors occupy a large area to maneuver thus eating up large areas that could be used for plantations and spraying can be not even
3. The greenhouse method of spraying pesticides through pipelines are not suitable in open fields, which will demand high power pumps to pump pesticides over long distances. Also, it will be difficult to actually build a pipe system in a particular area of pest infestation and spray only there. It occupies more time to locate the area of pest infestation and build a piping system as it involves a lot of labor and time too.
4. Line following robots may be hard to implement in an actual scenario as they are not good in rough and hilly terrains.

PROPOSED METHOD

In the proposed system, Quadcopter is used as a sprayer. So that most of the physical work can be avoided this helps in reducing health issues pertaining to pesticides. Quadcopter flight control is implemented with the help of radio frequency and spraying can be automated with the help of quadcopter's altitude input to operate pump. The method is designed for the beneficial activities of the farmers in which they will use quadcopter for spraying pesticides and fertilizers instead of using normal manual sprayers.

Advantages of the Proposed Method

1. Can be used to spray on hilly terrains Eg. On tea plantations as it is aerially sprayed and the terrain is of no consequence
2. Can be used to spray uni-crop, multi-crop pattern and almost any cropping pattern in fields
3. Can be used to spray on semi-aquatic fields Eg. On paddy fields as it's aerially sprayed and these aquatic fields is of no consequence
4. 4. Increases the efficiency of spraying and can substitute 50 workers thus saving 50 workers from the harmful effect
5. Reduces the time for spraying when compared to manual spraying.

HARDWARE DESCRIPTION OF PROPOSED METHOD

In proposed Method, it consists of three sections:

1. Chase Section.
2. Liquid Storage Tank Section.
3. RF Section.

Chase Section

Quadcopter uses four propellers, each controlled by its own motor and electronic speed controller. Using the accelerometers it is possible to measure the angle of the quadcopter in terms of X, Y, Z and accordingly adjust the rpm of each motor in order to self-stabilize it. The Quadcopter platform provides stability as a result of the counter rotating motors which result in a net moment of zero at the center of the quadcopter [3]. With this technique, it is possible to adjust the speed of each individual motor in order to correctly manipulate the quadcopter movements such as yaw, pitch and roll. Pitch and roll can be controlled by changing the speed of the appropriate motors. Figure 3 shows the block diagram of the proposed method.

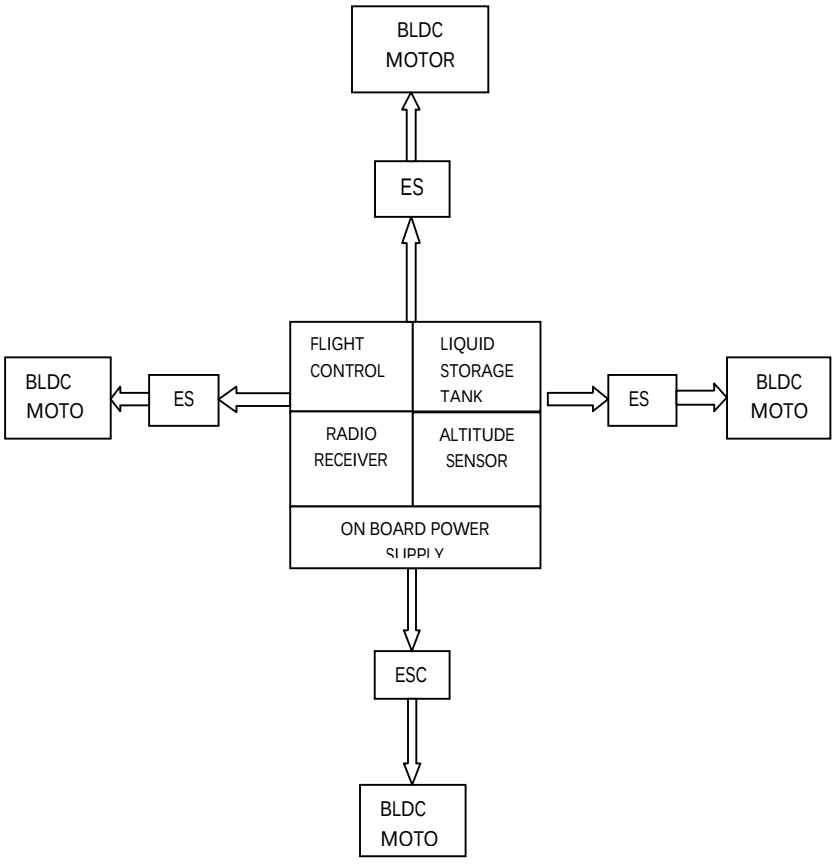

Fig. 3: *Block Diagram of the Proposed Method.*

Yaw Angle

The angle between an aircraft's longitudinal axis and its line of travel.

Pitch Angle

The angle between an object's rotational axis and a line perpendicular to its orbital plane.

Roll Angle

The angle of rotation of a vehicle about its longitudinal axis.

Figure 4 shows the Pitch, Roll and Yaw for quadcopter. Two of the motors, i.e., motor 1 and 3 are rotating in a clockwise direction and the other two motors, i.e., motor 2 and 4 are rotating in anti-clockwise direction, so as to ensure the perfect balance at the center of the quadcopter. Unlike common helicopters that have variable pitch angle, the quadcopter obtains the expected speed by its fixed pitch rotors whose speed is variable. The vertical movement of the quadcopter could be realized by adjustments of the speeds of all four rotors at the same time. The movement along the X direction depends on the inclination on Y, whose angle could be adjusted by slowing down the speeds of rotors 1 and 2, speeding up rotors 3 and 4. The inclination also generates the acceleration along X direction. The movement along the Y direction depends on the inclination on X analogously.

Yaw angle of the quadcopter can be changed to control the left and right motion. Forward motion is controlled by increasing speed of rear rotor. Backward motion is control by decreasing speed of front rotor. Quadcopter with fixed pitch rotors are use to control the vehicle motion and four propellers attached to rotor located at the cross side.

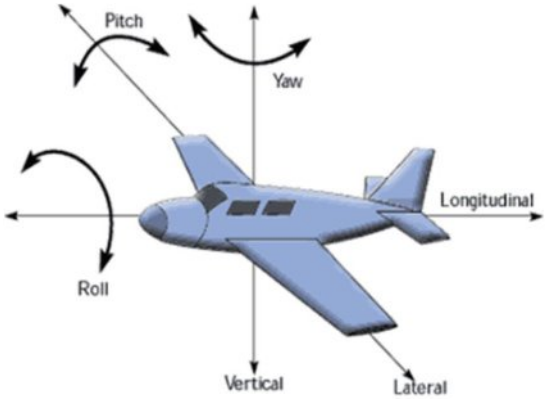

Fig. 4: *The Pitch, Roll and Yaw for Quadcopter.*

The imbalance of the moments, if calculated precisely could generate the expected yaw movement. For example, if the quadcopter needs to turn clockwise, the speeds of rotor 2 and 4 should be accelerating to overcome the moments generated by rotor 1 and 3. A good controller should meet the requirements

that the quadcopter should remain its altitude and pitch angle, when the yaw angle is turning to its expected value. Figure 5 shows the Direction of Rotation of Motors.

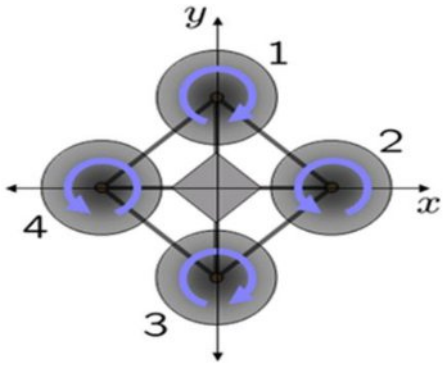

Fig. 5: *Direction of Rotation of Motors.*

Airfoil

An airfoil is the rotor blade which produces lift when it passes through the air. The aerodynamic forces necessary to keep it uphill are produced when air passes about the rotor blades. Non symmetrical airfoils have a wide variety of upper and lower surface designs. Symmetrical airfoils are suitable to rotary-wing applications and have almost no center of pressure level. Under the alternating conditions, symmetrical airfoil distributes acceptable performance with the benefits of low cost and ease of construction. The blade may be built with a twist, so an airfoil section has a larger pitch angle than a section near the tip.

Structure of Airfoil

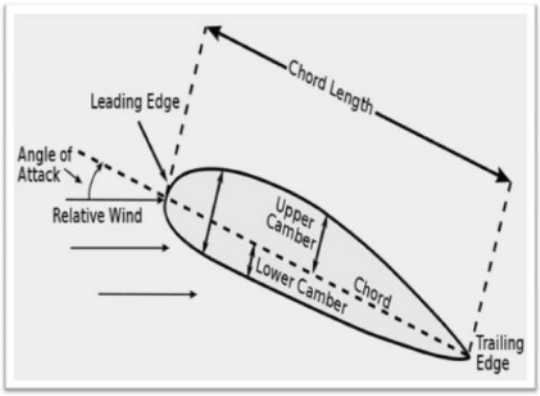

Fig. 6: *Airfoil-Schematic Layout.*

The Airfoil Layout is shown in the Figure 6.

1. Angle of attack is the angle between the lifting body's reference line (chord) and the incoming flow.
2. The chord of an airfoil is the imaginary straight line drawn through the airfoil from its leading edge to its trailing edge.
3. Chamber is the asymmetry between the top and the bottom surfaces of an airfoil.
4. The trailing edge is the back of the airfoil-the place at which the airflow over the upper surface of the airfoil joins the airflow over the lower surface of the airfoil.

The principle and working of a propeller is based on Bernoulli's Principle and Newton's Third Law. Bernoulli's principle states that for an inviscid flow,

an increase in the speed of the fluid occurs simultaneously with the decrease in pressure or the decrease in the fluid's potential energy. Newton's third law states that every action has an equal and opposite reaction.

An aerofoil is shaped so that air flows faster over to the top than under the bottom. Therefore, a greater pressure is prevailed below the aerofoil than above it. This difference in pressure produces the lift. Lift coefficient is a dimensionless coefficient that relates the lift generated by an aerodynamic body such as a wing or complete aircraft, the dynamic pressure of the fluid flow around the body and a reference area associated with the body.

STORAGE TANK SECTION

The purpose of this section is to store the fertilizers inside the tank. Fertigation is the injection of fertilizers, pesticides and other water-soluble products into some of the irrigation system. Fertigation is related to chemigation, the injection of chemicals into an irrigation system. The two terms are sometimes used interchangeably however, chemigation is generally a more controlled and regulated process due to the nature of the chemicals used. Reciprocating type pump is here used to displace the stored chemicals from tank to the fields. It sucks the chemicals and displaces with enough pressure. At the end sprayer is used to spray the chemicals in fine droplets as it is needed for the fields.

RF SECTION

In the Electronics and Telecommunication radio frequency is more reliable and can travel longer distances than infrared transmission. Three major categories in RF measurement are spectral analyzer, vector analyzer and network analyzer. The reason for using high frequency includes efficiency in propagation, immunity to some forms of noise, impairments and size of the antenna. An RF module is used to transmit and receive radio signals which are accomplished through radio frequency communication between two devices. At the receiver the information is received and interpreted and is used to give proper signals to the motor driver in desired direction.

Encoder with RF Transmitter

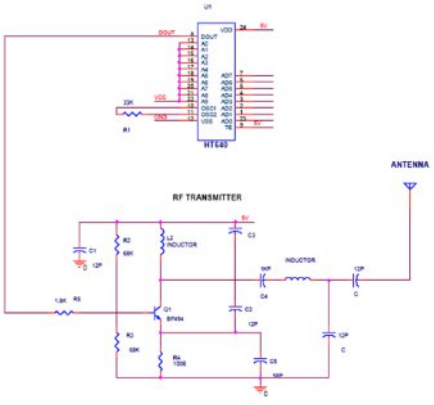

Fig. 7: *RF Transmitter-Encoding Process.*

Encoding Process of RF Transmitter is shown in Figure 7. In this circuit HT 640 is used as encoder. The 3^{18} encoders are a series of CMOS for remote control system application. They are capable of encoding 18 bits of information which consists of N address bit and 18-N data bits. Each address/data input is externally trinary programmable if bonded out. It is otherwise set floating internally. Various packages of the 3^{18} encoders offer flexible combination of programmable address/data is transmitted together with the header bits via an RF or an infrared transmission medium upon the receipt of a trigger signal [4]. The capability to select a TE trigger type further enhances the application flexibility of the 3^{18} series of encoders. In this circuit, the input signal to be encoded is given to AD7-AD0 input pins of encoder. The encoder output address pins are shorted so the output encoded signal is the combination of (A0-A9) address signal and (D0-D7) data signal. The output encoded signal is taken from 8^{th} pin which is connected to RF transmitter section.

Decoder with RF Receiver

Figure 8 shows the simplified circuit diagram of Decoding Process of RF Receiver.

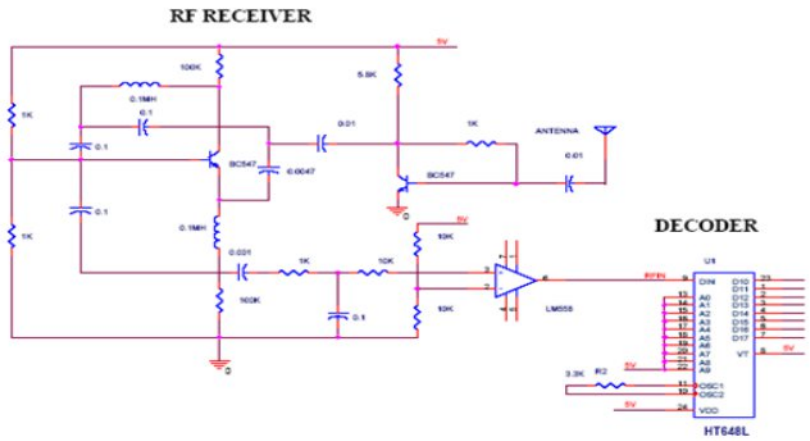

Fig. 8: *RF Receiver-Decoding Process.*

Quadcopter is designed to control the operation of movement by using RF technology. It consists of sensors, control systems, manipulators and power supplies to perform a task. The status of the switches is continuously monitored through RF encoder and it passes the data to the RF transmitter. In this circuit, HT648 is used as decoder. The decoder converts the 1 bit data to 8 bit data and send to the microcontroller. The microcontroller is used to read the data

and perform the action to move the quadcopter back, front, left or right.

BRUSHLESS DC MOTOR

Brushless DC Motor (BLDC) is commutately known as synchronous electric motors powered commutation systems. These motor do not have a brush on the shaft which is responsible of switching the power direction in the coil. Frequency-to-speed and current-to-torque relationships of BLDC motor are linear. BLDC motor may be described as stepper motors, with fixed permanent magnets and probably less poles on the stator than the rotor, or reluctance motors. It is a rotating electric machine with a standard three-phase stator like that of an induction motor. The rotor flux and stator flux will interact with each other, which defines the torque and the motor's speed. The characteristic of brushless dc motor is high reliability, no brush wear, high efficiency and it is driven by multi-phase inverter controllers. The stator windings works in concurrence with permanent magnets on the rotor to generate a nearby uniform flux density in the air gap. BLDC motor will continuously rotate the motor and use electric switches to recognize current commutation.

Fig. 9: *Brushless DC Motor.*

PROPELLER

Figure 10 shows the sketch of Two Blade Propeller.

Fig. 10: *Two Blade Propeller.*

The propeller plays a major role to lift the quadcopter by producing the thrust in high speed. Propellers are explicit by their diameter and pitch. The thrust can be generated based on the diameter of the propeller and more speed is required to spin the propeller. Propeller affects the quickness, stability and efficiency of the quadcopter. Stability can be improved by using lower pitch propeller and it also generates more torque.

HK-T6A TRANSMITTER

The transmitter system offers high reliability of 2.4 GHz technology and a receiver with 6 channels. The key feature is to control the basic models and this system must be programmed via PC cable. With four channel transmitter, it will be allowed to control 4 kinds of movements they are throttle, turning right, turning left and pitching forward and backward. Potentiometers change the settings on the quadcopter. Flight modes require the use of unique electronic modules and sensors. Transmitter is used to transform a unique signal onto the carrier wave, thus generating radio waves that are transmitted to the receiver, which upon receive demodulates the signal and retrieve the original intended signal. Figure 11 shows the HK-T6A Transmitter.

Fig. 11: *HK-T6A Transmitter.*

Higher frequencies require smaller antennas and will travel for a greater distance than waves of 2.4 GHz. Transmitters have two possible modes- mode 1 will control the throttle and ailerons and mode 2 will be using the right hand to control elevators and ailerons. Channel reversing have the ability to reverse the output of any channel. In transmitter, the digital data is represented as variations in the amplitude of carrier wave. A transmitter receives serial data and transmits it wirelessly through RF through its antenna connected.

HK-T6A RECEIVER

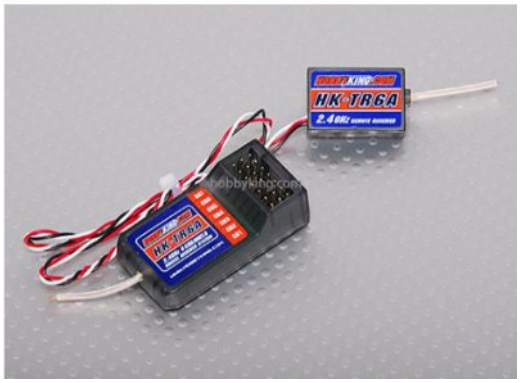

Fig. 12: *HK-T6A Receiver.*

The RF receiver is configured for the pre-defined signal/data pattern. The performance of an RF module will depend on numerous factors like by increasing the transmitter's power a large communication distance will be gathered. Receiver is an electronic circuit that obtains its input from an antenna, which is shown in the Figure 12. The received serial data can be converted to 4 bit parallel data using Decoder. The receiver

picks up the transmitted signal using the frequency receiver module.

LITHIUM POLYMER BATTERY

Lithium Polymer Battery is shown in the Figure 13. Polymer lithium ion, or more commonly lithium polymer batteries are rechargeable batteries (secondary cell batteries). Normally batteries are composed of several identical secondary cells in parallel addition to increase the discharge current capability**.** Unlike certain other types of batteries, lithium polymer batteries can be stored for one or two months without significantly losing charge [5, 6]. However, if storing for long periods, manufacturers recommend discharging the battery to 40% of full charge. In addition, other sources recommend refrigerating (but not freezing) the cell.

Fig. 13: *LiPo Battery.*

MICROPUMP

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps. DC powered pumps use direct current from motor, battery, or solar power to move fluid in a variety of ways. The main advantage of DC (Direct Current) pumps over AC (Alternating Current) pumps is that they can operate directly from a battery, making them more convenient and portable. They are easier to operate and control, since AC systems typically require a controller to manage speed. DC pumps also tend to be more efficient. However, AC pumps usually are designed for higher speeds and larger bursts of power. They also have a longer working lifespan than DC pumps. Figure 14 shows the diagram of Micropump.

Fig. 14: *Micropump.*

ELECTRONIC SPEED CONTROLLER

An Electronic Speed controller (ESC) is used on electrically powered radio controlled models with the intention to diverge an electric motor's speed and also

to act as a dynamic brake. ESCs need a voltage higher by connecting from an external power supply directly. It works from a radio frequency receiver module. Almost all speed controllers follow the gathering of toward the inside calibration mode when powered up while throttle is at maximum. The speeds of the motor will tries to turn is determined by ESC by controlling pulses of power. The signal send to the ESC is a digital pulse width and purely a control signal.

SOFTWARE DESCRIPTION

Overview about Microcontroller

Arduino-Inertial Measurement Unit controller is an open-source model raised area to use hardware and software. It makes powerful users to build them independently and eventually adapt them to their particular needs. The IMU is a collection of sensor, 3-axis gyroscope and 3-axis accelerometer. The angular position or attitude of the quadcopter can be determined from the output of these sensors. A FTDI cable is a USB to serial converter which allows connecting TTL interface devices to USB. There is jumper on the board that allows the board to be configured to either 3.3v or 5v. I2C is used to communicate data between the fight controller and the IMU board. The accelerometer measures the acceleration forces being applied to each axis. The gyroscope measures the rate of angular rotation for each axis.

Fig. 15: *ARDU-IMU Module.*

Operation and Working Principle

ARDU-IMU uses gyros, accelerometers and magnetometer to maintain a model of the board's orientation in space. Orientation with reference to the surface of earth can be able to measured using accelerometer. IMU measures the velocity, gravitational forces and orientation of the quadcopter. The IMU is a combination of the 3-axis accelerometer and 3-axis gyroscope. There are sensors connected to microcontroller to control the motor speed. ARDU-IMU is development environment that is used to run and upload computer code to the physical board. Analog pins can read the signal from an analog sensor and convert to a digital value that can be read. Reset button will temporarily connect the reset pin to ground and restart the code that is loaded on the Arduino. TX and RX indicating LEDs are responsible for serial communication. Mechanically, the

quadcopter for agriculture consists of following component such that propeller, supporting frame, brushless dc motor and construction frame. Here supporting frame is act as a landing supporting device. Frame of the quadcopter are rigid in nature that why absorb the vibration. Four propeller associated with DC motor are active device of the quadcopter. RF transmitter and receiver are used for communication and control purpose.

Radio controlled aircraft have been popular for military purposes for many years. Such aircraft include radio controlled quadcopter. Recently, it has been recognized that radio controlled, pilot less quadcopters may be used for a wide variety of functional purposes. In this paper quadcopter is used for agricultural purpose. Here gate valve is used to control the flow of fertilizer on agricultural land [7, 8]. For example, the use of such radio controlled quadcopters for military purposes such as militants has been found to be a criminal purpose. By employing radio controlled quadcopters for this use, it is possible to watch relatively travel to areas where it is required. This is possible because the radio controlled quadcopter can be operated close to the ground without danger with a very low height. The quad copter direction is controlled through wireless control from PC. The microcontroller is connected with driver circuits with relays and RF receiver; it controls the quad copter blade rotor and direction by what it receives from the RF signal. The camera is connected on the helicopter body which transmits the captured picture through wireless communication to the PC. In PC we are monitored the situation going on that place. Prototype Model for Aerial Sprayer is shown in Figure 16.

Fig. 16: *Prototype Model for Aerial Sprayer.*

MERITS AND DEMERITS

Merits

- Can be handled for relatively low heights.
- Reliable and Low power consumption.

Demerit

Operator requires technical skills to operate the quadcopter.

Applications

- Military applications.
- Agricultural Surveying.

- Weather forecasting.
- Traffic forecasting.
- Weapon for War crisis.
- Post natural and disaster analysis.

CONCLUSION

This paper is made with pre planning that provides flexibility in operation. This innovation has made the more desirable and economical. Spattering of pesticides and fertilizers is automated with the help of ARDU-IMU. This paper helps in reducing human efforts in agricultural fields to cover large areas, reducing health issues to farmers who were spraying pesticides and fertilizers. It is designed with the advancement technology which is very much helpful to farmers in the agriculture. Since thee pesticides and fertilizers are sprayed from lower altitude, environmental pollution can be reduced.

REFERENCES

1. Altug E, Ostrowski J P, Taylor C J. Quadrotor Control using Dual Camera Visual Feedback. *IEEE International Conference on Robotics and Automation*, Taipei, Taiwan. 2003; 4294–4299p.
2. Curtis G A, Beidler E J. Influence of ground ULV droplet spectra on aduticide efficacy for Aedes taeniorhynchus. J. *American Mosq. Control Assoc*. 1996; 368–371p.
3. Escare J, Salazar-Cruz S, Lozano R. Embedded control of a four-rotor UAV. *American Control Conference, Minneapolis*, MN. 2006; 3936–3941p.
4. Giulietti F, Pollini L, Innocenti M. Autonomous formation flight. *IEEE Control Systems*. 2000; 20(6): 34–44p.
5. Hardin P J, Jackson M W. An unmanned aerial vehicle for rangeland photography. *Range. Ecol. Mgmt.* 2005; 58(4): 439- 442p.
6. Harsh Vardhan P D P R, Dheepak S, Aditya P T, et al. Development of automated aerial pesticide sprayer. *International Journal of Research in Engineering and Technology (IJRET).* 2014; 3(4): 856–861 p.
7. Mokhtari A, Benallegue A. Dynamic feedback controller of euler angles and wind parameters estimation for a quadrotor unmanned aerial vehicle. *IEEE International Conference on Robotics and Automation*, New Orleans, LA. 2004; 2359–2366p.
8. Parth N Patel, Malav A Patel, Rahul M Faldu et al. Quadcopter for agricultural surveillance. *Journal of Advance in Electronic and Electric Engineering*. 2013; 3(4): 427–432 p.