Design and development of an Hexacopter for fertilizer spraying in agriculture fields

D Susitra, E Annie Elisabeth Jebaseeli, Venkata Kishore Chitturi and Vineet Chadalavada

Dept.of EEE, Sathyabama Institute of science and Technology, Chennai, India-600119

E-mail:susitradhanraj@gmail.com, anniejebaseeli@gmail.com

Abstract— The substantial advancement in drone technology has paved way to its implementation in agriculture. This has led to smart farming UAV’s that are implemented in many areas of agriculture. Smart farming employs drones right from sowing of seeds, crop monitoring, application of pesticide, fertilizer spraying, assessment of crop’s growth and so on. This paper describes the design of an hexacopter platform for fertilizer spraying purpose in the agricultural fields with a payload of 1kg approximately. The hexacopter is equipped with a payload which consists of water pump, tank, nozzles and a controller. Based on user’s instruction, the controller controls the operating status of the pump and monitors the condition of the drone during flight mode. When the battery is about to drain, the drone is automatically landed to the initial position. When payload is attached the flight time of drone is about 15 minutes.

1. Introduction
Agriculture is the foundation and stronghold of India's economy and contributes to approximately one fourth of the nation’s GDP. It ensures food security for the country and produces several raw materials for industries. India ranks second worldwide in farm output. As per 2018, agriculture employed 50% of the Indian work force. The use of pesticides and fertilizers are very important in crop yielding but manual spraying of these results in some chronic illness such as arthritis, asthma, cancer, watering of eyes and can also result to the deaths due to excessive consumption of harmful chemicals present in them. A recent incident took place in Maharashtra where 272 farmers were killed due to the harmful pesticides. So many modern technologies have evolved in the field of agriculture for enhancing the productivity of grains. So, by adapting the advanced technologies we can reduce the percentage of death and health issues of farmers. The government of India has announced a policy permitting the application of drones for agriculture in 2018. Thereby drones can be used for spraying pesticides and fertilizers in the cultivation fields in order to safeguard humans from hazardous exposure. In conclusion the immediate implementation and development of ‘Drones’ is essential in up keeping the health, lifestyle and economy of the nation and it can also be used for crop monitoring purposes, the illustration of the proposed idea is as shown in figure 1.
1.1. Related works
Drone is a remote controlled automated flying object. The drones are majorly classified into three types namely QUADCOPTER, HEXACOPTER and OCTOCOPTER. The quadcopter of four arms has less stability during flight time. They are small in size and have less payload capacity. The octocopter is bulky in size and more expensive as compared with all available technologies. In the proposed idea we are using hexacopter equipped with sprayer system as it is more stable during the spraying process as compared to that of quadcopter and it economical than octocopter. The types of UAV are shown in figure 2.

Figure 2. Types of UAV

The drones can be built using microcontrollers but those are less stable. So, we must use flight controllers to built a stabilized drone. There are many flight controllers namely APM, PIXHAWK, DJI NAZA these are most commonly used controllers. APM controller is cost efficient but less stable hence this can’t be used to carry payloads with stability. DJI NAZA is more stable compared to all other controllers but it is expensive. In the proposed idea we are using PIXHAWK flight controller as it is feasible and more stable and benefit is that at an efficient cost, we have built a stable drone which is capable of lifting an 1kg of payload. This controller can perform automatic take off, landing and reaching to the specific location in battery low conditions.

1.2. Literature survey
In [1] M. Manoj Vihari et al., have made the agriculture drone using quadcopter technology which is less stable in payload condition as it is made for less payload capacity.

Hence it is not efficient to use this technology for spraying. Monica Abarca et al., have designed hexacopter for air quality management in [2]. This drone can fly at 5000 meters above sea level. The technology is hexacopter but only used for air quality monitoring purposes only. In [3] Mani Sai Kumar et.al., have designed a quadcopter which is uses to deliver the packages and also developed for crowd monitoring purposes. This technology is also designed for less payload capacity hence this
cannot be implemented in applications requiring high payload.

Ahmed Bitar et al. have developed a medical assistant drone loaded with medical aids. This design aims in reducing the response time in attending the affected persons and it’s main area of application is skiing in large crowded parks [4]. Here there are two drones which are used to deliver medicines depending on the payload used to deliver medicines. Dr. J. Premkumar et al., have developed a GPS based navigating drone which serves as an emergency ambulance system. It has built in features for sensing the various physical conditions of the affected persons [5]. The payload capacity of this quadcopter system is also limited. In [6], an artificial vision based transmission line tracking system is designed. It is carried by a robot and positioned on power transmission wires for detecting any faults in the lines. Upon detection of any abnormalities, it sends alert information to the concerned in order to protect from damages.

Zainab Zaheer et al., have designed and developed a quadcopter used for general civil observation and also in military surveillance services [7] Hence assuring safety of citizens. This system has payload capacity of 400g with battery life of 1622 minutes. In [8], Arnab Kumar Saha et al., have proposed a drone which is used to monitor the crop health using various Machine Learning algorithms and IoT. Marthinus Reinecke et al., illustrated the application of drones in agriculture and their limitations [9]. Various designs of drones are analyzed for maximizing the harvest by detecting water requirement and pests at early stage.

Abd. Hafiz Zakaria et al., proposed gripper system able to hold and release the loaded object for an unmanned aerial vehicle [10] based on user’s command. The flight time has been considerably reduced and payload capacity has been increased. The drawback in the system is that, increase in payload increases the battery current to meet the power requirements of the motor and the stabilization of the system is affected. DC motor control for a robotic monitoring system powered by Raspberry pi is implemented in [11].

2. Design and Analysis of Hexacopter System

2.1. System block

The major objective of this research is to develop an efficient hexacopter system with an incorporated payload arrangement. The spraying mechanism can be triggered by using the remote control. Figure 3 illustrates the complete block of the system.

![Figure 3](image-url)

**Figure 3.** Complete block diagram of the system

2.2. Design of Hexacopter

The choice of hexacopter frame plays a main role in the terms of physical strength and weight. In the proposed idea the frame used consists of PCB board and landing gear with carbon fiber material for
less weight, more durability and strength. The framework is shown in figure 4. The selection of motors plays a vital role as it decides the amount of payload the drone can lift with stability. The choice of Electronic speed controllers should be compatible with the BLDC motors and the flight controller. According to the motor ratings and amount of thrust produced we can decide the payload weight.

**Figure 4.** Assembling of hexacopter frame and components

### 2.3. Frame assembly
The top PCB is mounted with all the six arms of the hexacopter. The bottom PCB is mounted with landing gear and also attached with the squishy pads which will act as shock absorber and hold the battery mount. Finally in the drone frame assembly both top and bottom PCB’s are allied together which is shown in figure 5.

**Figure 5.** Frame assembly

### 2.4. Motor and electronic speed controller mounting
The motor layout is shown in the figure 6. The six BLDC motors are mounted to the six arms of the frame. There are three clock wise (CC) and three counters clock wise (CCW) motors which will create net forces acting on a body should be zero.

**Figure 6.** Hexacopter motor layout.

The speed of the motor is regulated using an Electronic Speed Control system (ESC) and is depicted in figure 7. This ESC provides electric dynamic braking to the system. It also takes care of reversal of directions in the system by reversing the direction of rotation of the motor. The six ESC are soldered to Power Distribution Board (PDB). The output wires which are to be connected to the
BLDC motors. There are also digital pins in each ESC connected to pixhawk to control the speed of the motor. The frame with ESC mounted is shown in figure 8.

![Electronic speed controller](image)

**Figure 7.** Electronic speed controller

![Electronic speed controller mounted to PCB board](image)

**Figure 8.** Electronic speed controller mounted to PCB board

2.5. **Flight controller mounting**

The flight controller is mounted on the top of frame exactly in the center using ant vibration shock absorber which will decrease vibrations in flight controller during landing and takeoff time. A safety switch is connected to the controller and it is used to enable/disable the outputs to motors. A buzzer (or Tone Alarm) can be used to audibly indicate status changes for the vehicle. The digital pins of ESC are connected to the pixhawk following the motor layout. The receiver is connected to the RC pin of pixhawk. 6-pos connector of power module is connected to the power port of flight controller which will be the supply for the controller. The frame with flight controller mounted is shown in figure 9.
2.6. Transmitter and receiver
The receiver used is of 6 channel shown in figure 10 and to which pixhawk is connected. Initially the transmitter and receiver are connected. The transmitter will send the signal to the receiver which is present on the drone and it will send signal to the flight controller. Here the flight controller will process the signal and send it to the electronic speed controller so that speed of the motors is varied.

![Receiver](image)

**Figure 10.** Receiver

Sprayer assembly to the drone: The sprayer system consists of a dc pump, tank, controller, nozzles. Sprayer system should be attached to the drone in such a way that the drone is stable even after attachment. When the controller receives the signal from the user end it will turn on/off the pump. In on condition the pump gets turned on and sprays the fertilizers through nozzles. Drone attached with sprayer system is shown in figure 11.

![Drone with sprayer system](image)

**Figure 11.** Drone attached with sprayer system

2.7. Firmware Installation and Calibration
Installation of firmware in Ardupilot software is shown in figure 12. All the sensors and instruments used are calibrated to ensure accurate outcomes. The complete hexacopter drone system and the controller are thus calibrated against a standard model. The various calibrations performed in drone
system are a) Frame Type b) Accel Calibration c) Compass Radio Calibration and d) ESC Calibration and their illustrations are shown in figure 13.

![Image of Firmware Installation](image1)

**Figure 12. Firmware Installation**

![Image of Calibration of various units](image2)

**Figure 13. Calibration of various units**

3. Conclusion
This research has proposed and implemented a drone system that is used to spray the pesticides and fertilizers on the farm which reduces the health issues of farmer community. This hexacopter technology with pixhawk is the more stable and cost-efficient method. As a further development of the research, GPS module can be interfaced to the pixhawk. By using this, the drone automatically takes off and land. It can also reach to the desired location using GPS coordinates, this module can also help in mapping the certain amount of land for fertilizer spraying so, that the drone will automatically spray the fertilizers following the mapped path. To maintain a constant height and avoiding collisions an ultrasonic sensor can be interfaced with pixhawk. The drone comes to the initial position during the low battery and low signal range conditions using GPS.

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