Design And Construction of Octocopter Agricultural Drone

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Abstract- In today's agriculture, there are much too many technologies involved, one of which is the use of drones to spray pesticides and other chemicals. Manual pesticide spraying by farmers or personnel can be harmful to their health, causing chronic illnesses such as joint pain, asthma, watering eyes, and hypersensitivity. Pesticide exposure has also been linked to cancer, hormone disruption, and reproductive problems, as well as death, due to the excessive use of these resources with chemicals present in them. The drone will spray fertilizers, pesticides and crop protection products while being controlled by a single person operating from a safe area. The system greatly reduces the time taken and maintains the safety precautions for the farmer while spraying fertilizers. Drones are used in smart farming from seed sowing to cropping monitoring, pesticide application, irrigation management, fertilizer spraying, pesticide spraying, crop growth assessment, and so on. This study presents the design of an octocopter drone for agricultural tasks, such as irrigation management, fertilizer spraying, and pesticide spraying, with a payload of roughly 3 litres. The outcome of applying this solution guarantees the limitation of human intervention or manpower by improving the efficiency, accuracy in the production of healthy crops, it will also reduce the amount of time the farmer takes in spraying the chemicals or fertilizer during operation, saves money, reduces wastage, and manages resources.

Indexed Terms- Agriculture, Drone, Octocopter.

I. INTRODUCTION

Digital technologies are used to connect agricultural goods from pasture farms to consumers is known as digital farming. Digital farming also combines the latest and most powerful technologies into a single system to empower farmers and other agricultural value chain operators to increase production. The drone can be controlled autonomously using flight control software or manually using the transmitter [1]. Farmers are reaching out to agricultural drone technology to help mitigate the problems of supply not meeting up with the demand of crop production.

Using agricultural drones to lower production costs and enhance crop yields can save wheat and soybean growers $1.3 billion per year. Corn producers, according to a report by Informa Economics and Measure, a UAV service provider, should be the biggest beneficiaries of agricultural UAVs, saving $11.58 per acre. Corn has lower input costs than soybeans and wheat, bringing in $2.28 and $2.57, respectively. Corn and soybean yields will rise by about 2.5 per cent, while wheat yields will rise by 3.3 per cent. As a result, the employment of agricultural drones in agriculture yields a very high return on investment (ROI). The return on investment in wealthy countries will be around 146 per cent. Because of their great research and practical importance, several academic research institutes are interested in such combinations [2].

The Breguet Richet Gyroplane No. 1 was the first human-carrying quadrotor helicopter built by the Breguet Brothers in the early 1900s. Such a machine, according to the Breguet Brothers, exhibited poor stability characteristics. A quadrotor has numerous advantages over other rotary-wing UAVs such as helicopters, despite being difficult to control. Rather than changing blade pitch, control actuation means changing motor speeds. In the case of small, inexpensive electrically actuated UAVs when mechanical complexity is a disadvantage, quadrotors compare favourably to classic helicopter design. Small UAVs can be constructed relatively easily and cheaply thanks to recent advances in technology, including such sensors and microcontrollers. "UAV quadrotor applications will require a high level of controllability and flying capabilities". The problem of autonomous quadrotor operation in windy conditions while carrying an unknown payload remains unsolved [3].

Quadrotor helicopters are becoming more popular as rotorcraft platforms for unmanned aerial vehicles (UAVs). Two pairs of counter-rotating, fixed-pitch rotors were located at each of the aircraft's four corners. Their use as autonomous platforms has been proposed for a variety of applications, including surveillance, search and rescue, and mobile sensor networks, both as individual vehicles and as multi-vehicle teams. Two significant advantages of quadrotor design over comparable vertical take-off and landing (VTOL) UAVs like helicopters have sparked interest from a range of communities, including research, surveillance, construction, and law enforcement. Quadrotors, for example, can drive their vehicles with fixed pitch rotors and direct control of motor speeds, simplifying construction and maintenance by removing complex mechanical rotor actuation linkages. Second, because of the four rotors, individual rotors are smaller for a given airframe size than a helicopter's corresponding main rotor. Smaller rotors store less kinetic energy during flight and can be encased within a protective frame, making it possible to fly indoors and in densely populated regions with less risk of damage to the vehicles, their operators, or the environment. These enhanced safety benefits considerably speed up the design and flight process by allowing it to be completed indoors or outdoors, by rookie pilots, and with a rapid recovery time following an event [4].

However, manual pesticide spraying exposes the personnel involved in the spraying to harmful chemicals that cause many bad side effects ranging from mild skin irritation to birth defects, genetic changes, tumours, blood and nerve disorders, endocrine disruption, coma or death.

The practical applications of drones to agriculture will help the farmer to overcome several challenges in other to have better crop yields. The following are the functions of this project;

- Time-Saving: Farmers with tons of hectares of land finds it difficult to reach each nook and corner of the field for inspection from time to time. Drones do this task without any hiccup as farmers can do regular air monitoring of fields to know the status of their crops at regular intervals of time.
- Higher Agriculture Yield: The use of an agricultural drone to apply fertilizers and pesticides increase the yield of crop production.
- GPS Mapping Integration: With GPS mapping integrated with Drones, the farmers can draw field borders for accurate flight patterns.

Thus, the main aim of this project is to design and construct an octocopter agricultural drone. This will be accomplished by designing and constructing an octocopter agricultural drone that applies to pesticide spraying and fertilizer spraying, creating an interface between the drone or UAV and the remote controller, and also making sure there is communication between them when flying the drone. We will also design and construct an octocopter H configuration frame, design a payload which consists of servo motor, tank, nozzles and water pump, holes, calibrate the controller by using an application (mission planner) software on the personal computer in other to control the drone and interface the RF remote to control the drone.

II. LITERATURE REVIEW

The authors in [5] presented a paper in which "force and torque were used as control variables in a mathematical model". Finally, a nonlinear optimal control problem was used to assess the hexacopter's mobility, showing the difficulties in moving the x and y coordinate directions due to the lack of actuators on those axes. Position control for a hexacopter was designed in this paper. An extra controller was added to reject the modelling error.

The most common approach is to use the Failure Detection and Isolation (FDI) filter and then reconfigure the controller, but the FDI is too complicated for the hexacopter, so the controller was modified to use the Modified Linear Extended State Observer (LESO), which does not use the failure detection or reconfiguration strategy. The controller managed a safe flight, but there are still improvements to be made in terms of performance during the flight [6].

According to [7], “the compression of a low volume aerosol in an unmanned octocopter is possible. The octocopter's primary rotor measures 3 meters in diameter and can carry a payload of 22.7 kilograms. Every 45 minutes, at least a gallon of gasoline was consumed. This research cleared the door for the development of aeronautical application systems for drones, allowing for the production of products with greater target speeds and larger Volume Median Diameter (VMD) droplets".

According to [8], "an octocopter has 6 BLDC motors and 2Lipo batteries with 6 cells and 8000 mAh capacity". Their research also includes measuring the size and density of the droplets, as well as the spray rate and pressure of the spray fluid. They succeeded in developing a drone that can deliver 5.5 litres of liquid with a 16-minute resistance using their project

The authors in [9] observed that to make an octocopter drone and its spray mechanism, one will need some basic and affordable equipment. The universal spray system is used to spray liquid and solid substances. In their investigation, they looked at a variety of agricultural controllers and concluded that the octocopter system with the Atmega644PA is the most suitable due to its efficient implementation.

The usage of UAV is not new, it has been in production since the early 1900s. The technology was initially driven by military applications in World War I and expanded by World War II. Military UAV applications are more advanced than civilian applications. The civilian applications are likewise evolving in the same directions, due to their rapid utilisation in various applications such as firefighting assistance, police observations of civil disturbances and scenes of crimes, reconnaissance for natural disaster response, border security, traffic surveillance and precision agriculture.

The authors in [10] utilise unmanned UAVs equipped with cameras for site-specific vineyard management. Normalised Differential Vegetation Index (NDVI) values acquired by the Tetracam ADC-lite camera mounted on VIPtero were compared to ground-based NDVI values measured with the FieldSpec Pro spectroradiometer to verify the precision of the ADC system. The vegetation indices obtained from UAV images are in excellent agreement with those acquired with a ground-based high-resolution spectroradiometer.

The work in [11] addressed the design of an autonomous unmanned helicopter system for remote sensing missions in unknown environments. Focuses on the dependable autonomous capabilities in operations related to Beyond Visual Range (BVR) without a backup pilot by providing flight services. Utilizes a method called Laser Imaging Detection and Ranging (LIDAR) for object detection which is applicable in real-world development.

Generally, all aircraft are equipped with an IMU (inertial measurement unit), which is nothing more than a device that incorporates information from accelerometers, gyros, and an implanted controller to present accurate data on aircraft manoeuvring details as well as accelerations in all directions. Outdoor applications benefit from GPS since it provides a positional fix. GPS drift is a problem that may be overcome by combining data from an IMU or by employing a differential GPS. Navigation systems based on vision regularly choose between a single or stereo camera. Stereo vision lends itself to estimating the distance of features from the cameras via observation, whereas single-camera systems need other distance sensors such as ultrasound [12].

III. MATERIALS AND METHOD

To build the octocopter drone the hardware part must be considered such as the payload estimation. The weight of the payload motor, propeller, electronic speed controller, pump, radio transmitter and receiver, and the drone's frame design must be calculated; the drone battery must be selected by knowing the current and voltage requirements of the components; the thrust requirement must then be calculated; the drone's frame must be designed by determining the required arm number, arm length, and payload application; and the thrust requirement must be calculated.

A. Design Analysis

A typical design analysis starts with design conceptualization, which is the process of coming up with ideas for the best solution to the design challenge based on the product's expected functionalities. In other to construct the drone two important factors must be considered, these factors are what makes up the unmanned aerial vehicle (UAV). The design analysis of an octocopter UAV can be categorized into both hardware and software analysis.

B. Hardware Analysis

The hardware module of the design involves the structural design of the drone, the signal is sent from the transmitter and receives information from the flight controller and act on the electronic speed control which determines the speed received by the motor to make the propeller spin faster. The components used in design involves the LIPO battery, flight controller, frames, propellers, brushless motors, electronic speed control, landing gears, RC transmitter and receiver while the payload includes the spraying system such as the spraying tank, pump, nozzles and water pump. Figure 1 shows the illustration of hardware design analysis which consist of frame design, drone load (payload estimation, drone component weight estimation and total weight estimation), flight time, RC transmitter and spraying system

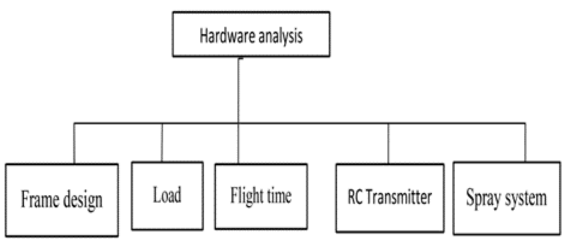

Figure 1: Block diagram of hardware design analysis

The octocopter drone's operating principle is based on aerodynamic principles. Aerodynamics The performance of unmanned aerial vehicles (UAVs) or drones is influenced by aerodynamic interactions between rotors. The signal will be transmitted from the transmitter and received by the receiver in the drone, as shown in the block diagram below. The signal is sent from the receiver to the flight controller, where it is processed using accelerometer and gyroscope sensors. The signal will be processed and delivered to the Electronic Speed Controller (ESC), which will allow the motor to receive a precise amount of current based on the signal it receives. The propellers are mechanically connected to the motors and rotate to generate thrust. The pump uses the current from the Li-Po battery to pressurize the liquid in the storage tank, which then flows through the pipeline to the nozzle, where it is sprayed. The pump's flow rate can be adjusted by altering the input current, which is controlled by the transmitter. The block graphic illustrates this explanation in Figure 2.

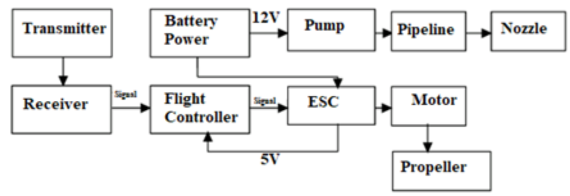

Figure 2: block diagram of the drone hardware

- Drone Frame Design

The OCTO H frame configuration was used, it consists of a quadcopter at the middle and two extra propellers each i.e. two propellers at the front and two propellers at the back. The frame used consists of aluminium material and plywood board which holds and prevents all the material used from falling off. The choice of octocopter frame plays the main role in the terms of physical strength and weight, the aluminium material and the plywood board was selected for less weight, more durability and strength. The aluminium material was drilled so air can pass through the holes and can make it less heavy when lifting the spraying tank, according to the motor ratings and amount of thrust produced we can decide the payload weight, which has been calculated in table 1. The landing gear was added for stability and support so that when the drone is returning to the ground level the landing gear with preventing the drone from falling. The drone frame design is shown in Figure 3.

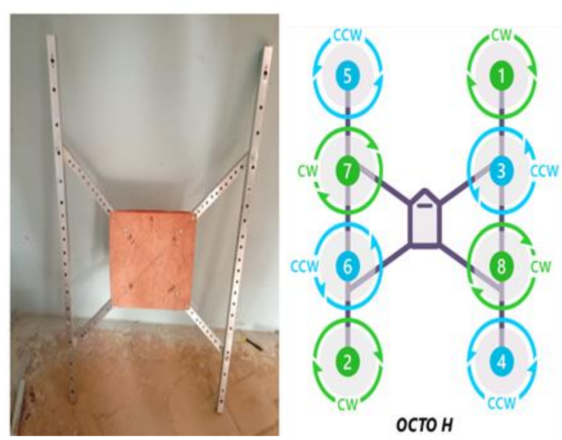

Figure 3: Frame of the drone

- Drone Load

In the proposed design the load will be considered to determine the amount of weight the drone will carry and the drone components, especially the battery which will be equal to the total weight of the drone. The following calculation must be done while considering the drone load; payload estimation of the drone, weight estimation of the drone components and the total weight estimation of the drone.

- Payload Estimation of the Drone

The payload of a drone or UAV refers to the amount of weight it can transport. It is normally counted separately from the drone's weight and includes anything not included in the drone's weight, such as sensors and the spraying system, which consists of a spraying tank, pump, and nozzle. The payload used in the design consists of a spraying system (5-litre spraying tank, pump and nozzle), which serves the purpose of spraying crops with fertilizers, or pesticides on the crops. The weight of the payload is estimated by adding the weight of the liquid (pesticide or disinfection), the storage tank of 5-litre capacity, the pump, and the nozzles. When buying a drone one important aspect is always the payload because the greater the payload the drone can carry gives you more flexibly to add additional technology and tools to the drone. This is tabulated in Table 1.

Table 1. Payload estimation

PARTS	WEIGHT (Kg)
5-litre liquid	2
5-litre liquid tank	0.25
Pump	0.2
Nozzle	0.3
Total	2.75

- Weight Estimation of the Drone Components

The weight of the drone components determines how well it performs on various parameters such as speed, agility and flight duration. During the construction of the drone, all vital components attached to the drone was taken into consideration, most especially the battery, which is the heaviest among all components, the components selected for the construction are light in weight and was tested in other to conclude the ones to use. It also determined the altitude and also the time duration at which the drone can fly, so all this was considered during the construction so that it does not affect the overall operation of the drone, the weight of the drone components is calculated by taking the weight of the frame, battery, motor, ESCs, propellers and flight controller and adding them together to get the weight estimation of the drone components. This is shown below in Table 2.

Table 2: Components Weight

PARTS	WEIGHT (Kg)
Frame	1.2 (Approx.)
Battery	0.5
Motor (8)	0.5
ESC (8)	0.2
Propeller (8)	0.2
Flight controller	0.02
TOTAL	2.72

Total weight = Payload + Weight of components
=2.75 + 2.72
= 5.47Kg (approx.)

The total weight of the drone calculated (5.47kg) is considerable and does not affect the overall operation of the drone.

- Drone Flight Time Calculation

Flight time is the amount of time the drone takes in staying in the air and maintain its normal operation from the start to landing. The following calculation must be done while considering the drone flight time; thrust calculation and battery life calculation.

- Thrust Calculation

When the drone is fully throttled, the thrust is the amount of upward force it can produce. The amount of thrust generated by a drone determines how much weight it can lift. If the thrust of a drone is less than the weight of the drone, it will not be able to fly. Thrust is computed since it is used to overcome the drone's drag as well as the payload's weight. The thrust developed at 100 per cent RPM can be three times the total weight of the drone, giving it more manoeuvrability and allowing it to soar to higher heights at a faster rate.

Thrust produced by one propeller with one motor = 1.853 Kg. Total thrust produced = Number of propellers x Weight = 8 x 1.853 = 14.824 Kg. Total weight of the drone = 5.47kg. Thrust to weight Ratio = Thrust produced total weight of drone

=14.824/5.47 = 2.71:1

The calculation shows the ratio of the thrust produced by the motors and the propellers to the ratio of the total weight of the octocopter drone with the payload. The final value shows that the drone will be able to fly since the ratio of the thrust produced is greater than the ratio of the total weight of the drone.

- Battery Life Calculation

This is the amount of time the battery will last during the operation of the drone. This calculation determines the value of how long the drone will operate.

Current output from battery= 5200* 2 = 10400 mAh. Total current consumption of all components = 52.63A. As calculated in the Table 3. Battery endurance = current output from battery/ Total current consumption of all components

= 10400 mAh / 52.63A

= 10.4*60 / 52.63 A

= 11.86 mins. (at 100% Throttle)

Table 3: Current Requirement Table

COMPONENT	CURRENT REQUIRED (Amp)
Motor	46
Receiver	0.1
Flight controller	0.1
ESC (8)	0.8
Transmitter	0.31
Receiver	0.32
Pump	5
TOTAL	52.63

To calculate the flight time of the drone, it is governed by a single formula:

Time = Battery capacity x Battery discharge / Average amp drawn from the drone (AAD).

where;

Time: is the flight time of the drone.

Battery Capacity: is the capacity of the battery, expressed in milliamp-hours (mAh) or amp-hours (Ah). The value (5200mAh) can be seen on the LIPO battery used for this design.

Battery Discharge: This refers to the amount of battery discharge that is permitted during a flight. When LIPO batteries are depleted, they can be destroyed. It is a customary practice not to deplete the battery more than 80%.

AAD (Average amp drawn from the drone): is the average amp drawn from the drone, it is calculated in amperes.

To calculate the ampere drawn;

AAD = AUW x P / V, AUW = total weight of the drone, P = power required to lift the weight, V= battery voltage

= 10.47 x 170 / 22.2

Finally, to calculate the flight time.

Parameters; Battery capacity = 10400mAh (10.4mAh), Battery discharge (%) = 80%

Flight Time = 10.4 x 80% / 80.18 = 0.16, 0.16x 60min= 10mins

- RC Transmitter

This is a drone remote controller, it is an electronic device that uses radio signals to transmit signals or gives a set of rules or commands to the receiver wirelessly via a set radio frequency over the radio receiver, which is connected to the drone being remotely controlled. The RC transmitter consists of the throttle stick, direction stick, power button, calibration key and sprayer key. To start the drone the power key will be used for switching on the RC controller, the throttle stick is used to arm the drone and it is also used to increase or decrease the altitude of the drone, the calibration key is used for calibrating the RC transmitter to work perfectly with the drone, then the direction key is used for moving the drone from one location to the other and finally the sprayer key is then triggered by the servo motor which sprays the crops with pesticides. This is shown in Figure 4.

Figure 4: RC transmitter

- Spraying System

The storage tank will be mechanically attached to the frame, and the tank's bottom will be tilted downward so that it forms a slope for the entire tank to be drained completely. A 1.3-meter-long plastic tube with four nozzles will be placed at 45mm intervals. A power distribution board was fixed to power the pump, which has an input that will be connected to a storage tank and an outlet that will be connected to a plastic tube with nozzles attached. The landing gear will be connected to the mainframe at a height of 300mm so that the drone will land safely and the storage tank does not touch the ground. The 12V DC water pump will be tested with water before attaching it to the 5-litre spraying tank. After completing the operation, a support stand will be mechanically constructed with aluminium material for holding the tank in place and preventing it from falling and finally the water pump will be attached to the spraying tank with the aid of glue. This is shown in Figure 5.

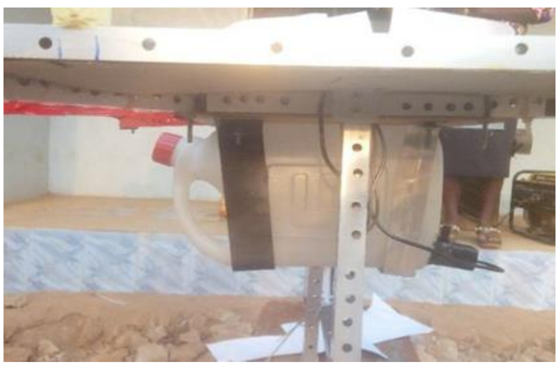

Figure 5: Spraying system

C. Software Analysis

The drone software is the drone's brain. The drone software was created to instruct the drone on where to go and what to do while it flew from point A to point B. To comprehend and connect all of the drone's relevant data. The drone's movement and functioning were calibrated using the mission planner simulation program. The software was installed and runs on the Windows 7 operating system, and it works in a layer-based structure. The layers were appropriately coupled to regulate flight simulations, altitude, and other critical information for the drone to perform and act accurately; this layer combination is known as flight stack or autopilot. A ground control station for planes, helicopters, and rovers is the mission planner. It's only compatible with Windows. Mission planner is an open-source, community-supported tool developed by Michael Oborne for the open-source APM autopilot project that can be used as a configuration utility or as a dynamic control supplement for the autonomous vehicle. The ArduPilot open-source autopilot project has a full-featured ground station application called Mission Planner. In the software analysis, the mission planner simulation software was implemented for this design

Which is used in calibrating the drone to aid its position and movement for a successful operation.

The mission planner environment can be shown in Figure 6.

Figure 6: Mission Planner Software

Steps for Installing and Setting Up the Mission Planner Software

- Download and install mission planner application software.
- Setup mission planner application software.
- Download the firmware for the ardupilot.
- Connect ardupilot to the computer system using the mission planner.
- Load the firmware to the ardupilot (flight controller).

Mission Planner Configuration and Calibration Procedures

The procedures followed when configuring and calibrating the movement of the drone are given below.

Frame Class and Type Configuration

- Select initial setup
- Select Mandatory Hardware

- Select the frame type for the drone, the default type is X,
- Select the H- type. The frame class and frame type parameters should be set to match the physical frame being used. The frame configuration is shown in Figure 7.

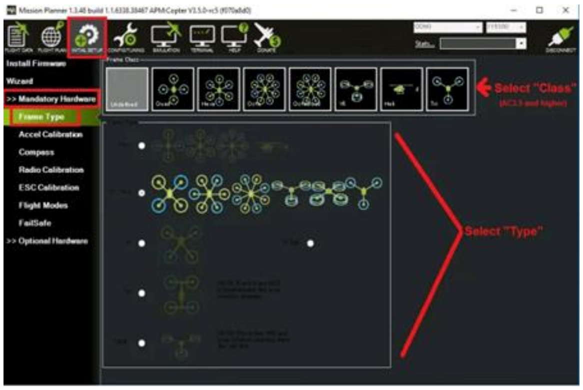

Figure 7: Frame configuration

Flight Mode Configuration

- Turn on the radio control transmitter.
- Connect the mission planner to the pixhawk (or another autopilot).
- Go to the necessary Hardware-Flight mode screen in the initial setup.
- Select the flying mode for each switch position using the drop-down menu on each line.
- Make sure at least one switch position is designated for stabilization.
- For the switch position, check the simple mode check box.
- When you're done, hit the save modes button. The flight mode configuration is shown in Figure 8.

Figure 8: Flight mode calibration

Radio Calibration

- Go to INITIAL SETUP in the mission planner, click Mandatory Hardware, and the radio calibration page will appear.
- Click the green "calibrate Radio" button on the bottom right.
- When requested, press "OK" to verify that the radio control equipment is turned on, the battery is not connected, and the propellers are not attached.
- Push the limits of the transmitter's control sticks, knobs, and switches. To show the minimum and highest values seen so far, a red line will appear across the calibration bars. The radio calibration is shown in Figure 9. When done, choose click.

Figure 9: Radio calibration

Acceleration Calibration

- Under setup – mandatory Hardware, select Acceleration calibration from the left-side menu.
- Click calibrates Acceleration to start the calibration.
- The mission planner indicates that the vehicle needs to be placed in each calibration position. Press any key to indicate that the autopilot is in position and then proceed to the next orientation. The calibration positions are: level, on the right side, left side, nose down, nose up and on its back.
- Proceed through the required positions, using the click when down button once each position is reached and held still.
- When the calibration process has been completed, the mission planner will display calibration success as shown in Figure 10.

Figure 10: Acceleration calibration

D. Construction Procedure of the Drone

The steps taken in other to construct an octocopter agricultural drone are listed below.

- Assembling Of Drone Frame: Cutting of frames, drilling & assembling of the frame.
- Assembling of drone components: Connection & Soldering of electronic speed controller, brushless motors and propellers fixing.
- Calibration of the drone operation
- Assembling of the spraying system (spraying tank, water pump and nozzles)

Assembling of Drone Frame

The aluminium material was used or selected for the construction of the drone frame due to less weight, strength and durability. The OCTO H configuration type was used for the frame construction of the drone, this configuration type was chosen to soothe the components that were placed on the frame, it consists of a quadcopter in the middle and two propellers at the front and two propellers at the back, and this makes up the H configuration. As the prefix octocopter implies ("octo" = eight), it is an eight-armed drone configuration. The aluminium material was measured and cut into desirable size, it was drilled with a drilling machine to create a hole so that during flight operation, the air will pass through it making it lighter and easier to lift the weight attached to the drone. Each arm length is 492 mm, a motor is attached at each free end of the arm, and the propeller is mechanically connected to the motor.

Assembling of Drone Components

The motor is attached to the output side of an Electronic Speed Controller (ESC), while the flight controller and battery are connected to the input side of the ESC. The other Electronic Speed Controller (ESCs), motors and propellers are linked in the same way, they are attached to the board with the aid of a glue gun (hot glue). The total number of ESCs, motors and propellers used is eight (8). To receive signals from the transmitter, a receiver will be linked to the Flight controller. The GPS (Global Positioning System is connected to the GPS section of the flight controller.

Calibration of Drone Operation

The mission planning application software was used to calibrate the radio transmitter. The procedures for accomplishing this calibration were as follows:

- To access the radio calibration screen, go to the mission planner's INITIAL SETUP and choose Mandatory Hardware.
- On the bottom right, pick the green "calibrate Radio" button.

Figure 11: Calibration of the Radio Transmitter

- When prompted, press the "OK" button to verify that the radio control equipment is not connected to the battery and that the propellers are not attached.
- Push the control sticks, knobs, and switches on the transmitter to their limits. To show the minimum and highest values seen so far, a red line will appear across the calibration bars.
- After the calibration was completed, then click the when done button, the diagram is shown in Figure 11.

Assembling of the Spraying System

The storage tank is mechanically attached to the frame, and the tank's bottom will be tilted downward so that it forms a slope for the entire tank to be drained completely. A 1.3-meter-long plastic tube with four nozzles is placed at 45mm intervals. A power distribution board was fixed to power the pump, which has an input connected to a storage tank and an outlet connected to a plastic tube with nozzles attached. The landing frame is connected to the mainframe at a height of 300mm so that the drone may land safely and the storage tank does not touch the ground. The 12v DC water pump was tested with water before attaching it to the 5-litre spraying tank. After successfully confirming the operation. A support stand was mechanically constructed with aluminium material for holding the tank in place and preventing it from falling and finally the water pump was attached to the spraying tank with the aid of glue.

Working Operation of the Drone

The proposed system shown in Figure 12 works as follows, the drone will take off using the RC transmitter and it is controlled by flying it to a specific area that is to be sprayed. When it arrives at the target area that is to be sprayed, the pesticide sprayer is be enabled by the servo motor and the pesticide is sprayed to the required area then after the spraying has been completed the pesticide sprayer will be disabled by the drone pilot used the RC transmitter. After the spraying operation have been completed the drone pilot will fly the drone back to the initial position. The proposed method uses GPS coordinates to determine where to spray the pesticides.

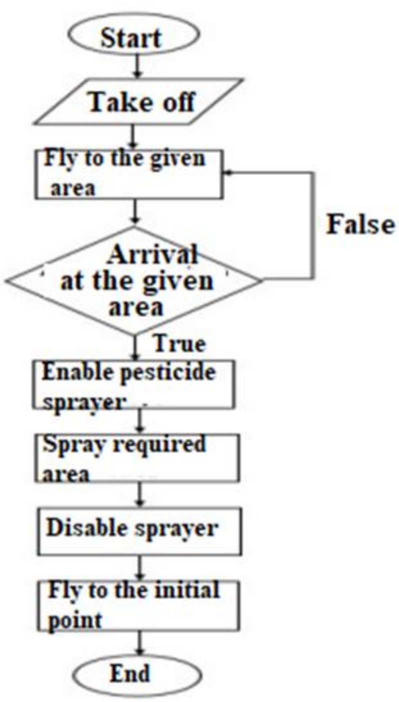

Figure 12: Flow chart of the working Operation

IV. RESULT AND DISCUSSION

Tests were carried out to test the certainty of the functionality of the construction work, to check for flaws and make use of corrective measures to rectify the error and ensure effective working of the entire components in the system, the drone was designed for the agricultural purpose it is equipped with a spraying system which consists of 5-litre spraying tank, 12v dc water pump, nozzle and servo motor for switching the pump ON or OFF.

A. Performance Test

Before the assembling of the complete system, the construction was tested and the operation was noticed, whenever there is an issue that needs attention, rectification was made. The payload applied to the drone was considerable which makes the overall weight of the drone lighter, this makes the drone operation successful because the higher the payload the lower the flight time and the higher the flight time the lower the payload. The flight controller was calibrated successfully with mission planner calibration software which was run on a personal computer. Each component was tested for verification of its standard functionality. The landing gear was checked whether it is well fixed to the drone which provides more support and finally the drone was ready for its first flight, during this operation the construction of the drone was successful and maintains stability during flight and it is not affected by wind or any environmental conditions.

- Flight and Payload Test

The following procedures were carried out to test the flight operation of the drone, this test was done to check the effect of the weight of the payload on the drone. This explanation is demonstrated in Figure 13. The following procedures were carried out;

- Fix in the propellers firmly on the motors.
- Connect the battery.
- Calibrate the radio transmitter and launch the drone
- Test for different weight of payload of 0kg, 1.5kg, 2.5kg, 3.5kg, 5kg.
- Launch drone

Figure 13: Flight and payload test

- Flight Time with Payload Test

This test was carried out to test the flight time of the drone with different payloads, this test was done to check the effect of the weight of the payload on the flight time of the drone. Test for different weight of payload of 0kg, 1.5kg, 2.5kg, 3.5kg, 5kg.

- Calibration Test

This test can be done both on the RC transmitter and a PC (personal computer), by balancing the level of responsiveness of the motors accordingly to each other. This avoids unnecessary vibrations that can disrupt flight movement. This helps to keep the brushless motors in check i.e it balances all the motors to move at the designated speed to avoid vibrations which will cause an improper flight of the octocopter. All the sensors and drone components used are calibrated to ensure accurate outcomes. The complete octocopter drone system and the controller are thus calibrated against a standard model. The various calibrations performed in the drone system are listed below.

a) Frame Type
b) Acceleration Calibration
c) Radio Calibration and
d) ESC Calibration.

All the following were calibrated in other to ensure that the operation of the drone was successful, this is done with help of a mission planner application software, the calibration of the various unit is shown in Figure 14.

Figure 14: Calibration of various units

After the test that was carried out, all errors were rectified to ensure that the system is responding effectively to its given command. The drone developed is more efficient compared to its contemporaries. The biggest advantage of the drone is that it is customizable according to the requirement.

- Drone Flight and Payload Result

After the test was carried out, the following values were gotten to know the amount of payload the drone can handle. From Table 4 the drone was unable to fly when the payload of 5kg was added to it and also when the payload of 3.5kg was added to it the drone was unable to fly in a good condition, this showed that when the total weight of the drone and payload is higher than the thrust the proportional system will produce.

Table 4: Flight test and payload test result.

S/N	PAYLOAD MASS (Kg)	TOTAL MASS (Kg)	ABILITY TO TAKE OFF 1=POOR, 2=FAIL, 3=GOOD
1.	0	2.72	3
2.	1.5	4.22	3
3.	2.5	5.22	3
4.	3.5	6.22	1
5.	5	7.72	2

- Flight Time with Payload Result

After the test was carried out, the following values were gotten to know the amount of flight time of the drone for the different payloads. From Table 5 the drone flight time was decreasing for an increased payload. This showed that the higher the payload the lower the flight time of the drone and vice versa.

Table 5: Flight time with payload result

S/N	PAYLOAD MASS (Kg)	TOTAL MASS (Kg)	FLIGHT TIME (MIN)
1.	0	2.72	15
2.	1.5	4.22	12
3.	2.5	5.22	10
4.	3.5	6.22	5
5.	5	7.72	0

When the total mass is at 2.72 kg, the time the drone will elapse is 15mins, if the total mass increase to 4.22kg the flight time is 12mins. With a total mass of 5.22kg, the flight time will reduce to 10min, at a total mass of 6.22kg the drone will only fly for 5mins. And finally, if the total mass is above 7.0kg, the drone will not fly.

The helps to keep the brushless motors in check i.e. it balances all the motors to move at the designated speed to avoid vibrations which will cause an improper flight of the octocopter.

B. Discussion of Result

The drone is piloted with a handheld radio remote control that controls the propellers manually. The controller's sticks allow you to go in different directions, while the trim buttons let you modify the trim to balance the drone. The signals are sent out by the transmitter and received by the drone's receiver. The signal is sent from the receiver to the Flight Controller, where it is processed. The signal will be processed and delivered to the ESC, which will allow the motor to receive a precise amount of current based on the signal it receives. The propellers are mechanically connected to the motors and rotate to generate thrust. The pump uses the current from the Li-Po battery to pressurize the liquid in the storage tank, which then runs via the pipeline to the nozzle, where it is sprayed. The pump's flow rate is adjusted by changing the input current, which is controlled by the transmitter.

CONCLUSION

In conclusion, the design and implementation of a drone system for spraying pesticides and fertilizers on farms, thereby reducing farmer community health issues.

In this project, we have designed a drone-mounted spraying mechanism for Agricultural purposes and spraying disinfectants. This method of spraying pesticides on Agricultural fields reduces the number of labours, time, cost and risk involved to the personnel involved in spraying the liquids. This drone can also be used in spraying disinfectant liquids over buildings, water bodies and highly populated areas.

As nothing is perfect in this world, there will be always some improvement that can be done, same goes for this project. In the future, there are a few recommendations or changes that could be done on this project;

- Auto return home option and GPS technology so that autonomous control can be achieved.
- And also by adding some sensors to the future drone it will be able to perform inspecting crop details and scanning of plants, security causes.

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