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# Design of an Unmanned Aerial Vehicle for Campus Area Surveillance

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**Abstract**—*This work details a remotely controlled Unmanned Aerial Vehicle (UAV) for surveillance. The navigation employs an Arduino based drone control system with an RF transmitter/receiver operating frequency of 433MHz, and an external Bluetooth device for the remote flight control. The developed drone control system was simulated on a Multiwii simulator, the simulation showed that the designed system requires a minimum thrust capable of lifting a weight of 2000g. Thus, each motor (four in all) will have to produce a thrust capable of lifting over 500g. Furthermore, the testing operation showed that each motor requires 1 ampere to produce a 100g thrust. The simulation showed a very stable flight operation at varying directions. The flight time within the capacity of the components used was computed to be 748.8 seconds. The prototype drone is capable of flying for a duration of 720 seconds under stable conditions. In conclusion, this design shows the possibility of fabricating a personal UAV for small area surveillance such as campuses, market place, stadiums, just to mention but a few, at an affordable cost.*

***Keywords:*** Drone, Security system, Surveillance, Unmanned aerial vehicle.



## 1. Introduction

The UAV appropriately called "drone" essentially, is a flying robot working in mix with global positioning system that can be controlled remotely or can fly self-governing (Rouse, 2013). UAVs are regularly utilised in military operations, additionally, they are used for climatic observation, fire fighting, hunting, rescue expedition, reconnaissance and movement checking (Boon, 2014). Although, UAVs are often for military applications, considering that it is a relatively new field; there are many research possibilities, many other possibilities exist and a lot of civil applications are waiting to be developed. Perhaps, residential utilisation of UAVs has great potentials in various fields beyond the

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military. UAVs can also be used in agriculture, where drones are used to wet crops and also to spray fertilizers on plants.

Reasad *et al.* (2015), designed and developed an unmanned aerial vehicle (drone) for civil application. The system was developed with a remote controller and a telemetry system was added for real-time communication. The drone was able to fly a distance of 1km from the controller but could not be operated beyond a 1km range due to the radio controller range. Earlier, Lugo *et al.* (2014), designed a surveillance UAV, the drone was developed with a flight board and was controlled with an RF module. The limitation was its inability to attain high heights (as it could only achieve an altitude of about 33 m). Josh *et al.* (2013), designed a system made up of a glider-type fuselage, which has a round nose and is lofted into a thin, circular shape that is met by a V-tail for increased manoeuvrability. The system was able to attain a minimum flight time of about 40 minutes but was not able to handle payloads up to 800g. Imam and Bicker (2014) designed and constructed a small-scale rotor craft UAV system, which is also called a quad rotor, to carry a high payload.

Pawar *et al.* (2015), in their work, designed an automated quad copter using android controlling system. The system was operated using graphical user interface and command given by the user through wireless communication system, the system was able to operate on the command from a smartphone and also the quad copter captured the images in the environment but the system couldn't attain a long range. In addition, Rodan *et al.* (2015), developed a versatile aerial drone for bridge inspection and fire extinguishing. The developed system incorporated a proximity sensor that could warn the operator of the proximity of the UAV to the bridge. The system met the intended purpose but was not able to extinguish large fires due to the instability in large updraft condition.

Noi *et al* (2017), designed a wireless-controlled system with stereo camera for machine-centric sensing and control. The design can be used for IoT/M2M for disaster rescue and healthcare; this shows the extent to which designs in this field has developed. Hanafi *et al.* (2013) worked on a simple wireless controller of quad copter that could be controlled by a graphic user interface. The quad copter was able to accept load disturbance up to 250g but any load disturbance above 250g distorted the quad copter's balance. Also, Chen *et al*. (2007) developed a real-time video relay for unmanned aerial vehicle traffic surveillance system through available communication network. In their approach, they used UAV for traffic surveillance. The surveillance cameras were built on microwave tower along high ways, and the UAV was used as high altitude to move the camera to cover a wide area. Videos were captured by the camera mounted on the UAV platform.

Nowadays, a lot of countries have high risk of natural disasters such as earthquakes, volcanic eruption and typhoon. These disasters can be devastating and quite complex to handle; perhaps, the surveillance drones can be used to mitigate the effects of such occurrence via the observation and sensing of early warning signs. The aim of this paper is the design and implementation of a quad copter unmanned aerial vehicle for campus area surveillance.

## 2. Materials and Method

The design and implementation of the quad copter (four rotor) UAV adopts the following technology: construction and fabrication of the airframe of the drone was done using very light weight but rigid materials such as aluminium; the use of brushless DC motors as the main rotor blade driver; the brushless DC motor was chosen due to their high speed and high torque; and the use of android application software as the main drone pilot -user interface to communicate with and control the drone.

Other relevant construction and installations based on this project include the installation of a super capacity battery lithium polymer type of 5200mAh and the installation of an RF transceiver, which is the medium through which communication and control is made between the drone and the ground operator or drone pilot.

The drone consists of brushless DC motors, flight controller, electronic speed controller (ESC), RF module and 5200 mA lithium polymer battery, a camera, a smart phone, and a propeller. The drone is controlled by an Android application through a smart phone Bluetooth. The RF module is capable of providing a distance range of about 3km, the smart phone Bluetooth was connected to an external Bluetooth module which is connected to the transmitter of the RF module. The transmitter relays signal to the receiver, the receiver then sends the command to an Arduino chip which sends the command to the flight controller for execution. Figure 1 gives a full representation of the connected blocks for the different modules of the design while Figure 2 details the description of the operation in a form of a flowchart.

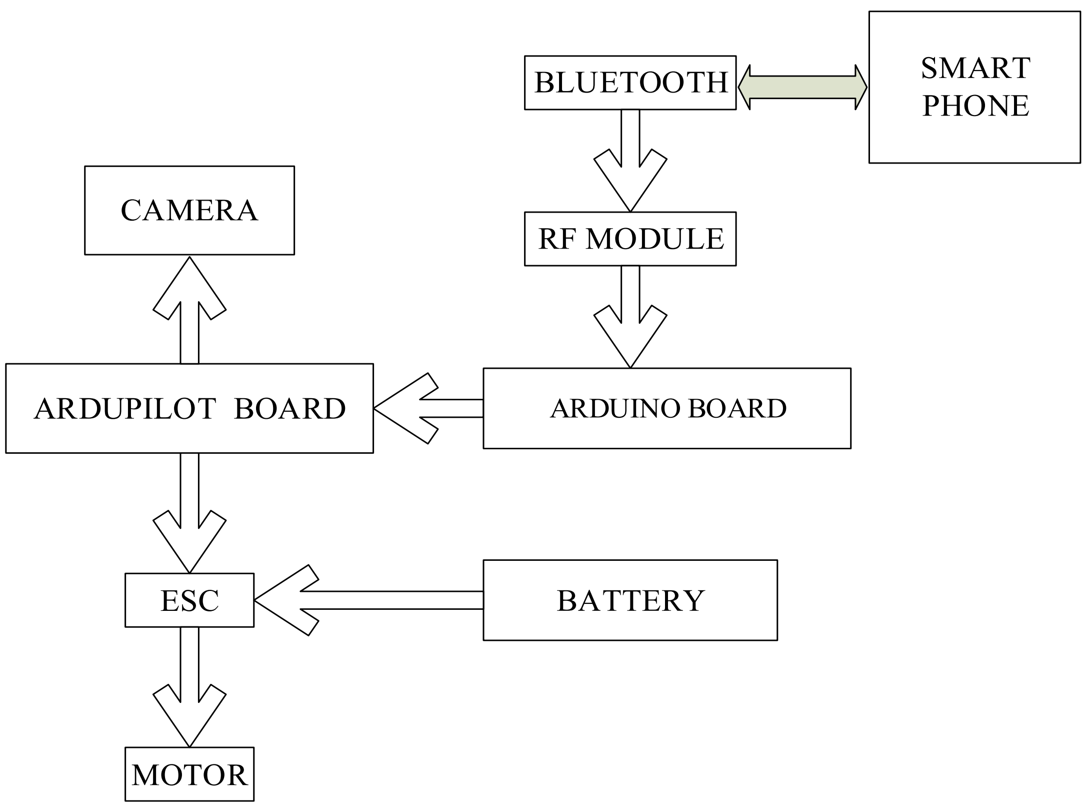


**Figure 1**: System block diagram

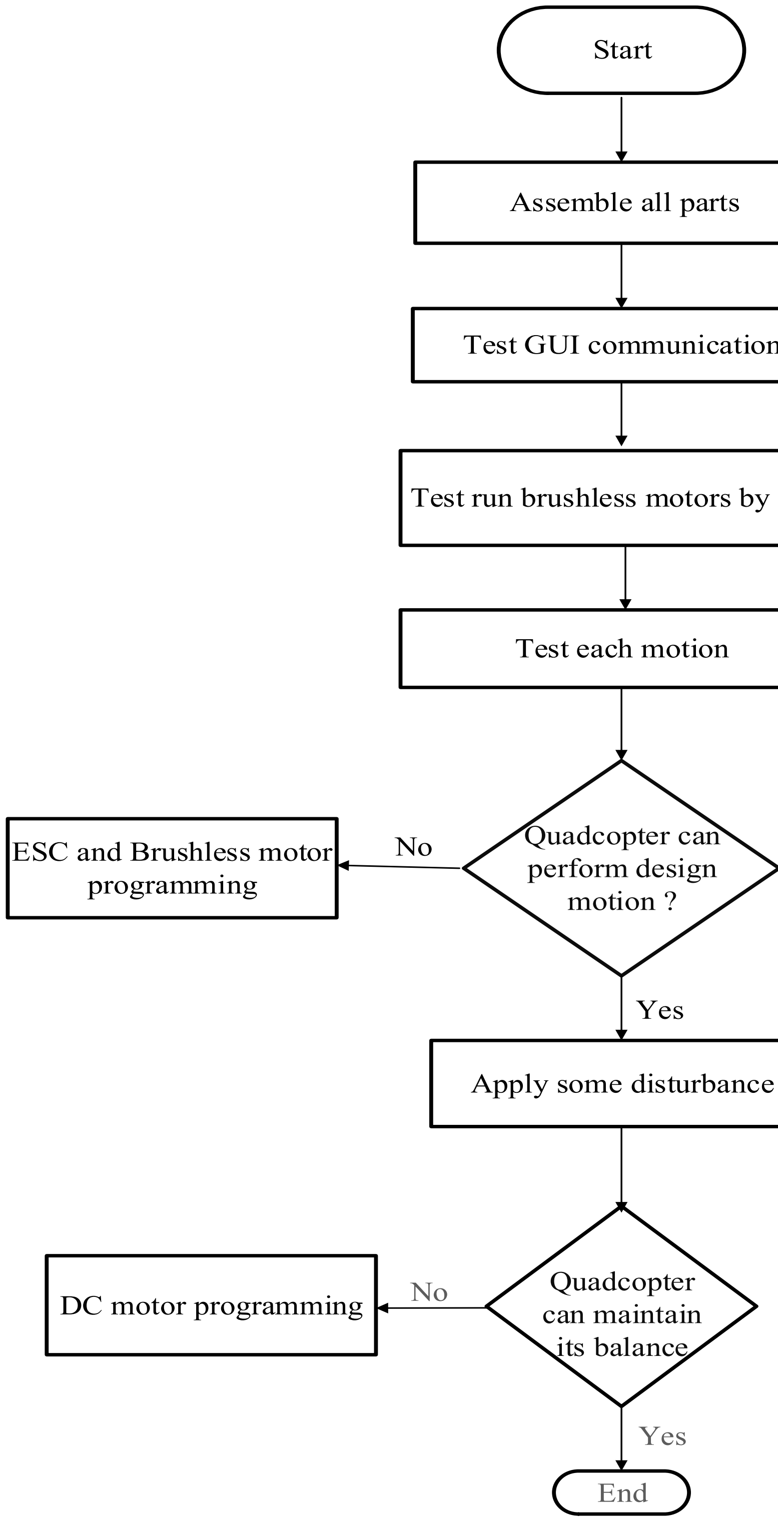


**Figure 2**: The system flowchart

The individual module in the final design was put to test in simulation and real life. The project employed a 5200mAh battery**.** From the Lipo battery warning, it is very dangerous when the battery level becomes lower than 20% of its full charge, and this can lead to permanent damage. Thus, the minimum state of charge of UAV battery was kept above the 20% mAh during flight, i.e. the effective capacity that can be utilised during flight time is deduced as follows:

(5.2Ah * 80) /100 = 4.16Ah (1)

The average ampere drawn was deduced on the basis of the values for the carrying weight of the quad copter and the parameter of the quad copter motor. From the motor instructions, it was realised that each of the motor would draw 1 amp to produce 100g of thrust. Hence, it would require about 2000g to fly the drone, each motor had to produce a thrust of 500g (500g = 2000g/4 motors), which required 5 ampere each. Therefore, the quad copter average amp drawn is 20A (5 A for each of the 4 motors).

The components used to design the prototype was gotten individually. Below is the cost of each of the components. With above listed components and their various prices a total of ₦80,970 (Eighty thousand, nine hundred and seventy Naira).

## 3. Result and Discussion

Figure 3 shows a pictorial view of the assembled UAV after the various proposed parts have been assembled together to form the UAV while Figure 4 shows the control panel for the UAV on the flight simulator (multiwii.comv240).

**Figure 3**: Assembled UAV


**Figure 4**: Multiwii Simulator Caption

The UAV has the uplink operating at a frequency of 410MHz and the downlink operating at a frequency of 433MHz. They were being operated at different frequency so as to avoid the issue of interference. After the telemetry circuit setup, the down link telemetry circuit was tested in a raw format and raw information was gotten from the down link telemetry which include: Yaw value of the UAV; Pitch value of the UAV; Roll value of the UAV; Ultrasonic distance value of the UAV; Longitude position of the UAV; Latitude position of the UAV; Number of satellites the GPS is locked onto; The altitude of the UAV above sea level as briefly captured in Table 2. Figure 5 shows the connection of the hardware to the simulator.

**Table 2**: Flight Control Parameter

| **Parameters** | **Values** |
|---|---|
| Yaw value | 6.8 |
| Pitch value | 3.3 |
| Roll value | 3.3 |
| Number of satellites the GPS is locked onto | 3 |
| The altitude of the UAV above sea level | 120metres |

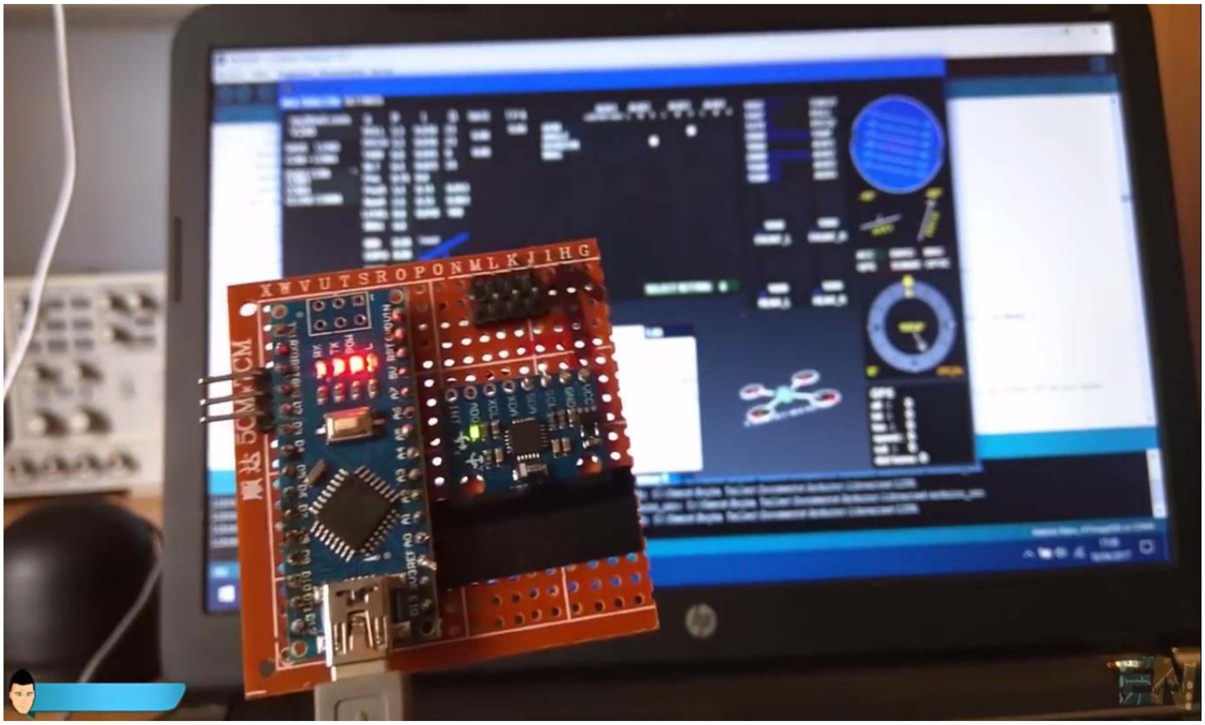

**Figure 5**: Linking the hardware to the simulator

## 4. Conclusion

This paper presents the design and implementation of an unmanned aerial vehicle with ground control station for monitoring and surveillance. The design entails the requirement to consider when selecting an unmanned aerial vehicle chassis, the flight controller, the motors, the electronic speed controllers and the battery. It also explains the design of the ground control station for the drone, as well as the design and implementation of a manual control system for a drone. The system can be used for both military purpose such as spying and monitoring of enemy territory and commercial surveillance purposes such as goods delivery services.

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