Design and Development of a Quadcopter with Ground Station Monitoring Unit

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Abstract- In this study, the development of a kit-form quadcopter is described. This suggests that Altrium build software was used to build the transmitter and receiver circuitry and that the enclosure was produced locally. The renovation was required as a result of the frequent cult fights and bloody incidents that have become a problem on the Cross River University of Technology campus in Calabar. Using the quadcopter, a few images of students and a few hotspot locations were captured for this project. This quadcopter's components included a tiny F450 constructed of glass fiber, four Hubson x4 brushed DC motors with Walkera Ladybird propellers, an electronic speed control (ESC), a nano nRF24L01 module, an inertial measurement unit (IMU) MPU 6050, a LiPO battery, and an Atmega 328. The data collected from testing the UAV was simulated using MATLAB. These findings are fairly comparable to work that was done at the Lovely Professional University in Phagwara, Punjab, India's School of Electronics and Communication. In their research, a quadcopter was created with the express intent of obtaining information regarding atmospheric carbon dioxide. Our quadcopter's flight time was only about three quarters of an hour, and it could only reach a vertical height of about 150 meters, whereas theirs had a GPS module, could properly stabilize itself, could pinpoint its location thanks to its GPS module, could reach a vertical height of over 700 meters, and had a flight time of about 4 hours.

Indexed Terms- Quadcopter, Brushed DC motor, ESC, MPU 6050, LiPO battery, Propeller, UAV MATLAB.

I. INTRODUCTION

A quadcopter, also known as a quadrotor, is a type of unmanned aerial vehicle (UAV) or drone that is propelled by four rotors. It is one of the most common and popular designs for consumer and hobbyist drones. The term "quadcopter" arises from its four rotors, with two pairs of rotors spinning in opposite directions. These rotors generate thrust, providing vertical take-off and landing capabilities, as well as control over altitude and directional movements. [1]. Quadcopters are typically equipped with various sensors, including gyroscopes and accelerometers, to stabilize and maintain flight stability. They can be operated remotely using a controller or autonomously using on-board software and GPS. Quadcopters have a wide range of applications, including aerial photography and videography, recreational flying, surveillance, search and rescue operations, and even delivery services in some cases. They are popular due to their maneuverability, ease of use, and versatility in different environments [2].

People have said that drones have been around since 1849 in Italy. At that time Venice was trying to become independent from Austria. Soldiers from Austria used balloon filled with hot air, hydrogen or helium and bombs to attack Venice [3]. In 1918, during World War 1, the US Army created a special type of aircraft called the Kettering Bug. It could fly without a pilot and was controlled by radio [4]. However, this aircraft was not used in actual battles.
Although drone was originally designed for military purposes, it has seen rapid growth and advancements that include a break into consumer electronics [5]. This technology is extensively used today in the agricultural, construction, entertainment and security industries [6].

Security issues are prevalent worldwide, particularly in public spaces like schools. In the first six weeks of 2023, there have been roughly seven mass shootings in the United States, along with eight in Mexico, six in South Africa, one in Kenya, and many more [7]. It has happened at the Cross River University of Technology (CRUTECH) as well. Several previous cult fights at this university resulted in the deaths of students and the damage of school property on the Calabar campus. The requirement for a surveillance instrument that can provide a real-time reconnaissance to the security staff in the school grounds gave rise to the idea for this research.

Other than monitoring in universities, there have been a variety of studies on quadcopters. For instance, a group of engineers at Lovely Professional University in Punjab, India, used the KK 2.1.5 Flight Controller to create a kit-form quadcopter. They used the same fundamental parts as mine, but added a GPS module and a carbon (IV) oxide measurement sensor instead. Since KK 2.1.5 is a flight control board for multi-rotor aircraft, it increased their quadcopter's vertical displacement and assured greater stability. This clarified how their kit-form quadcopter was able to soar above 700 meters in the air. For the accurate compilation of data on carbon (iv) oxide, this height was required [8].

Jacquelyne and Kovac, two Belgian engineers, designed and created a quadcopter with a 3-D printer for usage in the construction sectors in 2018. They claim that the availability of these autonomous quadcopters has made it possible to conduct building operations in remote locations. In Belgium and Luxemburg, they have built and repaired tall buildings with their quadcopter.

In addition, in 2018 two Belgian engineers, Jacquelyne and Kovac, designed and developed a Quadcopter fitted with 3-D Printer for use in the construction industries. According to them, these autonomous Quadcopter has opened up the possibility for construction projects in areas that would otherwise be out of reach. They have used their Quadcopter to construct and repair high-rising buildings in Belgium and Luxemburg. The use of 3-D technology in the construction industry has revolutionized this industry and led to the development of floating structures, often known as buoyant homes [9].

Additionally, a group of engineers from the Imperial College, London, under the direction of Professor Eiris John, created UAVs for the architectural, engineering, and construction (AEC) industries in 2017. He asserts that the AEC sector is well-positioned for the expansion of quadcopter applications and that UAV technology is most suited for these applications since it can access areas that are dangerous, challenging to access, or inaccessible to workers [10]. He came to the conclusion that quadcopters could complete several AEC-related jobs more quickly and cheaply than people could.

II. MATERIALS AND METHOD

2.1 This section presents the materials and the method used in the research. These were the materials used in this research:

- Micro F450 frame: This provides support to all other components in the UAV. Basically, there are available in these form: carbon fibre, aluminium and wood, such as plywood [11]. FIG. 1 shows the micro F450.
- Electronic Speed Control (ESC): This is an electronic circuit designed to change the speed of an electric motor, change its route and also act as a dynamic brake [12]. They are rated according to maximum current. The ESC used in this work has a current rating of 0.5 mA. FIG 2 shows an ESC.
- Brushed DC Motors (BDC): Brushed and brushless motors are the two types of motors used in drones. Despite the fact that these two motors operate on distinct principals, it is important to note that the latter are more powerful relative to their weight and have an efficiency of approximately 85–90% as opposed to the brushed motor, which has an efficiency of about 75–80%. [1]. This difference in efficiency, in accordance with [12], indicates that more of the total power is being transformed into rotational force and less into heat energy. Four Hubson x4 brushed DC (BDC) motors are used in this quadcopter, as shown in FIG. 3.
- Propellers: These are special types of fans that generates thrust whenever aerodynamic or

hydrodynamic forces act on the blades. A pressure difference is created between the front and back of the foil, accelerating the fluid (such as air or water) behind the wing [13]. They are classified according to these four variables: length, number of the leaves, shape of the propeller and angle of the twist. In this work, the Walkera Ladybird propellers was used and it is 55mm in length. FIG. 2.4 shows the Walkera Ladybird.

- RF-nano (nRF 24L01) Module: A radio frequency (RF) transceiver module used for wireless communications. It is designed to operate in the 2.4GHz (Industrial, Scientific and Medical Radio Band) frequency band and uses Gaussian frequency-shift keying (GFSK) modulation for data modulation. Its transfer rate for data is configurable and can be set to operate at 250kbps, 1Mbps or 2Mbps respectively [8]. FIG. 2.5 shows an nRF 24L01.
- MPU6050 IMU Module: IMU means inertial measurement unit. This is an avionic device which measures as well as detects the angular motion of a UAV while on flight. It is a micro electro-mechanical systems (MEMS) which consist of a 3- axes gyroscope, 3- axes accelerometer and a digital motion processor integrated all on a single chip [1]. Its accelerometer employs some mathematical algorithms to calculate the acceleration of the Quadcopters in a 3-perpendicular axes [11]. On the other hand, its gyroscope comprises 3-axes sensors and measures the change or rate of rotation in 3 the x, y and z axes [11]. FIG.2.6 shows an MPU6050.IMU Module.
- Lithium polymer (LiPO) Battery: Lithium polymer batteries are rechargeable, pouch-sized batteries that use lithium-ion technology [6]. According to [14], LiPO batteries have three main advantages over other rechargeable batteries such as NiCad or NiMH and these include: light weight. high discharge rate and high power holding in small package. A lithium polymer battery is shown on FIG. 2.7.

FIG. 2.1

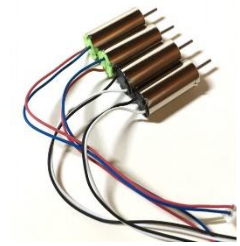


FIG. 2.2

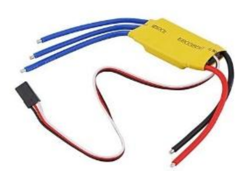


FIG. 2.3

FIG. 2.4

FIG.2.5

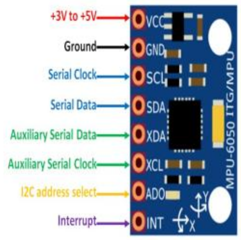


FIG. 2.6

FIG. 2.7

2.2 Methods

These were the steps taken in this work:

a) Designing the transmitter and receiver circuits using Altrium Designer software.
b) Producing the designed circuits at JLCPCB located in Guangdong, Shenzhen City, China.
c) Mounting the electronic and avionic components on the circuit boards.
d) Assembling of frame, connecting the ESC's, fixing of brushless motors and the propellers.
e) Programming the atmega328 used in the receiver using Arduino board
f) Configure the receiver and transmitter calibrations using MuiltiWii 2.0 software.
g) Flying the Quadcopter.

2.2.1 Design considerations

2.2.2 Choosing the Quadcopter Casing

Having weight ranges of 2 kg to 20 kg and 25 kg to 20 kg, respectively, a mini and small quadcopter must be extremely light [15] and [16]. This necessitates that their shells be exceedingly lightweight. The quadcopter's optical fiber housing allowed it to accomplish this feat.

2.2.3 Choosing the nano F450 frame

Regarding weight, sturdiness, and vibration resistance, there are three criteria that decide the sort of frame that should be employed in any UAVs, including quadcopters [15]. Frames can be manufactured from fiber, glass, wood, steel, and other materials according on the quadcopters' size and intended uses.

The main exception is DJI quadcopters, which practically all nano, micro, and mini quadcopters have light frames made of carbon and glass [15]. Glass fiber was employed in this study because it is lighter, more durable, and lighter—though a little heavier than carbon fiber.

2.2.4 Choosing the Motors

Step 1: To determine the weight of the quadcopter

The quadcopter's overall weight was set by the researcher at 300g. This was supported by the weight group range that [16] provided. This weight was multiplied in accordance with the international norm to determine the bare minimum of thrust that will be required. So, the quadcopter's assumed weight changed to:

300gm + 300gm = 600gm

Step 2: Add the weight of any other object that the quadcopter will carry.

A 2MP camera, weighing about 25g, and a circuit board, weighing about 75g, will be used in the quadcopter that will be created. Consequently, its assumed weight will be:

600gm + 100gm = 700gm

Step 3: Add 20% to the assumed weight to ensure that the Quadcopter can hover

Now, the assumed quadcopter's weight is 700g and 20% of it is 140gm.

That is, $\frac{20}{100}$ x 700 = 140gm

So, the final total weight will be

700gm + 140gm = 840gm

Therefore, the quadcopter will require 840g of thrust to get it off the ground

Step 4: Divide the thrust total by the number of motors your drone will use.

The overall thrust will be divided by four because the research's quadcopter has four motors. This is,
$\frac{840gm}{4}$ = 210gm

Step 5: Check all DC brushless motors available online for different thrust values
The different thrust numbers for DC brushless motors were examined in the various online vendor stores. According to tradition, the quadcopter's overall design thrust must be equal to or more than the thrust value to be selected.

The Hubson x4 motor was selected in this manner. The details of this motor are as follows:

- voltage: 3.7
- shaft diameter: 1mm
- dimensions: 20 x 8.5mm
- weight: 10gm. So, the total weight of the four brushed motors was 40gm
- colour: silver
- material: alloy
- 4 pcs motor: 2 x clockwise and 2 x counter-clockwise
- Thrust per motor: 50g

Consequently, given that each Hubson x4 motor produces 50g of thrust. This indicates that the motors are appropriate for the quadcopter designed because the total thrust produced by the four propellers will be (50 x 4) = 200g.

2.2.5 Choosing the Battery

When selecting a battery for any quadcopter, it's necessary to take into account its type, capacity, maximum permitted discharge (burst), average discharge (constant) rate, and weight [14].

- Type: There are numerous battery options that can be employed in the majority of electrical applications. There are, however, only a limited number of battery options for usage in UAVs, of which quadcopters are one. These possibilities consist of graphene-based batteries, lithium polymer batteries, and lithium ion batteries [14]. The LiPO battery is the most popular and often utilized of the three batteries available for use with UAVs. This is predicated on the LiPO battery having the highest storage capacity when compared to other li-on and graphene-based batteries, as well as being the lightest of the three [17].
- Capacity (mAH): The amount of chemical energy that the battery can store is determined by this storage. The quadcopter's operating time on a single charge increases with capacity [14]. The battery capacity is measured in milliamps, claims [14]. Watt-hour (W) or mAH
- Maximum permitted discharge (burst) and average discharge (constant) rates: A LiPO battery's maximum permitted discharge (burst) is the highest current—measured in amps—that it can draw without experiencing damage. [14]. Usually, the battery's manufacturer will set this variable, and it serves the primary purpose of limiting high discharge rates that could harm the battery or lower its capacity. On the LiPO battery, it is denoted by the letter C. This figure is crucial since it aids the quadcopter at startup while the average discharge (constant) rate helps with current flow during normal operation. The maximum discharged rate is calculated mathematically as follows:

Max Current Drawn = Capacity (mAH) x C rating

- Weight: Choosing a battery with a higher capacity and maximum discharge current is in the best interest of the researcher and the supervisor because weight is crucial when developing a quadcopter. Only LiPO batteries are suitable, according to empirical analysis of the numerous batteries currently on the market. This explains why LiPO batteries are used in almost all nano, micro, and mini UAVs.

2.2.6 Choosing the Propeller

The length, number of leaves, shape, and angle of the twist were the criteria used to select the propellers for this project. It was essential to design a propeller that is extremely light while still producing extra thrust of up to 3g. Traditionally, a propeller with a length of 55mm must be used by all micro and tiny UAVs [11]. Despite the abundance of available propellers, the Walkera Ladybird propeller was selected due to the following qualities:

- number of leaves: 2
- Length: 55mm

- Angle of twist: 6°
- Weight: 1g
- Additional thrust: 3g

2.2.7 Choosing the Inertial Measurement Unit (IMU) MPU6050

The quadcopter's central processing unit (CPU), the IMU, must be selected carefully if it is to have balance, be aerodynamic, and not vibrate. The IMU that is used must feature a 3-axes gyroscope and accelerometer. This will make it possible for it to maneuver aerodynamically in the x, y, and z axes. The IMU must also be immune to magnetic interference. This is due to the fact that the quadcopter will be utilized in school settings where there will be a lot of interference from devices like machines, phones, motors, and others. [11].

Accordingly, the IMU MP6050 was selected for the job. In order to avoid magnetic interference, it exploits the Hall effect and contains a 3-axes gyroscope and accelerometer.

2.2.8 Choosing the nRF24L01 module

For ultra-low power wireless applications, the nRF24L01 is a single chip, 2.4GHz transceiver with an inbuilt baseband protocol engine. It includes a crystal oscillator modulator, demodulator, power amplifier, beat controller, and frequency generator [10].

It can cover about 100 metres (that is about 200 feet) when operated efficiently, making it suitable for wireless remote control projects. On the line of sight, it has about 800+ metres as a range. It is powered by 3.3volts, so it can easily use 3,2volts and 5volts system. It consumes only 11.3Ma at 0 dBm transmit power and consumes 13.5mA in receive mode [10]. It was chosen because of the aforementioned reasons.

III. THEORETICAL BACKGROUND/ANALYSIS

3.1 Aerodynamic forces of Quadcopter

Basically, lift, drag, weight, and thrust are the four forces that govern how a quadcopter operates. While the principle of buoyancy is used by lighter-than-air craft like balloons and hovercrafts, flight in all heavier-than-air craft like quadcopters is only made possible by a careful balancing of these four physical forces, where the lift must balance the weight and the thrust must outweigh the drag [18].

- Lift(L)

A force that is equal to or greater than the force of gravity must be generated in order for a quadcopter to take off into the air. We refer to this force as lift. The Walkera ladybird propeller's design causes air to flow quicker on its top than on its bottom, which causes the air pressure around these propellers to fall. A lift force is produced because there is more air pressure below the propeller than above [19]. Bernoulli's equation, which is given as the best representation of these pressure changes of flowing air, shows that

$$P + 0.5*\rho * V^2 = k \quad [1]$$

where P= the air pressure; ρ = air density; V = air velocity and K = a constant.

Equation [1] can be further explained by the continuity equation which is given below:

$$\rho*A*V = k \quad [2]$$

where P = pressure; V = velocity and A = cross sectional area of flow. All propellers, including the Walk era Ladybird propeller, are designed such that there is opposite angular-twist at both end of the propeller. This is to cause the air flowing through it to divided into low pressure on top and high pressure below it. It is this air pressure differential that causes lift. The lift equation is therefore given as

$$L = c_L*s*[0.5*\rho * V^2] \quad [3]$$

where S = propeller area; $[0.5*\rho * V^2]$= the dynamic pressure and C_L= lift coefficient.

Since the lift coefficient for all flight stages, in Quadcopter, lies between0.8 and 1.4, an average value of 1.1 was chosen for the work. The propeller area, otherwise called swept area = 3.14*[2.75^2] = $23.74625mm^2$.Hence the lift for this Quadcopter is given as

$$L = 1.1*23.74625mm^2*29.29Pa$$

$$L = 765.08$$

- Drag

The air flow must present some resistance to all quadcopters that are propelled through the air. Drag is the term for this resistance [18]. Drag is proportional to dynamic pressure and the area it acts on, much like lift is. Similar to the lift coefficient, the drag coefficient quantifies how much dynamic pressure is transformed into drag. However, the drag coefficient is typically intended to be as small as possible, unlike the lift coefficient. Because quadcopters become more efficient as drag reduces, low drag coefficients are preferred [18]. In mathematics, it is denoted as

$D = c_D$*s*[0.5*$\rho * V$^2] [4]

Where S = 23.74625nn^2; [0.5*$\rho * V$^2] = 763.08Pa. The drag coefficient, D, of a drone lies between 0.25 and 0.35 and its average value of 0.3 was used in this work.
D = 0.3*23.74625*765.08
D = 5450.3343

- Weight (W)

A quadcopter's weight poses a significant design constraint [19]. A heavier quadcopter needs more lift than a lighter one if it is intended to carry heavier payloads. To accelerate on the ground, greater thrust might be necessary [19]. The mathematical equivalent is

W = m*g [5]

Where m is the mass of the Quadcopter and equals 840g and g is 9.8N

So, the weight of the Quadcopter is 840*9.8 = 8232N.

- Thrust (T)

Newton's second law can be used to explain the force of thrust. According to Newton's second law, the mass of the body and the net force acting on it both affect how quickly a body accelerates [20]. On the other hand, a body's acceleration is directly correlated with the net force acting on it and inversely related to its mass ([20]).

a ∝ F [6]

a ∝ $1/m$ [7]

Therefore, F = m*a [8]

But the position of any accelerating Quadcopter depends on both time and the square of its time. This gives rise to:

y = $y_0 + v_0$ *t + 0.5*a* t^2[9]
On differentiating [7], we have
y = $y_0 + v_0$ *t +a*t [10]

The Quadcopter begins at rest and flies upward with an acceleration of 4.755 m/s2 between 0.3s and 1.0s before reaching a constant upward velocity of 3.67 m/s between 1.0s and 1.5s, as can be shown in FIG. 4.1. The four Hobson motors provide thrust forces conventionally. This effective net-force from the four motors in the vertical direction can therefore be calculated using the force-motion relationship as follows:

$F_{net-Y} = m * a_y$ [11]
However, equation [9] can be further divided into two separate vertical forces, namely the downward gravitational force, mg, and the upward thrust force, F_T. Weight is another name for the latter force. When these two decomposed forces are substituted into equation [10], it then becomes

$F_{net-y} = F_T$ – m*g [12]
Then on combining equations [10] and [11] we have
$F_T = m * a_y$ + m*g [13]

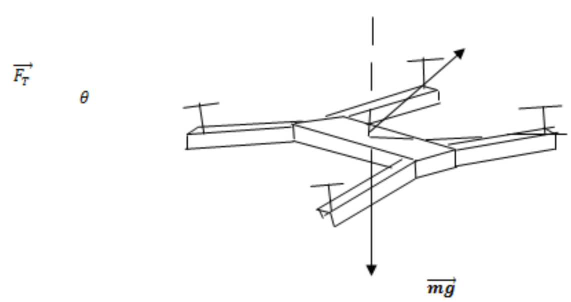


FIG. 3.1: A Quadcopter flying at angle θ

On resolving equation [12] into its vertical and horizontal components, as shown on FIG. 2.8, it will become

F_T*Sin$\theta = m * a_x$ [14]
F_T*Cosθ = m*g [15]

Therefore, the vertical and the horizontal thrusts of this Quadcopter are given as

F_T*Sinθ = $m * a_x$= 840*a_x[16]
F_T*Cosθ = m*g= 840*9.8N = 8232N [17]

3.2 Transmitter and Receiver circuits

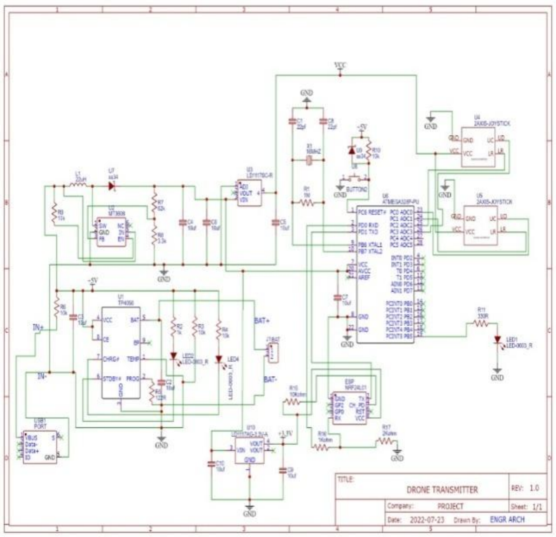


FIG. 3.2: Transmitter Circuit

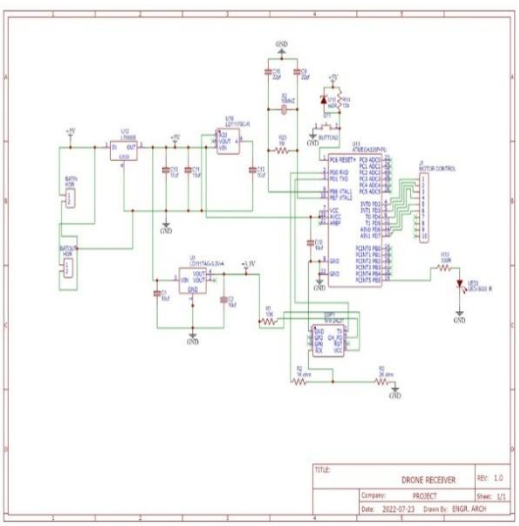


FIG.3.3: Receiver Circuit

IV. RESULTS

4.1.1 Quadcopter movement along the X and Y axes

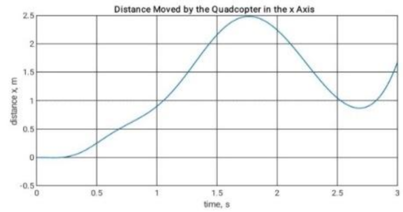


FIG. 4.1(a)

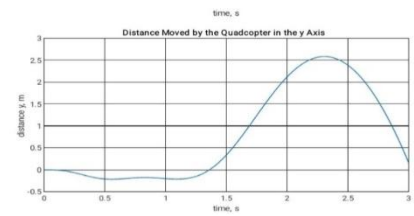


FIG. 4.1(b)

FIG.4.1(a) &(b): Distance moved by the Quadcopter along the X and Y axes

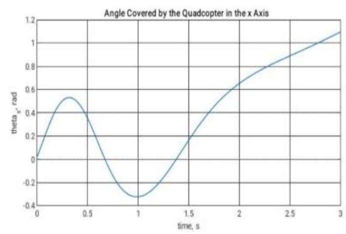
4.1.2 Discussion of the simulated results for FIG. 3.1(a) & FIG. 3.1(b)

FIG.4.1(a):The quadcopter's four motors briefly rotated after being turned on. The Quadcopter then starts to raise up when it yawns, and this lifting up procedure was gradual because the Quadcopter was attempting to defy gravity.

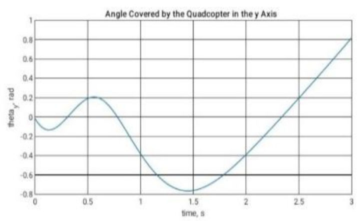
The opposing force was finally overcome and the Quadcopter rose to about 2.5m. At 2.5m, the Quadcopter started to hover. A quadcopter must have two of its four rotors rotating clockwise while the other two are moving counterclockwise in order to hover.

FIG. 4.1(b): Yaw is the term for a quadcopter's motion along the y-axis. As depicted in FIG. 4.1(b), the quadcopter briefly leaned and went either forward or backward before beginning to progressively ascend at a specific angle until it defied gravity at a height of about 2.5m.

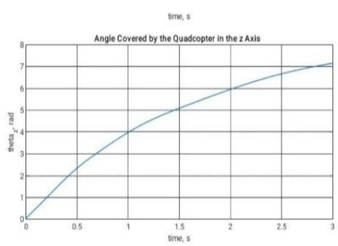
4.2. Quadcopter angles along the X, Y and Z axes



(a)FIG.4.2.1



(b)FIG.4.2.1



(c) FIG.4.2.1

4.2.1 Discussion of FIG. 4.2.1(a), FIG. 4.2.1(b) & FIG.43.2.1(c)

FIG. 4.2.1(a), FIG. 4.2.1(b) & FIG.4.2.1(c) Display the quadcopter's angle in relation to the x, y, and z axes, accordingly. There are six degrees of freedom on this quadcopter. This suggests that six variables (x, y, z, φ, θ, ψ) are required to express its position and orientation in space [14]. The x, y, and z variables show how far the quadcopter's center of mass is from a fixed reference frame along the x, y, and z axes, respectively. The remaining three variables are the three Euler angles that represent the orientation of the quadcopter (,φ, θ, φ,,). The roll angle is the angle about the x axis; the pitch angle is the angle about the y axis; and the yaw angle is the angle around the z axis [14].

FIG. 3.2.1(a): Most times, roll is confused with yaw. Roll is making the Quadcopter to fly sideway at an angle. The dips in the roll angle, shown on FIG. 4.21(a), is due to the IMU MPU6050 reacting to the wind pressure impinging on the propellers and the Quadcopter itself. In countering this air resistance, the IMU MPU6050 sent signals to the ESC to either increase or decrease the speed of the motor. As seen in FIG. 4.2.1(a), it took a fraction of second for the communication between the motors and the IMU to be effected.

FIG. 4.2.1(b): This shows the pitch angle, which determines whether the quadcopter moves forward or backward. The throttle stick is typically dragged forward to do this, which causes it to tilt and travel at an angle [21]. Wind pressure and a reduction in propeller thrust had a significant impact on the Quadcopter's movement at this angle. The IMU MPU6050 and ESC, which regulate stability, required to send signals to the BDC motors to either raise or reduce their speed in order to establish balance in this system. This is what FIG. 4.2.1(b) depicts.

FIG. 4.2.1(c): This depicts ψ which is the angle about z axis and is called yaw angle. Yaw is the control which describes the swiveling of the Quadcopter to either right or left. So, ψ describes the leftward or rightward movement of the Quadcopter at an angle. As seen from FIG. 4.2.1(c), the graph increased gradually from left to right. This showed that the speed of the Quadcopter was actually increased gradually by the ESC to achieve stability as the drone was swiveling at an angle.

4.3 Quadcopter displacement above the ground

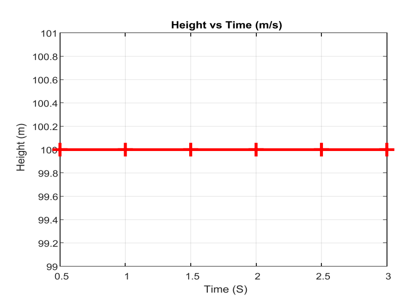


FIG. 4.3

4.3.1 Discussion of FIG. 3.3

The proportional integral derivative (PID) controller of the quadcopter helped achieve a constant altitude of the UAV which is the vertical displacement of the quadcopter over the ground [21]. FIG. 4.3 showed a minimal vertical displacement of the quadcopter as the controller ensured hovering of the UAV at an almost constant height. From FIG.4.3 this maximum vertical displacement is about 100 metre and this value would vary or drop if there is a turbulence or an increase in the wind current. This vertical displacement can increase to about 150 metres should the aerodynamic conditions be conducive.

4.4 Linear velocity of the quadcopter in the X, Y and Z directions

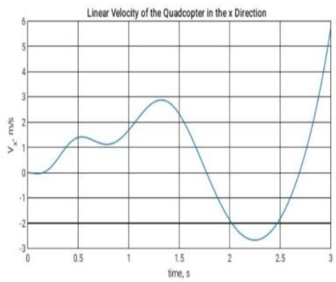


FIG.4.4(a)

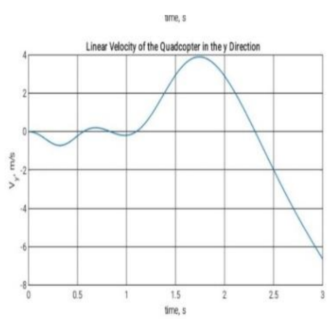


FIG.4.4 (b)

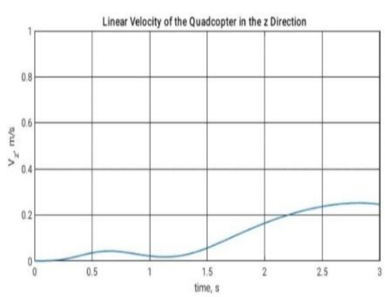


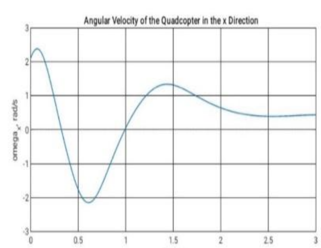
FIG.4.4 (c)

4.4.1 Discussion of FIG. 4.4(a), FIG. 4.4(b) & FIG. 4.4(c)

FIG. 4.4(a) and FIG. 4.4(b) showed the directional speeds of the Quadcopter in the three axes. As seen from the graphs, these directional speeds are not constant. This instability in the velocity was caused by the coupling of the pitch and roll in the x and y axes. Coupling in this context simply means that the rotors and propellers are fixed and, as such, possess less maneuverability and agility. Therefore, the Quadcopter's velocity is affected when it is in a tilted position and when there is a strong air current. In FIG. 4.4(a)the Quadcopter's velocity is unstable and, in order to balance it, the Quadcopter was yawed for more power. The IMU, using some algorithm, will calculate the angle of tilt with the wind current and send a signal to the ESC to increase or decrease the speed of the motors accordingly. This will to some extend give the Quadcopter some maneuverability and agility but not total stability. This is why the FIG. 4.4(a) and FIG.4.4(b) are the same. Total stability is achieved by using tilt wing mechanism and tilt rotors mechanism [22].

FIG. 4.4(c): The linear velocity of the quadcopter in the z-direction is negligible during the simulation time in comparison to those in the x- and y-directions, FIG. 4.4(a) and FIG. 4.4(b). This was expected as the UAV was simulated in the hovering vertical position.

4.5 Angular velocity of the Quadcopter in the X, Y and Z directions.



FIG,4.5(a)

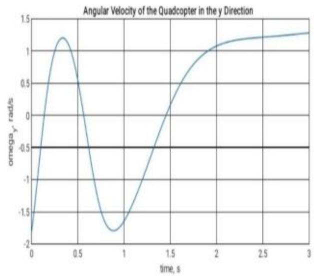


FIG.4.5(b)

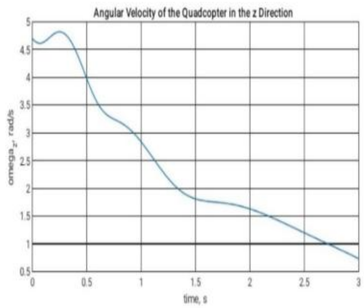


FIG.4.5(c)

4.5.1 Discussion for FIG. 4.5(c), FIG. 4.5(b) & FIG. 4.5(c).

According to [23, angular velocity helps to bring vibration rejection and stability to quadcopters while on flight. Therefore, from the i, j and k plots, it is lucidly clear that the quadcopter was most stable along the z-plane, more stable along the x-plane and least stable along the y-Plane. By implication, the quadcopter experienced vibration more while in the x-plane than in the y-plane.

4.6 Screenshots of certain spots in University of Cross River State

CONCLUSION

This project was borne out of the need to have a locally-made gadget that can give a real-time surveillance in the University of Cross River State. A few pictures of the various places with students were taken. Moreso, in this research, four Hubson x4 brushless DC motors with four Walkera Ladybird propellers, a micro F450 made of glass fibre, electronic speed control (ESC), nano nRF24L01 module, inertial measurement unit (IMU) MPU 6050, LiPO battery and Atmega 328 were all used in this simple design. The acquired data derived from this work was then simulated using MATLAB software and the various results were represented in graphical formats. The few shortcomings of this kit-form Quadcopter include low altitude (as the highest altitude of this Quadcopter is about 150 metres) and a flight time of about a quarter of an hour. I strongly recommend that further research be carried in this field, especially on one that can ascend up to 800 metres and have a flight time above 4 hours.

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