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Design and Construction of a Quadcopter System with Surveillance Facilities

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Abstract
The design and construction of a drone delivery (quadcopter) system with a surveillance facility encompass the development and implementation of an unmanned aerial vehicle (UAV) capable of performing precise delivery tasks while also capturing high-quality aerial images and videos. The primary objective is to create an efficient, reliable, and autonomous drone capable of performing dual functions: delivering packages and capturing high-quality aerial images. The photography subsystem incorporates a gimbal-stabilized camera to achieve superior image quality, minimizing motion blur and vibration. Despite advancements in battery technology, the limited battery life of drones remains a significant constraint, restricting flight duration and operational range. Extended flights for both delivery and continuous photography require efficient power management, which is challenging to achieve with current battery capacities. Combining delivery and photography functions into a single drone system presents significant design and operational challenges. Optimizing the drone for both purposes without compromising performance in either area is complex and may result in trade-offs. In the construction phase, meticulous attention is given to assembling and calibrating the drone to achieve optimal performance. Rigorous testing is conducted to evaluate the system's reliability under various environmental conditions and payload scenarios. The final prototype demonstrates the potential for a wide range of applications, showcasing the drone's ability to deliver packages promptly and capture stunning aerial imagery. Additionally, the integration of real-time data transmission allows for instant monitoring (data collection) and adjustments during flight. i.e. allowing live streaming of footage to the ground station, enabling immediate monitoring and adjustments. Through the internet (Real-time Transmission). Testing phases focus on assessing flight performance, delivery accuracy, and image resolution under various environmental conditions. Results indicate that the drone system successfully meets the design specifications, demonstrating reliable delivery capabilities and high-quality photographic output.

Keywords: ***Unmanned vehicles (UVs), Flight Control, Payload capacity, Navigation, Drone delivery system and photography***

1.0 Introduction
The integration of drone technology into various industries has significantly transformed traditional methods of operation, offering innovative solutions for efficiency and cost-effectiveness. One such application is the development of drone delivery systems and their use in photography. This study explores the design and

construction of a drone delivery system and its dual functionality in capturing high-quality aerial photographs, addressing the technical, logistical, and regulatory challenges involved. Drones can significantly reduce delivery times and the labour cost associated with delivery operations.,(Ullah Muneeb. 2021).
Drones have evolved from basic remote-controlled aircraft to sophisticated devices equipped with GPS, high-definition cameras, and advanced navigation systems. Innovations in battery technology, lightweight materials, and automated flight control have significantly enhanced their capabilities. Modern drones can carry substantial payloads over long distances and navigate complex environments autonomously (Adewumi, 2016).

The concept of drone delivery systems involves using unmanned Aerial vehicles (UAVs) to transport goods from a central hub to designated delivery points. This system leverages the speed, efficiency, and flexibility of drones to provide timely and reliable delivery services, especially in areas with challenging terrain or infrastructure limitations. Key components of a drone delivery system include the drone hardware, navigation and control systems, payload mechanisms, and communication interfaces. Parallel to delivery systems, drones have become an essential tool in photography and videography, providing unique perspectives and high-resolution imagery that were previously difficult or impossible to capture. Drones equipped with advanced cameras and stabilization systems are now widely used in various industries, including real estate, filmmaking, journalism, and environmental monitoring. The integration of photography capabilities in drones requires meticulous design to ensure camera stability, image quality, and operational safety.

The idea of using drones as a delivery system is popular. Delivery drones may become widespread over the next decade, specifically for what is known as the “last-mile” logistics of small or light items. As the demand for commercial deliveries increases within cities, companies face a fundamental limitation in terms of surface road capacity. By exploiting the vertical dimension above city streets, drone delivery aims to overcome that limitation. Companies such as Amazon, Google, and DHL have all launched substantial technical and, in some cases, coordinated public policy programs to bring drone delivery to fruition. A host of smaller start-ups are also working on delivery drones for developed and emerging markets (D’Andrea, 2014). In a related development, start-ups and established aerospace players (e.g., Airbus) alike are pursuing larger aerial on-demand mobility platforms—flying taxis designed to autonomously transport individual passengers from point to point (Vance and Stone, 2016). Not only do the larger passenger-carrying concepts share many of the same airframe, propulsion, and autonomy technologies as the smaller delivery drones, but they may be productively used to deliver larger, bulkier cargoes.

In the future, drones could augment, or in some situations even replace, truck fleets and could have important implications for energy consumption, public safety, personal privacy, air pollution, city noise, air traffic management, road congestion, urban planning, and goods- and service-consumption patterns in urban areas, (Jia, X 2017),

The concept of drone delivery has garnered significant interest, especially for its potential to revolutionize logistics and supply chain management. Companies like Amazon, Google, and UPS have been pioneers in testing and implementing drone delivery systems to enhance last-mile delivery efficiency. These systems promise faster delivery times, reduced transportation costs, and the ability to reach remote or inaccessible areas. However, the practical implementation of drone delivery involves addressing challenges such as payload capacity, battery life, navigation accuracy, collision avoidance, and regulatory compliance.
Therefore, the conceptual framework for the design and construction of a drone delivery system integrated with photography encompasses various interrelated components, including technological, regulatory, and operational aspects. This framework provides a structured approach to understanding the key factors and their interactions, guiding the development and implementation of the drone system.

The concept of solar energy on a drone involves integrating solar panels into the drone's design to harness solar power. This can provide significant advantages, such as extended flight time, reduced reliance on battery charging, and potentially enabling continuous or very long-duration flights, especially for high-altitude or stratospheric drones. Solar-powered drones represent a promising intersection of renewable energy technology

and unmanned aerial systems, offering a sustainable solution for a wide range of applications. However, the challenges of this concept rely on weather dependence which is availability of sunlight varies with weather conditions, time of day, and geographical location, affecting the consistency of power generation. And also Energy efficiency which involves Balancing power generation, storage, and consumption to ensure the drone can operate efficiently under varying conditions is complex.

The concept of integrating a cell phone into a drone combines the communication capabilities of a smartphone with the mobility and versatility of a drone. This integration can enable various innovative applications, ranging from remote communication and surveillance to emergency response and environmental monitoring.

Developing drones with built-in smartphone capabilities enables drones to operate autonomously using the phone's AI and processing power. Its communication capabilities involve operating the drone using apps on the cell phone, leveraging its GPS, accelerometer, and other sensors for improved control and navigation. More so, using the phone's camera to stream live video to a remote location will send sending and receiving data, such as images, video, or sensor readings. Integrating a cell phone into a drone leverages the strengths of both technologies, creating a versatile and powerful tool for various applications. By combining the communication and data capabilities of smartphones with the mobility and flexibility of drones, this concept opens up new possibilities for remote operations, real-time data collection, and enhanced situational awareness across multiple fields.

For small-scale delivery drones that are flying short distances, electric power offers several advantages. An electric motor can be made reliable because it has only one moving part. In addition, electricity is cheap. At an average of ten cents per kilowatt hour (kWh), the energy cost of an electric road vehicle is only one-quarter of that of a comparable gasoline-powered vehicle in the United States. Yet despite improvements in battery capacity, orders of magnitude still separate the energy density of production lithium ion batteries (optimistically at 260 Wh/kg for battery cells only) and gasoline (11,944 Wh/kg). The impact of reduced energy density is less severe for short-range aircraft, which do not have to carry the batteries as far to complete the missions. Also, the disparity in energy density is partially compensated for by the substantially greater efficiency of the electric power system, particularly at a small scale: Small electric motors can be as much as nine times as efficient as comparable internal combustion (IC) engines. Furthermore, the power density of the motor does not suffer at low output levels. At delivery drone scales, electric motors have an eight-to-one advantage in specific power versus small IC engines. The comparatively scale-free nature of electric power translates into weight, volume, and drag savings for small vehicles. Batteries do take time to charge, which places a bound on the utilization rate of the drones. However, the proliferation and technical maturation of rapid, multiphase charges for road vehicles mean that charging is unlikely to be a limiting constraint, particularly given the low energy capacities of small drones that are flying short distances. Hot-swapping batteries are another way to decrease turnaround time and can allow the battery capacity (and, hence, the battery mass) to be tailored for individual missions.

Drones, or Unmanned Aerial Vehicles (UAVs), have emerged as a transformative technology in various fields, including delivery systems and photography. This theoretical framework aims to outline the principles, design considerations, and technological components involved in the development of a drone delivery system that also incorporates advanced photography capabilities.
Drones are aircraft without a human pilot onboard, controlled either autonomously by onboard computers or by remote control. They can be classified based on design (fixed-wing, rotary-wing, and hybrid), size, and functionality. They are employed in sectors like logistics, agriculture, surveillance, and media production (Colomina & Molina, 2014)

Combining delivery and photography in a single drone involves integrating payload management with high-quality imaging systems and operational scenarios use cases like delivering packages while capturing promotional footage, surveying areas during deliveries, and documenting delivery processes for quality control (Gonzalez et al., 2020). Its technological components include frame and structure**,** propulsion system and power supply. The physical build of the drone must be lightweight yet sturdy, typically using materials like carbon

fibre or aluminium. Balancing the payload and stability of the drone ensures the drone remains stable and efficient in flight while carrying the additional weight of packages and camera equipment (Floreano & Wood, 2015).

The motors and propellers provide the thrust necessary for flight. The choice between electric motors and fuel-based engines depends on the desired flight duration and payload capacity while batteries (Li-Po or Li-ion) are common power sources, selected based on capacity, weight, and rechargeability. Modern drones utilize autopilot systems for navigation, often supported by GPS for precise positioning. Manual control is facilitated through remote controllers or mobile apps. Incorporating sensors like accelerometers, gyroscopes, barometers, and obstacle detection systems ensures stability and safety. Reliable communication channels are required for real-time control and data transmission. This includes radio frequency (RF) systems, Wi-Fi, and 4G/5G networks. Sending telemetry data (altitude, speed, battery status) back to the operator is crucial for monitoring drone performance. (Athanasiadis et al., 2018)

The integration of delivery systems and photography capabilities in drones offers vast potential for innovation across multiple sectors. By addressing design considerations, technological components, and operational challenges, the development of such systems can lead to significant advancements in logistics, media production, and beyond. Software for processing and transmitting images, including real-time streaming capabilities and High-resolution cameras with gimbals for stabilization are used to capture clear images and videos (Honkavaara et al., 2013).
This theoretical framework, supported by relevant literature, provides a foundation for further research and development in this interdisciplinary field.

2.0 Materials and Method

The research methodology is tailored towards the design and construction of a drone delivery drone (quadcopter) system with a surveillance facility encompassing the development and implementation of an unmanned aerial vehicle (UAV) capable of performing precise delivery tasks while also capturing high-quality aerial images and videos.

2.1. Materials

The materials used in the construction of the circuit (drone) are:

1. Body Frame - Carbon Fiber 550 Frame
2. Motor - 4 pieces of 3508 700kv motor
3. 2 pair of Propeller 1255
4. ESC - BLHELI 40A ESC (Electronic Speed Control)
5. Power Distribution Board - Matek PDB XT60 W/ BEC 5v & 12v
6. Flight Controller Board - Pihawk 4
7. Radio Transmitter - FLYSKY FS - I6X
8. Radio Receiver - FS - IA6B
9. Drone Release System - Dropping System Payload Delivery Thrower Air Dropper
10. Device For DJI Mini 3 Pro Mavic Air 2/2s FIMI x8 Drone Accessories
11. Video Receiver - 5.8G FPV Goggles LS - OO8D 4.3 Inch 40CH Support DVR Dual Antenna Built-in Battery 480. 272 LSOO8D Helmet
12. Video Camera - Foxeer Mini Micro Cat 3 1200TVL 0.00001Lux Starlight FPV Camera Night Version Freestyle Racing Drone Accessories
13. Video Transmitter - Rush Tank II Ultimate VTX 5.8G 48CH Raceband Pitmode 25mW 200mW 500mW 800mW Adjustable FPV VTX 2-8S for RC Racing Drone.

2.1.1. Frame Design and Fabrication

The difficulty lies in choosing the suitable material for the manufacture of the Quadcopter since it is necessary to get a material that has a degree of strength and hardness to bear the impact of motors in addition to the weights that will be on the quadcopter such as the camera, battery and other things and also must be used weight to be able to make off without any problems. We can divide the frame into two partitions, the first is to select the material and the second is to select the dimensions which means we should use an angle of 90 between the two axes because it will make the quadcopter more balanced and also about the length of the quadcopter, the suitable option is making it small to get more stable.

A quadcopter is a multi-rotor drone that has four arms having a brushless DC motor on each arm. Quadcopter drone arms are designed in fusion360 software. Hence this is a delivery drone; the middle part of the body has to be strong to carry the loads. So, a sheet metal body has to be used for the upper and bottom parts of the drone connecting four arms. The drone planned for the current work is initially modelled in Fusion 360 software. Figure 1 shows the design frame of the drone in Fusion 360 software



Figure 1: Modeling and rendering of a quadcopter drone in Fusion 360

2.1.2. Block and Wiring diagram of a quadcopter components

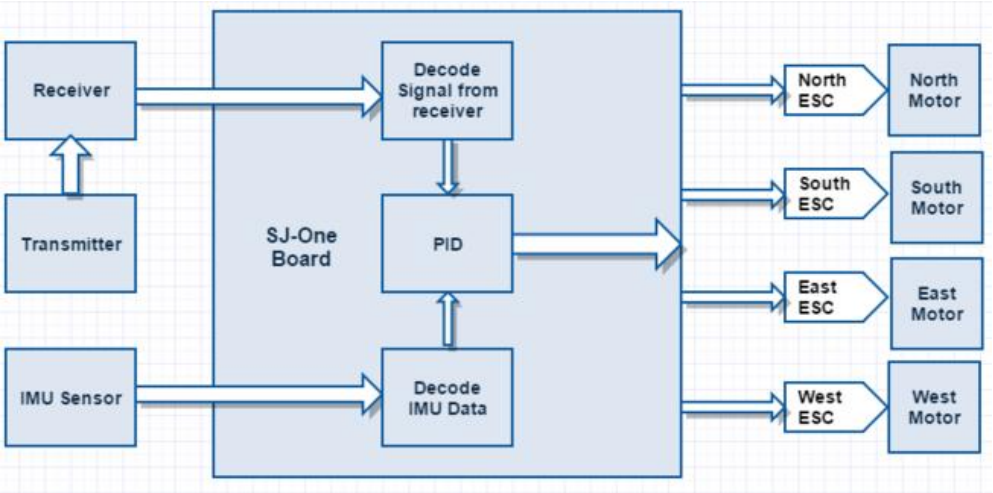


Figure 2: Block diagram

The block diagram illustrates the control system of a quadcopter, specifically how the SJ-One board (a flight controller) processes input signals and sensor data to control the motors. The power is fed to the motors using the power distribution board which comes from the LIPO batteries Pack. Four ESCs (North, South, East, and West) receive control signals from the SJ-One board and adjust the speed of the corresponding motors accordingly and four motors (North, South, East, and West) provide lift and thrust for the quadcopter. Their speeds are adjusted based on the signals from the ESCs to achieve the desired flight behaviour. This control

system ensures that the quadcopter remains stable, responds to pilot inputs, and maintains the desired orientation and position during flight. Below is the wiring diagram of the quadcopter;

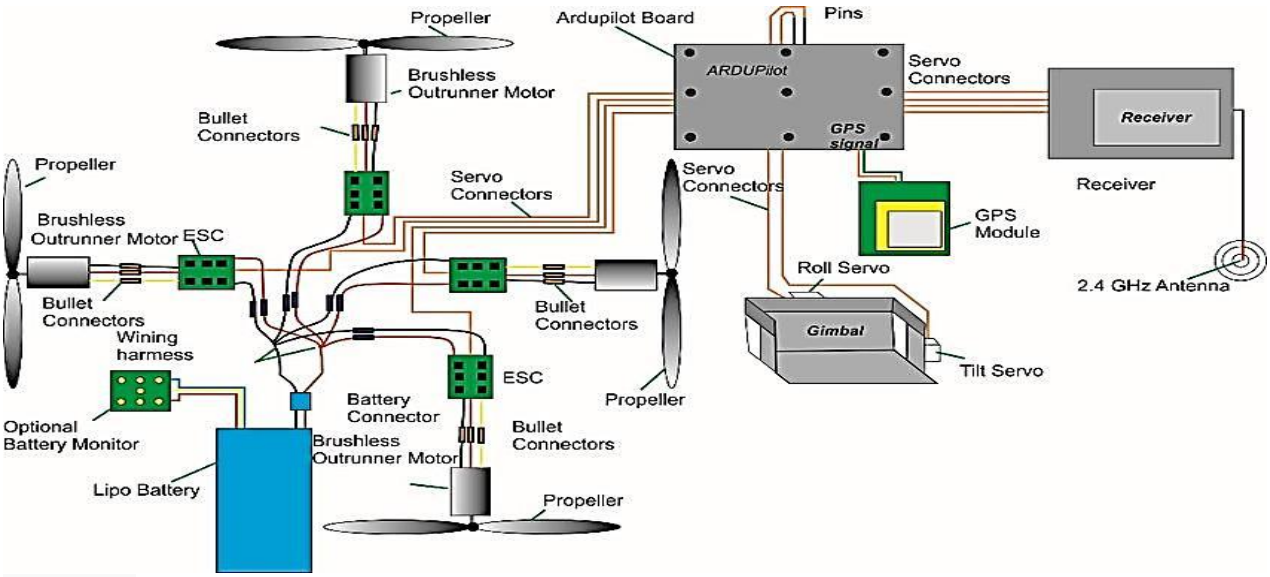


Figure 3: Wiring Diagram

The diagram illustrates the wiring and component layout of a quadcopter, showing how various parts are connected to form a functioning drone. This setup allows the quadcopter to receive user inputs, process them through the flight controller, and adjust motor speeds and servo positions to achieve stable flight and controlled movements.

2.2. Design Calculation

2.2.1 Mathematical Modeling

The equations of motion that define the quadrotor system are developed and analyzed. Non-linear equations which make accurate simulation as well as control difficult are simplified by making assumptions. The resulting model is simple while still being as realistic as possible.

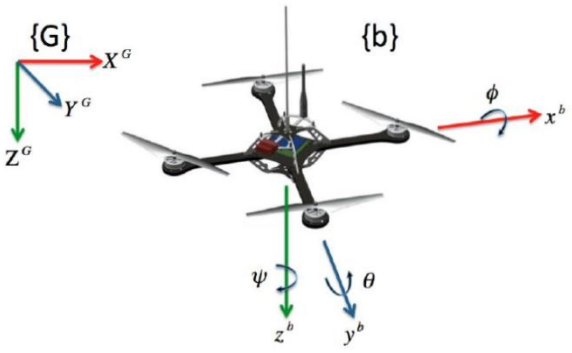


Figure 4: Euler angles of roll, pitch, and yaw

Euler angles of roll, pitch, and yaw, a body coordinate frame {b}, and the global coordinate frame {G} are shown in the figure above. The following assumptions are made:

1. The structure is rigid and symmetrical with a centre of mass aligned with the centre of the body frame of the vehicle
2. The thrust and drag of each motor is proportional to the square of the motor velocity.
3. The propellers are considered to be rigid and therefore blade flapping is negligible.
4. The curvature of the earth and the change in gravity due to altitude is ignored.
5. State variables are shown in the list below. This notation used is the North, East, and Down (NED) coordinate system.

X^G = Global north position of the vehicle (m)
Y^G = Global east position of the vehicle (m)
Z^G = Global down position of the vehicle (m)
x^b = Local north position of the vehicle (m)
y^b = Local east position of the vehicle (m)
z^b = Local down position of the vehicle (m)
Ø = roll angle along x^b (radians)
Θ = pitch angel along y^b (radians)
ψ = yaw angel along z^b (radians)
p = roll rate along x^b (radians/ second)
q = pitch rate along y^b (radians/ second)
r = yaw rate along zx^b (radians/ second)

2.2.2 Motor System Parameters

Four 3508 700kv motors are used in this quadrotor. The simplified electrical equation (Kirchhoff's Law) and the dynamic equation for the motor coupled to a load (Newton's Second Law) are defined below in the time domain. Back EMF is proportional to the angular velocity of the motor. Faraday's law can be used to describe the voltage created by the changing magnetic field in a coil. Lorentz's law which describes the force upon a coil in a magnetic field results in the produced torque being proportional to the motor current. These equations are shown below in the time domain.

PWM_{app} = Applied PWM signal (s)
U_{emf} = Back EMF (volts)
i = Motor current (amps)
R = Resistance of the coils and windings (ohms)
L = Inductance of coils (Henries)
j = Inertial load (kg – m^2)
K_e = EMF constant (Volt-s/rad)
K_τ = Armature constant (N-m/ amp)
K_f = Motor friction constant (N-m-s /rad)
ω = motor speed (rad/sec)

$$PWM_{app}(t) = Ri(t) + L\frac{di(t)}{dt} + U_{emf}(t)$$

$$J\frac{d\omega}{dt} = \sum \tau_i$$

$$U_{emf}(t) = K_e w(t)$$

$$\tau(t) = K_r i(t)$$

$PWM_{app}(t) = Ri(t) + L\frac{di(t)}{dt} + K_e w(t)$

$J\frac{d\omega}{dt} = K_r i(t) - K_f w(t)$

2.2.3 Motor Dynamic Identification

To model the system dynamics of the motor, the transfer function that describes the motor dynamics is calculated. The TF's output is the propeller speed, and the input is the motor voltage. The TF is used to calculate the time constant of the motor and the DC gain. In the equations below, the equations are converted from the time domain to the frequency domain using the Laplace transform.

$PWM_{app}(s) = (sL + R)I(s) + K_e w(s)$

$K_\tau I(s) = (Js + K_r)w(s)$

$G(s) = \frac{w(s)}{PWMapp(s)} = \frac{K\tau}{s(L+R)(Js+Ki)+KeK\tau}$

$G(s) = \frac{K\tau}{JLs^2+(RJ+KiL)s\ RKi+KeK\tau}$

$RJ >> K_i L$

$K_e K_\tau >> RK_i$

$L = 0$

$G(s) = \frac{K\tau}{Rjs+KeK\tau} = \frac{1/Ke}{\left(\frac{Rj}{KeK\tau}\right)s+1}$

DC Gain: $K_{DC} = \frac{1}{Ke}$

Time Constant = $\frac{Rj}{KeKr}$

Several assumptions are made to reduce the transfer function to approximate a first-order system. The force due to friction in a brushless DC motor is primarily due to bearing drag and is thus very small. Also, since the motor is small, we can assume the inductance is low and neglect this term as well. This results in the transfer function above. Additionally, the equations for the time constant and DC gain are calculated.

2.2.4 Thrust calculation

To know if the weight of the drone is suitable for standard flight, the thrust produced by each motor-propeller combination and therefore the net thrust should be calculated. The formula below provides an estimate of the thrust for each motor-propeller combination.

$T = [(eta * P)^2 * 2 * pi * R^2 * rho]^{0.3333}$

Where T = Thrust (in Newton)

eta = Propeller hover efficiency = 0.7 – 0.8

P = shaft power = Voltage * Current * motor efficiency (watts)

Pi = 3.14159

R = Propeller radius (in meters)

Rho = air density = $1.22 kg/m^3$

Conversion from Newton grams

1N = 1.10197162 kgf

kgf = kilograms force

For each of our motors at mx current, we have the thrust produced to be;

Given

Max Current = 12A/ 60 sec

Max voltage = 12.6v i.e 3S Li-poly battery

Max Efficiency = 80% i.e 0.8

Full power (p) = 12.6 x 12 x 0.8 = 120.96W

Half power (p) = 60.48w

Assuming the air density to be (Rho) = 1.22kg/m^3

Assuming Propeller hover efficiency (eta) = 0.75

Propeller Radius (R) = 5 inch = 0.127m

Pi = 3.14159

Therefore, $T = [(eta * P)^2 * 2 * pi * R^2 * rho]^{0.3333}$

$T = [(0.75 \times 120.96)^2 \times 2 \times 3.14159 \times 0.127^2 \times 1.22]^{0.3333}$

Thrust = 10.05

Converting Newton to kgf

1N =0.101971621kgf

Therefore, thrust at full power for each motor

i.e at the point the throttle stick is a maximum value (2000 µs)

10.05 x 0.101971621 = 1.02 kgf

Net thrust at full power (for 4 motors)

4 x 1.02 = 4.08kgf

Thrust at half power (P) = 60.48w

i.e at the point the throttle stick is at centre value (1500 µs)

$T = [(0.75 \times 60.48)^2 \times 2 \times 3.14159 \times 0.127^2 \times 1.22]^{0.3333}$

Thrust = 6.335N = 2.584 kgf

Net thrust = 4 x 0.646 = 2.584 kgf

Finally following the rules of thumb,

Required thrust = weight x 2

Weight = required thrust / 2

Therefore weight = 2.584 / 2 = 1.292kg

This means that at half power the weight of the quadcopter must be less than or equal to 1.292kg for a successful left.

3.0 Results and Analysis

Multiple simulations were run on the Simulink model to determine the relations between load capacity, range, speed, and flight time of the quadcopter. Thus for the ability to fly and hover, the quadcopter must overcome the gravity force. Based on the above calculation, each motor must produce a thrust of 4637.28 grams with the assumption that all motors have equal thrust.

3.1.1 Simulation result of the UV for aerial surveillance

This section presents the result of the UV simulation in a Simulink environment. Using the UV and control system toolbox, the UV was simulated in the 3D simscape section of Simulink and the result was presented in Figure 5, while Figure 6 presents the control dashboard;

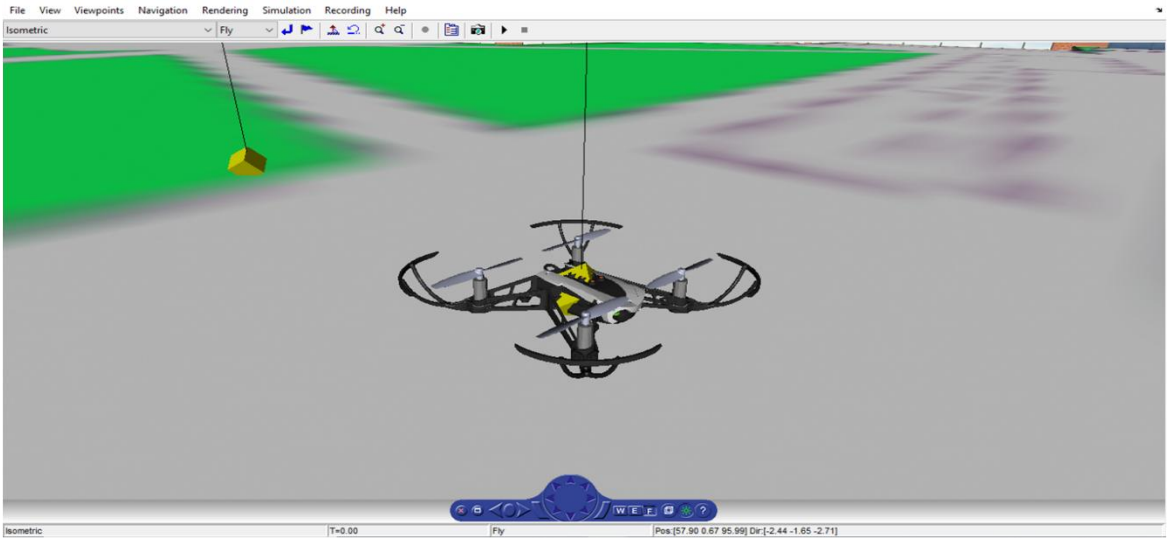


Figure 5: Simulation result of the UV in 3D (Nwabueze and Eneh., 2024).

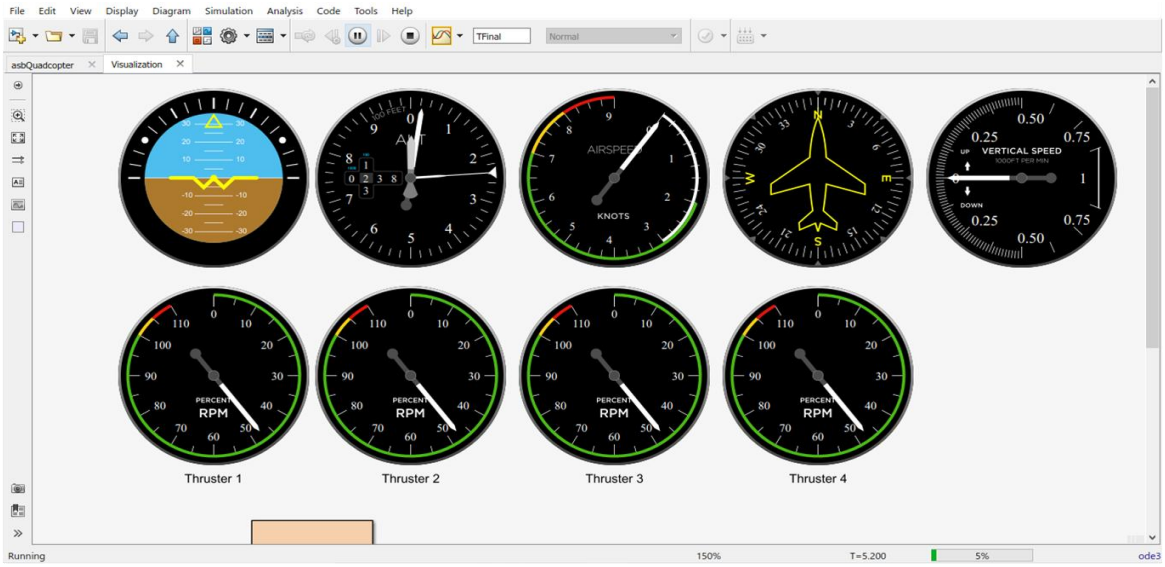


Figure 6: The Control Dashboard (Nwabueze and Eneh., 2024).

Figure 5 presented the simulation result of the UV flying in a computer-aided environment, while the dashboard to monitor and control the dashboard was displayed in Figure 6. The flying UV demonstrated the reality of a UV navigation process.

3.1.2 Assembly and Flight Testing

3D printed arms of quadcopter drone assembled to the sheet metal body of the drone. Figure 7 shows the fabrication of the sheet metal body. A brushless DC motor is connected to the electron speed controller (ESC). Motors are placed on the edge of the arms and ESC is placed in the middle of the arms. A power distribution board is used to distribute the power to all components. APM flight controller is placed in the middle of the drone and it's connected to the receiver, ESC GPS module, and power module. The assembled drone is shown in Figure 7, the drone is flight-tested. With the designed drone, a weight of 3kg has been lifted successfully.

3.1.3 Prototype

After several tuning of the PID, appropriate values for the gain were obtained and all errors were compensated for by the corrections made during the turning. We observed that most of the errors we experienced during the flight test were corrected and the quadcopter attained a more stable vertical flight, irrespective of wind and other disturbances, all of these were considered and the results were tremendous as shown in the prototype



Figure 7: Prototype of the Quadcopter

The use of light materials in the device's design allows the quadcopter drone to fly fast to its goal. The design and assembly of a quadcopter are explained in this section. Additive manufacturing is used to create quadcopter components that were designed in Infusion 360 and then 3D printed. The document includes a list of electronic components and their specs that were used in the fabrication process. An APM flight controller provides control. The drone is more stable, and it can also fly on its own and use GPS to return to its launch location. The quadcopter can deliver tiny items such as drugs, food and other supplies to remote locations.

3.1.4 Principle of operation of the drone

In a quadcopter drone, two of the motors rotate in a clockwise direction and the other two motors in an anti-clockwise direction. The speed of the motors is controlled by the electronic speed controller. If the two motors on the rear side of the drone rotate at high speeds, then the drone moves in a forward direction. If the two motors on the front side of the drone rotate at high speeds, then the drone moves in a backward direction. If the two motors on the Left side of the drone rotate at high speeds, then the drone moves in a rightward direction. If the two motors on the right side of the drone rotate at high speeds, then the drone moves in a leftward direction. The transmitter sends the desired signal to the receiver and the flight controller sends the corresponding signals to the ESC. The navigation of the drone can be done by connecting the GPS to the flight controller. If the two motors on the front side of the drone rotate at high speeds, then the drone moves in a backward direction. If the two motors on the left side of the drone rotate at high speeds, then the drone moves in the right direction. If the two motors on the right side of the drone rotate at high speeds, then the drone moves in a leftward direction. The transmitter sends the desired signal to the receiver and the flight controller sends the corresponding signals to the ESC. The navigation of the drone can be done by connecting the GPS to the flight controller.

4.0 Conclusion

This project has been able to design analysis and construct a drone delivery system with photography which is a cable of flying and lifting the payload. The quadcopter is a feasible vehicle for performing small package delivery. The vehicle can deliver up to 700 grams to any location within 1 kilometer radius in less than 6 minutes. The cost of delivery is 48 times less than the traditional delivery system. With relatively low cost, less delivery time, and much more convenience; delivery drones are bound to succeed in making last-mile deliveries. The use of light materials in the device's design allows the quadcopter drone to fly fast to its goal. The drone is more stable, and it can also fly on its own and use GPS to return to its launch location. The quadcopter can deliver tiny items such as drugs, food and other supplies to remote locations. A consumer authentication framework is proposed to ensure a complete and reliable last-mile delivery through autonomous drones. Through the proposed consumer authentication framework, the drone first reaches the exact GPS location of a customer, it verifies the customer via a two-factor Authentication method which involves customer authentication via OTP. If the authentication is successful, it delivers the package otherwise it returns without delivering the package. The Contribution to Knowledge of this research includes: Combining delivery and photography functions into a single drone system presents significant design and operational challenges;

Optimizing the drone for both purposes without compromising performance in either area is complex and may result in trade-offs and finally, the proposed consumer authentication framework.

Declarations

Credit authorship contribution statement

Nwabueze: Conceptualization. Writing, original draft, Methodology Resources, and Project administration.
Ezeh, and Chukwu: Formal analysis, Data curation, Resources, and Project administration.

Declaration of competing interest

The authors declare no conflict of interest.

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