International Journal of Computer Sciences and Engineering
Vol.11, Issue.12, pp.09-15, December 2023
ISSN: 2347-2693 (Online)
Available online at: www.ijcseonline.org

Research Paper

A Quadcopter at Your Service-108 with Secure Delivery of Medicine

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Received: 03/Nov/2023; **Accepted**: 05/Dec/2023; **Published**: 31/Dec/2023. **DOI**: https://doi.org/10.26438/ijcse/v11i12.915

Abstract: Revolutionizing supply chain dynamics, medicine-carrying drones facilitate a stable vertical flight for seamless supply transfers to remote areas. Empowered by Ardupilot, an open-source Unmanned Vehicle Autopilot software suite, these drones showcase advanced flight control capabilities. GPS ensures precise navigation, while Mission Planner, intricately connected with MAVLink, optimizes quadcopter operations. The RFID-Arduino Nano interface secures the container housing medical resources. Post-compilation, the code dynamically runs, extracting RFID card serial numbers for heightened security. Exclusive access is granted solely to cards with designated UIDs, fortifying overall mission security and reliability. This abstract encapsulates a technological nexus, converging advanced flight systems and robust security measures, propelling medicine delivery to new frontiers with efficiency and precision.

Keywords: Unmanned aerial vehicle, ArduPilot, MAV, Mission Planner, RFID, UID, GPS.

1. Introduction

Our groundbreaking project is dedicated to revolutionizing emergency medicine supply to rural hospitals, ensuring swift response in critical situations to save lives. Leveraging advanced technology, our system integrates electronic speed control and a GPS module with a drone, covering an impressive range of 30 miles within a remarkable 15-minute delivery window. By feeding GPS coordinates at the transmitter end, our drone precisely navigates and lands at pre-marked locations, providing rapid, secure medicine delivery.

To enhance security and ensure the legitimacy of the recipient, our system employs a password-based verification process at the time of order placement. Upon delivery, the receiver gains access to the package by entering the designated password. Furthermore, to streamline communication and provide a seamless user experience, we've incorporated an acknowledgment button, allowing the recipient to confirm the successful reception of the package with a single click. This dual-layer authentication not only reinforces the integrity of our delivery system but also enhances user confidence in the reliability of our service.

This innovation is not just a technological marvel but a potential life-saver in remote health emergencies, aligning with the government's commitment to accessible healthcare. While the public healthcare system strategically places secondary and tertiary facilities in urban hubs, our project complements these efforts by focusing on rural areas through the establishment of Primary Healthcare Centres (PHCs). Our solution bridges the gap, offering a 108-emergency service equivalent for medicine supply, using cutting-edge drone technology to ensure timely and authenticated deliveries.

This visionary initiative aligns seamlessly with the government's commitment to modernizing healthcare services, offering a lifeline to those in need, especially in remote areas. Our project envisions a future where technology transforms emergency medicine delivery, underscoring the significance of efficient, tech-driven solutions in healthcare, echoing the success of the widely recognized 108 emergency services

2. Related Work

Andrew S. Hardy and Mohammed T. Rajeh [1] In their paper titled "**Design of the Life-ring Drone Delivery System for Rip Current Rescue"** explore the integration of drones in water rescue missions to enhance life-saving efforts. The authors specifically delve into the comprehensive design of a rescue system centered around drones. They prioritize lifeguard preferences in determining the most effective flotation device, with the ring buoy emerging as the optimal choice. Through simulations, their goal is to validate that the Life-ring Drone Delivery System (LDDS) effectively fulfills its mission of reducing fatalities by improving response times and increasing victims' survival chances before lifeguard intervention.

Xiaoli Wang and Aakanksha Chowdhery [2] In their study on **"Networked Drone Cameras for Sports Streaming,"**

address the challenge of effectively managing a network of drone cameras in real-time during live events, particularly high-action sports games on large fields. To tackle this issue, they introduce a fog-networking-based system architecture. This innovative approach enables the automatic coordination of drones equipped with cameras to capture and broadcast dynamically changing scenes in sports games. The centralized controller employs a predictive strategy, allowing for coordination and re-assignment at a slower timescale dictated by network roundtrip latencies. Meanwhile, the drones autonomously optimize their trajectories and video stream qualities. The evaluation of their proposed fog-networking solution demonstrates an optimized coverage-throughput trade-off, achieving 94% coverage and an average 2K video support at 20 Mbps in a network of eight drones, with four assigned for coverage and an additional four acting as relays.

Brad Hyeong-Yun Lee and James R. Morrison [3] In their paper titled **"Multi-UAV Control Testbed for Persistent UAV Presence: ROS GPS Waypoint Tracking Package and Centralized Task Allocation Capability**," explore the potential of unmanned aerial vehicles (UAVs) in providing uninterrupted services by seamlessly transferring mission responsibilities from fatigued UAVs to fresh counterparts. The key components developed for this purpose are the ROS GPS waypoint tracking package and the Centralized Task Allocation Network System (CTANS). The multi-UAV system they present boasts a centralized task allocation capability. Utilizing the ROS package and CTANS, the researchers successfully constructed and tested a prototype of the multi-UAV system, demonstrating its ability to execute mission handoffs. Future endeavours involve integrating the existing GPS tracking capability with vision-based tracking and further research on landing mechanisms onto recharge platforms.

Building upon the current state of the art, the authors harnessed the prowess of Unmanned Aerial Vehicles, specifically Quadcopters, to achieve their objectives. In this innovative endeavour, we elevate our approach by seamlessly integrating a Quadcopter with the sophisticated capabilities of Mission Planner software, marking a strategic advancement toward achieving our project's goals.

3. Theory

SYSTEM OVERVIEW

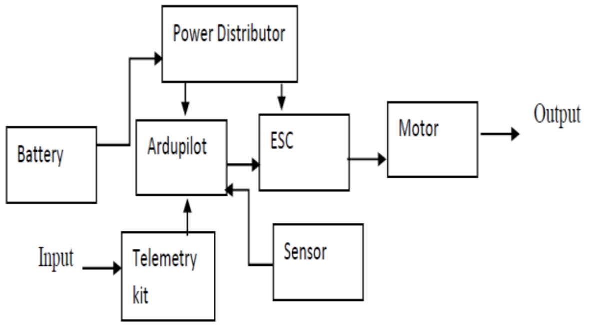

Figure 1. Block diagram of drone.

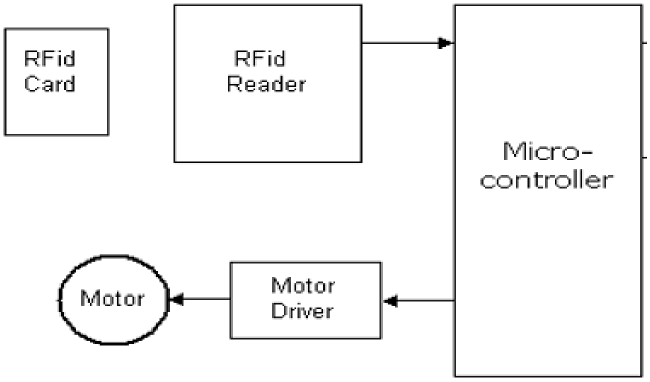

Figure 2. Block diagram of container lock

In our UAV system, the Telemetry Kit takes centre stage as a sophisticated digital two-way communication channel. This system not only transmits crucial flight data to the Mission Planner but also facilitates command flow to the autopilot. Leveraging a dedicated radio link, the Telemetry Kit ensures unparalleled reliability, serving as a secondary control system to enhance operational safety.

This Telemetry Kit seamlessly interfaces with the Ardupilot Flight Controller, a pinnacle of autonomous drone control. ArduPilot, an open-source software suite, endows our UAV with cutting-edge autopilot functionalities, enabling precise navigation and control.

Power distribution is orchestrated through a centralized power distributor, guaranteeing efficient energy supply to all drone components. Electronic Speed Controllers govern motor speeds, optimizing performance with a high degree of precision. The integration of microwave sensors adds a layer of sophistication, detecting obstacles and relaying real-time commands to the Ardupilot for enhanced situational awareness and adaptive responses.

At the core of our container lock system lies a circuit featuring an RFID reader intricately interfaced with Arduino. This three-part synergy involves a reader capturing RFID tag data, a controller processing this information, and a lock system responding accordingly. This technologically intricate landscape, spanning from advanced Telemetry Kits to Ardupilot control and RFID-based container security, underscores our commitment to pushing the boundaries of UAV innovation for heightened efficiency, reliability, and safety.

4. Experimental Method

HARDWARE IMPLEMENTATION DRONE IMPLEMENTATION

Within our project framework, we've seamlessly integrated an X frame Drone alongside a container featuring an innovative RFID-based locking and unlocking system. This dual implementation not only signifies our commitment to cutting-edge technology but also reflects our meticulous approach to ensuring both aerial and ground components work in tandem, elevating the overall efficiency and security of our solution.

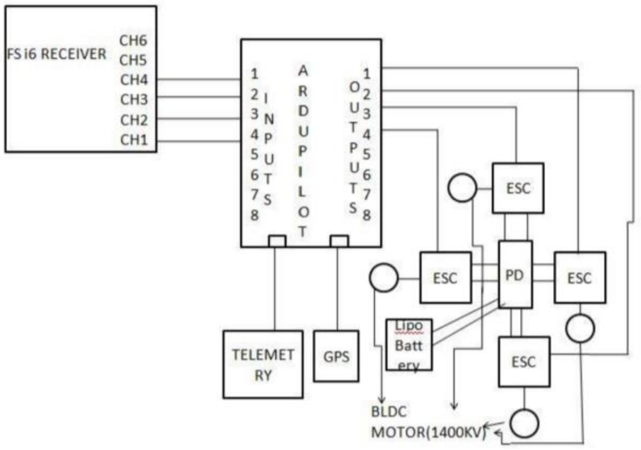

Figure 3. Circuit Diagram of Drone

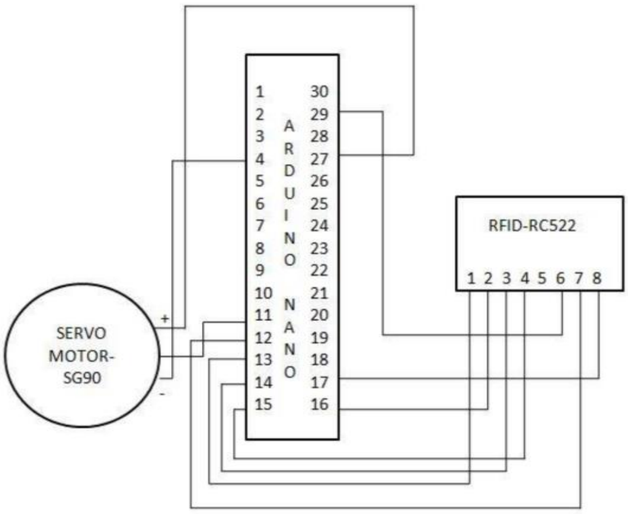

Figure 4. RFID Lock Circuit Diagram.

In Figure 1, the circuit diagram of our drone showcases a cutting-edge configuration, featuring the Ardupilot flight controller with the latest APM2.8 model. Boasting an in-built gyro meter, barometer, and GPS, it supports external GPS, utilizing a 3D GPS Compass for enhanced navigation. Our telemetry kit facilitates real-time location tracking and drone control, while the Fly Sky FS-i6 transmitter and receiver provide seamless radio control. The four channels of the transmitter intricately link to the flight controller's input pins (1 to 4), connecting to 30A Electronic Speed Controllers (ESCs) powering 1400kv BLDC motors. This setup optimizes performance with clockwise and anticlockwise rotations, ensuring precise maneuverability.

In Figure 2, the circuit diagram illustrates the integration of Arduino Nano with RFID technology and a servo motor for door lock control. The RFID reader interfaces with the Arduino Nano through meticulous pin connections, enabling secure data transmission. The servo motor, a nimble SG90, is strategically employed for locking and unlocking mechanisms. Its signalling pin intricately links to digital input 8 on the Arduino Nano, showcasing a sophisticated fusion of RFID technology and servo motor control to ensure the integrity and security of the container housing our advanced drone system.

SOFTWARE IMPLEMENTATTION DRONE IMPLEMENTATION

To execute the operational functionality of our quadcopter or drone, we've seamlessly integrated the Mission Planner software tool connected through MAV Link, facilitating program loading onto the drone. Mission Planner plays a pivotal role in this process, requiring comprehensive calibrations for arming the quadcopter successfully. The arming sequence is intricately outlined in the accompanying flow chart below, providing a systematic overview of the calibration steps essential to ensure optimal performance and readiness of the quadcopter for its designated tasks

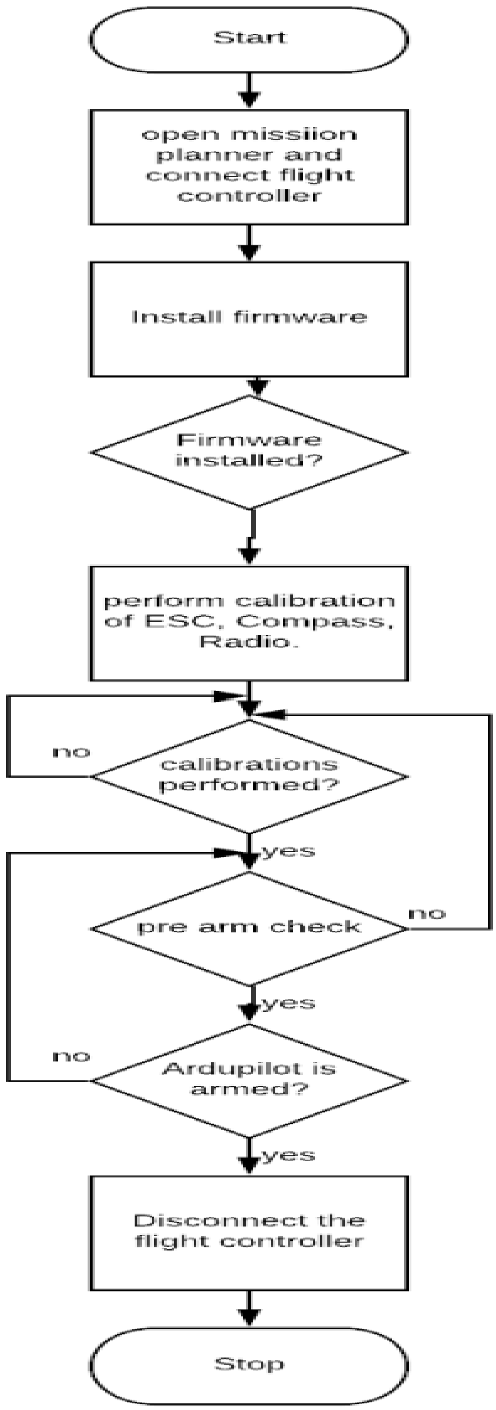

Figure 5. Flowchart.

Embarking on the intricacies of our quadcopter implementation, the process kicks off with the installation of firmware onto the wizard, a pivotal step that sets the foundation for our drone's intelligence. Choosing the X frame type from Mission Planner's array of options aligns with our project's specific demands for optimal performance.

Following this, the calibration phase unfolds, beginning with the critical GPS Compass calibration, ensuring precise orientation by systematically rotating the quadcopter in all directions. ESC calibration is a meticulous process involving safety precautions, disconnection from power sources, and a step-by-step check of each motor's direction and speed. This precise calibration ensures the ESCs synchronize seamlessly with the flight controller.

Radio calibration adds another layer of precision, setting throttle, pitch, roll, and yaw levels to ensure responsive and controlled flight dynamics. With these calibrations meticulously completed, connecting the battery to the Ardupilot marks the initiation of the final phases.

The Flight Plan feature in Mission Planner serves as a digital waypoint setter, allowing us to input precise latitude and longitude coordinates for the medicine delivery destination. This data is then loaded into the controller, configuring the quadcopter for the upcoming mission. The arming process follows, signifying that our drone is ready to take flight.

The amalgamation of cutting-edge technology, from GPS Compass calibration to ESC and radio calibration, propels our quadcopter into a state of precision and readiness. As we attach the propellers and execute our meticulously calibrated mission, the quadcopter takes flight, exemplifying the synergy of technical prowess and operational finesse in the field of advanced aerial systems for critical applications like medicine delivery

Figure 6. Firmware Installation.

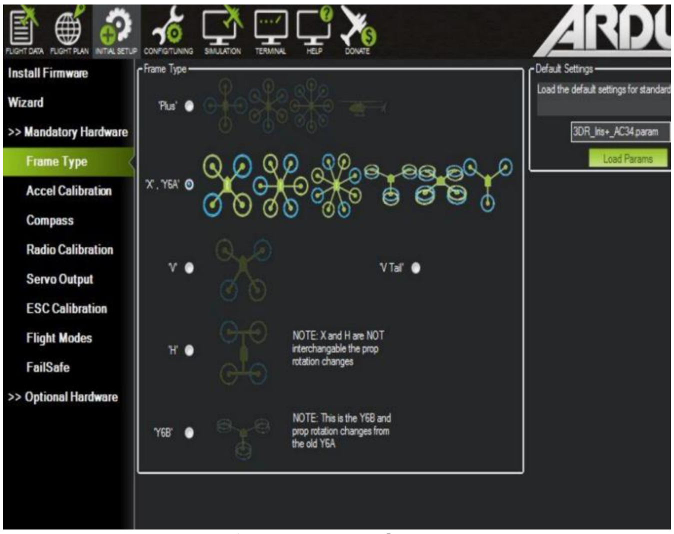

Figure 7. Frame selection.

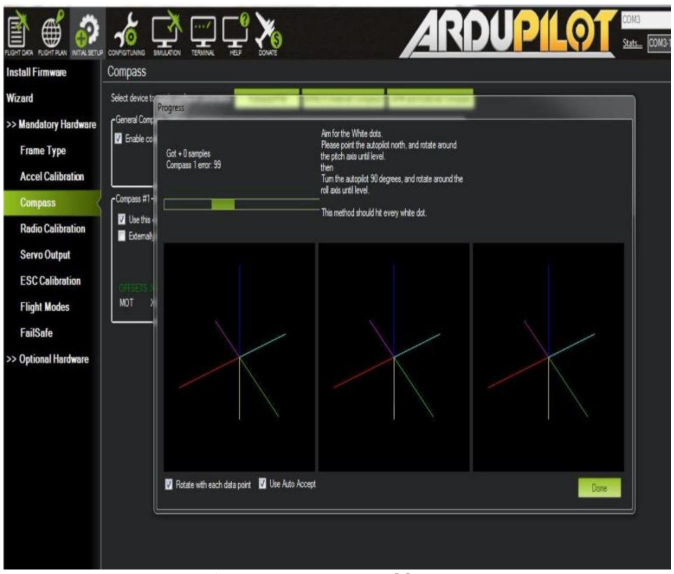

Figure 8. Compass Calibration.

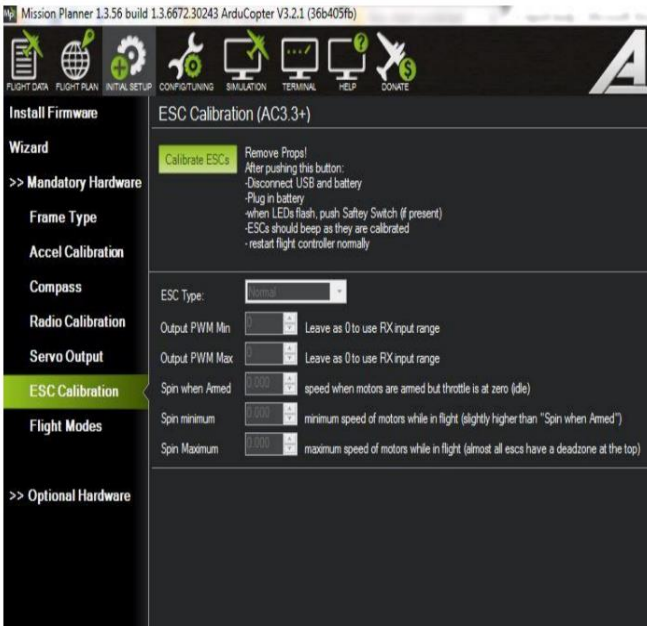

Figure 9. ESC Calibration.

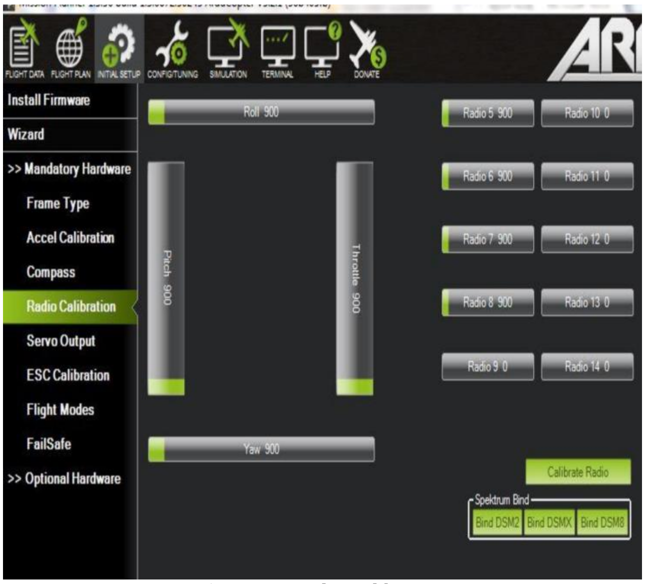

Figure 10. Radio Calibration.

Figure 11. Setting The Waypoints.

CONTAINER IMPLEMENTATION

In the code snippet depicted below, we unveil the intricate workings of our container system, where RFID seamlessly interfaces with Arduino Nano. The compilation process is a pivotal step, setting the stage for the operational prowess of our secure entry mechanism. Upon running the code, the RFID reader comes to life, ready to extract the unique serial number from any RFID card placed upon it.

What follows is a meticulous process of UID extraction, whereby the serial number is manually transcribed into the code. This strategic step ensures that only RFID cards bearing the specified UID are granted access to open the container door. It's a sophisticated fusion of technology and security, where the minutiae of RFID data become the key to unlocking the door.

This two-fold process, from code compilation to UID verification, establishes an impregnable layer of security, reinforcing our commitment to controlled access. By delving into the intricacies of code execution and UID validation, we fortify the container system's capability to discern and authorize only those RFID cards that align with the pre-defined access criteria.

RFID_Door_Lock_ino | Arduino 1.8.5

File Edit Sketch Tools Help

RFID_Door_Lock_ino

```
  if ( ! mfrc522.PICC_IsNewCardPresent())
  {
    return;
  }
  // Select one of the cards
  if ( ! mfrc522.PICC_ReadCardSerial())
  {
    return;
  }
  //Show UID on serial monitor
  Serial.print("UID tag :");
  String content= "";
  byte letter;
  for (byte i = 0; i < mfrc522.uid.size; i++)
  {
     Serial.print(mfrc522.uid.uidByte[i] < 0x10 ? " 0" : " ");
     Serial.print(mfrc522.uid.uidByte[i], HEX);
     content.concat(String(mfrc522.uid.uidByte[i] < 0x10 ? " 0" : " "));
     content.concat(String(mfrc522.uid.uidByte[i], HEX));
  }
  Serial.println();
  Serial.print("Message : ");
  content.toUpperCase();
  if (content.substring(1) == "D1 F6 E5 2D") //change here the UID of th
  {
    Serial.println("Authorized access");
    Serial.println();
    delay(500);
    digitalWrite(LED_G, HIGH);


    tone(BUZZER, 500);
    delay(300);
    noTone(BUZZER);
    myServo.write(180);
    delay(5000);
    myServo.write(0);
    digitalWrite(LED_G, LOW);
  }

 else   {
    Serial.println(" Access denied");
    digitalWrite(LED_R, HIGH);
    tone(BUZZER, 300);
    delay(1000);
    digitalWrite(LED_R, LOW);
    noTone(BUZZER);
  }
}
```

Figure 12. ARDUINO Code for Container

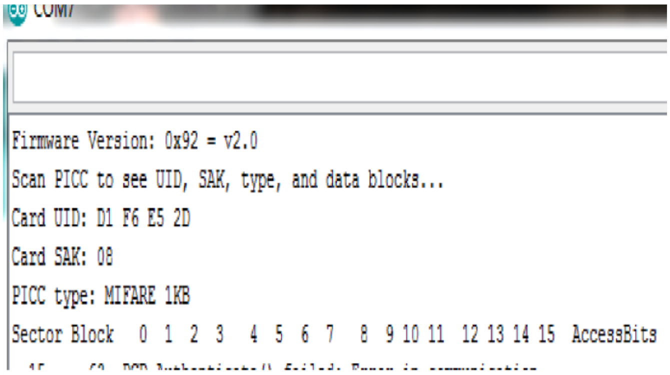

Figure13. RFID Card UID

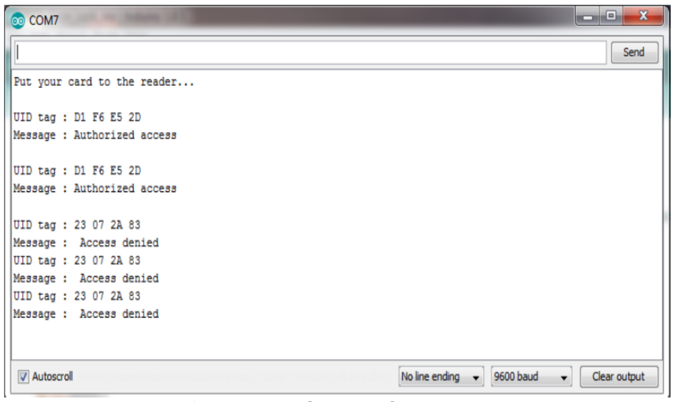

Figure 15. Authenticated Container.

4. Result

Achieving the "ARMED" status in the Mission Planner represents the successful culmination of meticulous calibrations, signifying the quadcopter's readiness for flight. However, the true experiment's outcome remains pending, as the system's efficacy will be thoroughly tested in real-world conditions during the mission execution. The container authentication, driven by RFID verification, sets the foundation for secure access, awaiting validation during the live experiment. As the quadcopter takes flight, the technical intricacies of its armed status and RFID authentication will be put to the ultimate test, providing critical insights into the system's performance, reliability, and the seamless coordination between airborne capabilities and ground-based security measures. The impending experiment serves as the crucible for unveiling the system's operational prowess and authentication effectiveness. The true efficacy and performance of the system will be revealed during the upcoming experimental phase, providing valuable insights into its operational capabilities and authentication mechanisms.

Figure 14. Armed Quadcopter.

5. Equation

Guided by a specialized mathematical formula, we embark on a technical journey to elevate our drone's capabilities. This dynamic algorithm becomes the linchpin for systematic enhancements, and fine-tuning variables for optimal performance. From extending flight durations to amplifying payload capacities and refining power efficiency, each calculated adjustment propels our drone into heightened realms of technological prowess. This mathematical framework isn't just a formula; it's a dynamic tool, ensuring our drone remains on the cutting edge of unmanned aerial systems, continuously evolving to meet the demands of an ever-changing technological landscape.

$$t = \eta \times (60/100) \times [(c \times v_n) \div ((4p_m) + p_e)] \text{ mins}$$

where,

t = Flight Time

c = Battery Capacity in mah

Vn = Battery voltage in V(nominal)

Pm = Power of Individual motor

Pe = Power required for Flight Controller

η = Efficiency Factor

$$\text{Torque} = \text{Motor Kv} \times \text{Battery Voltage(RPM)}$$

6. Conclusion and Future Scope

Our Quadcopter, a pinnacle of automotive and UAV integration, establishes itself as a cost-effective paradigm in contrast to global courier service drones such as Zipline and Amazon Prime. Its compact and lightweight architecture, housing integrated electronic speed controllers and sensors, underscores efficiency in swift deliveries with minimal power utilization. Despite an initial 5-minute battery lifespan, the inventive propeller mechanism engages mid-air, substantially augmenting operational endurance. Incorporating a robust RFID lock system for password protection on the medicine container adds a sophisticated layer of security, ensuring unparalleled product authenticity. This amalgamation of technological prowess in efficiency and security solidifies our drone's position as a trailblazer in the ever-evolving domain of autonomous delivery systems.

The prototype showcases a future-ready design, demonstrating exceptional compatibility with upcoming applications, particularly in time-sensitive scenarios necessitating rapid medicine delivery. Its adaptability is not only promising for the present but positions it as a potential disruptor in emergency services with strategic enhancements. In an era where companies are actively pioneering automated drone solutions for medicine delivery in remote areas, our prototype emerges as a beacon of innovation. Envisioning a future where automated drones seamlessly navigate and deliver medicines to the most inaccessible regions; the prototype underscores its reliability and transformative potential in revolutionizing emergency healthcare services. Its fusion of cutting-edge technology and adaptability positions it as a pivotal player in shaping the landscape of futuristic, automated medicine delivery solutions.

CONFLICT OF INTEREST
I declare that there is no conflict of interest about the project discussed.

FUNDING SOURCE
The project, currently self-funded, necessitates further experimentation to validate and refine its findings, and additional funding is sought to support the next phase of research and development.

AUTHOR's CONTRIBUTION
All authors contributed to the conceptualization of the project, outlining the goals and objectives and in the preparation of the manuscript, contributing to the drafting, review, and editing processes.

Author 1 - Actively participated in the design and development of the medicine-carrying drone system, including the integration of Ardupilot, GPS, and RFID technologies, and was involved in implementing the software aspects of the project, utilizing tools such as Mission Planner and Arduino Nano for effective control and security measures. Author 2 - provided supervision and guidance throughout the project, overseeing its progress and ensuring alignment with the project's objectives.

ACKNOWLEDGEMENT
This project has been a culmination of collaborative efforts and unwavering support from various individuals and resources, and I express my sincere gratitude to all who contributed to its realization. I extend my deepest appreciation to Dr. Minavathi for her invaluable guidance, mentorship, and insightful contributions throughout the project. Her expertise and commitment played a pivotal role in shaping the project's success.

Special thanks to AbhiRam and Harish for their technical expertise, support, and constructive feedback that enriched the project. This project stands as a testament to the collective efforts and collaboration of these individuals, and I am truly grateful for their contributions

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AUTHOR'S PROFILE

MS. Gokula G, a dedicated professional, holds a Bachelor's degree in Electronics and Communication Engineering. she has exhibited a keen interest in research and innovation. She worked as a Research Assistant under the expert guidance of Dr. Minavathi at PES Engineering College. This invaluable experience laid the foundation for her deep dive into the realms of academia and research. She marks her debut in scholarly publications with this paper, showcasing her commitment to advancing knowledge in the field.

Dr. Minavathi is currently working as Professor and HOD in Department of Information Science and Engineering, PES College of Engineering, Mandya. She has completed her Doctor of Philosophy and have been guiding for research scholars from the past 9 years. she has published more than 35 research papers in peer reviewed journals and international conferences. Her area of interest are Medical Image processing, IOT, Machine Learning, Network and cyber security.

