

A Comprehensive Exploration of Medical Drones for Rapid Response and Patient Care



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Abstract This paper presents the design and implementation of an autonomous drone system tailored for the efficient delivery. First aid kits to locations requiring urgent medical assistance. Leveraging advanced navigation algorithms and sensor technologies, the drone identifies emergency situations promptly and navigates to the precise location indicated. Equipped with essential medical supplies, it serves as a crucial first responder in various scenarios, such as accidents, natural disasters, or remote areas lacking immediate medical access. Through rigorous testing and validation procedures, the reliability, efficiency, and safety of the autonomous drone system are demonstrated. Collaboration with healthcare professionals, emergency services, and regulatory authorities ensures compliance with applicable standards and regulations governing unmanned aerial vehicles. This innovative solution promises to significantly enhance emergency response protocols, ultimately saving lives and mitigating the impact of critical situation.

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1 Introduction

Effective first aid delivery in emergency scenarios is paramount for mitigating the severity of injuries and saving lives. Traditional methods of first aid delivery are often hampered by logistical challenges, such as traffic congestion and inaccessible terrain. To address these limitations, we introduce an innovative solution: an autonomous drone system designed specifically for the swift and efficient delivery of first aid kits to locations in need. Leveraging advanced navigation saving equipment, the drone serves as a crucial first algorithms and sensor technologies, our drone system autonomously identifies emergency situations and navigates to precise locations indicated for assistance. Equipped with essential medical supplies, including bandages, medications, and life-saving equipment, the drone serves as a crucial first responder, significantly reducing response times and enhancing the effectiveness of emergency medical interventions. This paper outlines the design, implementation, and validation of our autonomous drone system, offering a promising solution for improving emergency response protocols and saving lives.

2 Literature Review

Novel developments in drone technology have attracted considerable attention in its use in emergency medical services such as the quick delivery of first aid kits to location that need medical attention. Ganesan and Mokayef [1] have conducted studies that reveal the autonomous drones capabilities such as employing advanced navigation algorithms and sensor technologies and the ability to recognize emergency circumstances and navigate to assistance locations. More recently, contributions such as those by Smith et al. [2] and Brown and Jenkins [3] have focused on optimizing the drone network for faster delivery of medical supplies during emergencies. With drones containing essential medical supplies including bandages and Automated External Defibrillators (AEDs), it makes them key first responders in cases of accidents, natural disasters, and in remote areas where immediate medicare is not available.

All academic studies, including the one conducted by Majd et al. show that autonomous drones are reliable, effective, and safe due to the thorough testing and validation processes they went through. Further, these autonomous drones are coordinated with doctors, first responders, and regulators in order to ensure that unmanned drones are safely integrated into existing emergency response systems. As Benson et al. [4] pointed out, the integration and use of drones for medical emergencies still faces significant issues such as technical limitations and legal restrictions. Still, the

inventive approaches presented by these autonomous drone systems offer greater benefits through improving the response mechanisms to critical medical emergencies, therefore increasing survival rates. This research aims to provide solutions to the integration of drone technology and the modern day demand for efficient medical response. Further literature [5–15] provided concepts about practical issues, design principles, and innovative technologies in medical drones that informed our development of the proposed system.

3 Components Hardware

The main hardware components of this drone are:

- S500 Drone Frame
- Cubepilot orange flight controller
- HereLink Air controller
- HereLink Air unit
- Here3 + GPS Module
- Electronic flight controllers
- 1000 kV motors
- 3300 mAh Li-Po Battery
- Buck converter
- Safety switch
- Xt-60 connectors
- Male banana bullets
- Buzzer

3.1 *S500 Drone Frame*

The S500 Carbon Fiber Quadcopter Drone Frame Kit is a high-quality frame made from carbon fiber material. It comes with landing gear and a pre-installed power distribution board. The frame is easy to assemble and durable, with ultra-durable Polyamide-Nylon arms that resist breakage during hard landings. The S500 design includes support ridges for stability and faster forward flight.

3.2 *Cubepilot Orange Flight Controller*

The HereLink is an integrated remote controller, ground station, and wireless digital transmission system. It's designed for use with the Cube Autopilot, Ardupilot, or PX4. The HereLink allows RC control, HD video transmission, and telemetry data up to 20 km between the ground station and air unit.

3.3 3300 mAh Li-Po Battery

The 3300 mAh Li-Po Battery powers your drone, providing the necessary energy for flight. Known for their high energy density and lightweight design, Li-Po batteries offer extended flight times and quick recharging capabilities, ensuring long-lasting performance during your aerial missions.

3.4 HereLink Air Unit

The HereLink Air Unit acts as the communication bridge between the controller and the drone, facilitating seamless transmission of commands and telemetry information. Its robust connectivity and low-latency performance ensure responsive control and reliable data exchange, even in challenging environments. With easy setup and compatibility with a wide range of drones.

3.5 Here3 + GPS Module

The Here3 + GPS Module provides high-precision positioning data for your drone project. Its advanced features include dual-frequency RTK technology for accurate positioning in challenging environments, making it ideal for professional applications. With its compact size and lightweight design, it integrates seamlessly into your drone system, ensuring reliable navigation during flight.

3.6 Electronic Flight Controllers

Electronic flight controllers serve as the brain of your drone, processing sensor data and sending commands to the motors for stable flight. Equipped with gyroscopes, accelerometers, and other sensors, these controllers offer precise control and stabilization, essential for smooth aerial maneuvers and autonomous operation.

3.7 1000 kV Motors

1000 kV motors are commonly used in drone propulsion systems, offering a balance between power and efficiency. With their high RPM and torque output, these motors provide sufficient thrust to lift your drone off the ground and maintain steady flight, making them suitable for various drone sizes and payloads.

3.8 Power Module 7 V

A 7 V power module for drones is a vital component that manages and supplies stable electrical power to various drone parts, ensuring efficient operation. It accepts an input voltage, typically from a 2S LiPo battery, and regulates it to a consistent output, often 5 V, to power the flight controller, GPS, and other electronics. Key features include current sensing, battery monitoring, and protection against overvoltage, overcurrent, and short circuits. The module relays telemetry data to the flight controller for real-time monitoring, enhancing safety and performance. Its compact, lightweight design allows for easy integration within the drone's limited space, making it essential for reliable and safe flight operations.

3.9 Safety Switch

A Safety switch acts as a failsafe mechanism, allowing you to power on/off your drone safely. With its easy-to-access design, the safety switch helps prevent accidental activation and minimizes the risk of mishaps during flight preparations.

3.10 Xt-60 Connectors

Xt-60 connectors provide a reliable and secure connection between the battery and electronic components of your drone. Known for their high current handling capacity and robust construction, Xt-60 connectors minimize power loss and ensure efficient energy transfer, enhancing the overall performance of your drone system.

3.11 *Male Banana Bullets*

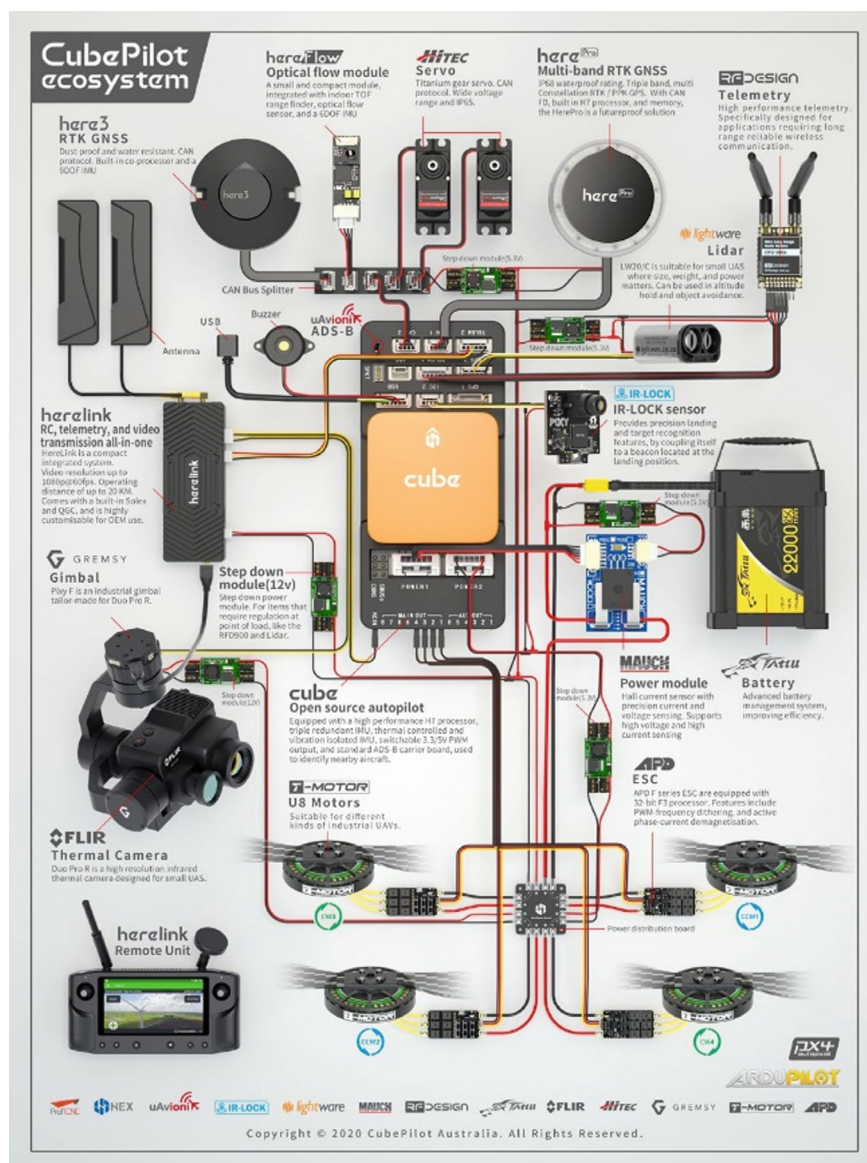
Male banana bullets are commonly used connectors for linking electronic speed controllers (ESCs) to the motors. With their simple plug-and-play design and secure connections, male banana bullets facilitate quick and hassle-free setup of your drone propulsion system, enabling smooth operation and easy maintenance.

3.12 *Buzzer*

A Buzzer serves as an audible alarm system, providing real-time feedback and alerts during flight. With its compact size and loud sound output, the buzzer notifies you of critical events such as low battery voltage or signal loss, helping you to take prompt action and ensure the safety of your drone.

4 Circuit Diagram

The quadcopter drone's intricate circuitry is meticulously designed around its central processing unit, the Pixhawk Flight Controller, which serves as the neural hub of the entire system. Its multifaceted functionalities include the processing of sensor data from an array of sensors like accelerometers, gyroscopes, and barometers, enabling precise control over the drone's movements and flight characteristics. This crucial component not only interprets user commands from the RC transmitter and receiver but also orchestrates the Electronic Speed Controllers (ESCs) to adjust motor speeds dynamically.



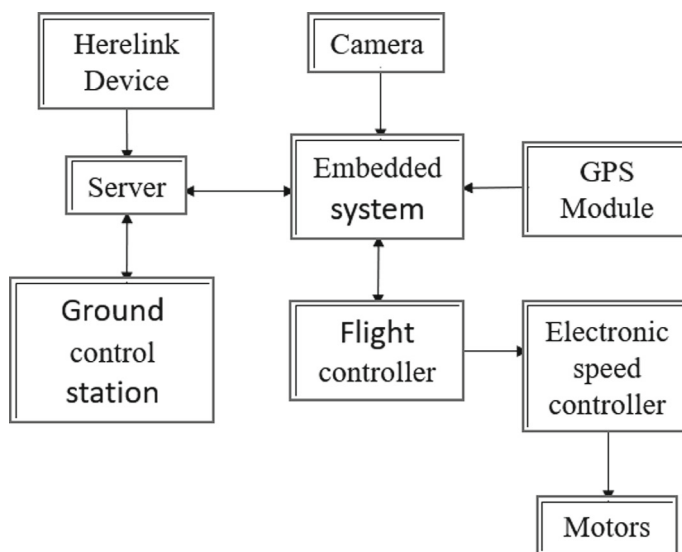
Additionally, the Pixhawk manages various flight modes, offering versatility in performance ranging from stabilized flight to autonomous waypoint navigation. Connected to the Pixhawk are an array of indispensable components that collectively contribute to the drone's seamless operation. The GPS Module (Here3+) provides indispensable positioning data, allowing for accurate navigation and precise waypoint tracking. Telemetry Radios establish a vital communication link with the ground

station, facilitating real-time data transmission, telemetry updates, and mission planning. Meanwhile, the Power Module serves as the backbone, regulating and supplying power to the entire drone system, ensuring consistent and reliable performance. Electronic Speed Controllers (ESCs) work in tandem with the flight controller to regulate motor speeds, translating electrical signals into mechanical thrust for controlled flight. Motors with a specific KV rating (1000 kV) provide the necessary lift force, allowing the drone to ascend, descend, and maneuver with agility. The Li-Po Battery (3300 mAh) acts as the energy source, powering all components of the drone during flight operations, while a Buck Converter ensures that voltage levels remain within safe operating limits, safeguarding sensitive electronics from damage.

Additionally, a Safety Switch enhances operational safety by providing a means for arming and disarming the drone, preventing accidental activation of the motors. XT-60 Connectors and Male Banana Connectors ensure secure electrical connections, minimizing the risk of power loss or disconnection during flight. A Buzzer provides audible alerts, signaling critical events such as low battery voltage or system errors, enhancing situational awareness for the pilot. Furthermore, an I2C Splitter expands the drone's capabilities by enabling the integration of additional sensors or peripherals, broadening its range of functionalities. Interfaces for a Gimbal and Camera allow for the seamless integration of aerial photography or videography equipment, providing stabilized footage during flight. Lastly, an RC Transmitter and Receiver System afford the pilot manual control over the drone, enabling precise maneuvering and control overrides when necessary. Together, these meticulously interconnected components form a robust and reliable system, working in harmony to deliver stable, controlled flight operations for the quadcopter drone across a diverse range of applications and environments.

5 Methodology

The drone's operational methodology epitomizes the convergence of cutting-edge technology and humanitarian aid. In a paradigm shift from conventional manned aerial deliveries, this drone operates autonomously, alleviating the need for constant manual control. However, human intervention is crucial during the initial stages, particularly for takeoff, where a pilot initiates the drone's ascent. Once airborne, the drone seamlessly transitions into autonomous mode, guided by a sophisticated system of GPS navigation. This technology ensures precise and efficient traversal of predetermined flight paths, guaranteeing optimal safety and reliability.



A distinctive feature of this drone is its payload, a specialized medical container securely affixed atop its structure. This container serves as a lifeline, ferrying vital medical supplies to remote or inaccessible locations swiftly and efficiently. The integration of a medical payload underscores the drone's potential in augmenting emergency response efforts, particularly in regions with limited infrastructure or during crisis situations.

The operational workflow commences with signal transmission from a dedicated smartphone application to a centralized server. This signal, augmented by GPS coordinates, serves as the blueprint for the drone's journey. At the Ground Control Station (GCS), operators meticulously monitor and interpret incoming signals, ensuring seamless coordination between the drone and the server. These signals relay crucial information, including flight instructions and destination coordinates.

Central to the drone's mission is the delivery of medical aid to individuals in need. This process begins with the transmission of GPS coordinates representing the patient's location to the server. Upon receipt, the server orchestrates the drone's flight path, guiding it towards the designated destination. The drone autonomously adjusts its trajectory, ensuring precise alignment with the patient's coordinates. Upon arrival, the medical payload is deployed, providing timely assistance to those in need.

In summary, the drone's operational methodology embodies a fusion of technological innovation and humanitarian imperative. By leveraging autonomous flight capabilities and GPS navigation, it heralds a new era in emergency medical delivery, promising swift and efficient aid delivery to underserved communities worldwide.

6 Results

The project attains a significant milestone with the successful deployment of an autonomous drone, reshaping the landscape of medical supply delivery within the confines of a college environment. Through meticulous planning and innovative engineering, the drone seamlessly navigates its surroundings, offering a glimpse into the future of healthcare logistics. Operated autonomously, it acts as a dependable intermediary, bridging the gap between medical facilities and remote or inaccessible areas. The drone's swift response to requests for medical supplies highlights its efficiency and adaptability in meeting urgent healthcare needs. Its autonomous operation ensures seamless execution, minimizing human intervention and maximizing operational efficiency. Guided showcasing its agility and reliability in dynamic environments.





The successful deployment of the drone within the college setting signifies a paradigm shift in healthcare delivery, demonstrating the transformative potential of unmanned aerial vehicles. By streamlining the delivery process, the drone optimizes resource utilization and reduces reliance on traditional transportation methods. Its ability to operate autonomously enhances accessibility to medical supplies, particularly in emergency situations where time is critical. Moreover, the drone's seamless execution ensures the timely delivery of critical supplies, mitigating the risk of delays and improving patient outcomes. As the drone continues to evolve and expand its capabilities, its potential to revolutionize healthcare logistics on a broader scale becomes increasingly evident.

7 Conclusion

It contributes to the broader goal of societal welfare. Through its innovative approach and commitment to improving medical response capabilities, the project exemplifies the potential of interdisciplinary collaboration to address pressing healthcare challenges and ultimately make a positive impact on the well-being of communities.

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