IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⋇ Peer-reviewed & Refereed journal ⋇ Vol. 15, Issue 4, April 2026

DOI: 10.17148/IJARCCE.2026.154275

A Secure and Intelligent Drone-Based Healthcare Logistics System with Real-Time IoT Monitoring

Dr. V. Ponniyinselvan[1], R. Srihariharan[2], S. SuryaPrakash[3], S. Poovarasan[4], K. Sandhuru[5]

Professor, Dept. of Electronics and Communication Engineering (ECE),

Mahendra College of Engineering, Salem, Tamil Nadu[1]

UG Students, Dept. of Electronics and Communication Engineering (ECE),

Mahendra College of Engineering, Salem, Tamil Nadu[2,3,4,5]

Abstract: The rapid advancement of drone technology has enabled transformative applications in healthcare, particularly for delivering medical supplies to remote and emergency-affected regions. Conventional transportation systems often suffer from delays due to traffic congestion, inadequate infrastructure, and geographical constraints, limiting timely access to critical resources. This paper proposes a Smart Drone-Based Medical Supply Delivery System integrated with Internet of Things (IoT) technology to enable efficient, secure, and real-time logistics. The proposed system employs GPS-based navigation for autonomous routing, environmental sensors for payload condition monitoring, and wireless communication modules for continuous data transmission. A secure authentication mechanism is incorporated to ensure that only authorized personnel can access delivered medical packages. The system architecture is designed to enhance delivery reliability, minimize response time, and ensure payload safety under varying environmental conditions. Experimental evaluation demonstrates improved delivery efficiency and reduced latency compared to conventional methods, highlighting its potential to enhance healthcare accessibility in critical and time-sensitive scenarios.

Keywords: Unmanned Aerial Vehicle (UAV), Internet of Things (IoT), Medical Supply Delivery, Real-Time Monitoring, Secure Authentication, GPS Navigation, Smart Healthcare System.

I. INTRODUCTION

The rapid advancement of drone technology has significantly expanded its applications across various domains, particularly in healthcare. Unmanned Aerial Vehicles (UAVs) offer a promising solution for efficient and rapid transportation due to their autonomous operation, flexibility, and ability to access geographically challenging regions. These features make UAVs highly suitable for time-critical medical applications where conventional transportation systems often fail to deliver timely services.

In many rural and remote areas, inadequate infrastructure, traffic congestion, and long travel distances pose serious challenges to the delivery of essential medical supplies. Delays in transporting medicines, vaccines, blood samples, and emergency equipment can lead to severe consequences, especially in critical situations. UAV-based delivery systems address these limitations by enabling fast, reliable, and on-demand logistics, thereby improving healthcare accessibility and response time.

The significance of drone-assisted healthcare logistics was further highlighted during the COVID-19 pandemic, where contactless and rapid delivery of medical supplies became essential. UAVs were effectively utilized for transporting diagnostic samples, personal protective equipment, and vaccines, minimizing human interaction and reducing the risk of infection transmission.

Despite these advantages, several challenges remain, including safe navigation, real-time monitoring, payload security, limited carrying capacity, and regulatory constraints. Existing systems often lack integrated solutions for continuous tracking, environmental monitoring, and secure access control, which are critical for reliable medical delivery.

To address these challenges, this paper proposes a Smart Drone-Based Medical Supply Delivery System integrated with Internet of Things (IoT) for real-time tracking, environmental sensing, and secure authentication. The proposed system aims to enhance delivery efficiency, ensure payload safety, and provide a reliable and scalable solution for healthcare logistics in critical and remote environments.

DOI: 10.17148/IJARCCE.2026.154275

II. LITERATURE REVIEW

Recent advancements in drone technology have significantly influenced healthcare logistics, particularly in improving the delivery of medical supplies to remote and underserved regions. Chowdhury and Rahman [2025] demonstrated that Unmanned Aerial Vehicles (UAVs) can effectively transport critical medical resources such as vaccines, blood units, and emergency drugs, thereby reducing delivery time and overcoming infrastructural limitations. Their findings highlight the potential of drones to ensure timely medical intervention in geographically challenging environments.

Further enhancements in drone-based healthcare systems have been achieved through the integration of intelligent technologies. Kim et al. [2025] proposed an optimized drone routing model incorporating artificial intelligence, GPS navigation, and real-time data analytics to improve delivery precision and operational efficiency. Their approach enables dynamic route selection based on environmental conditions and urgency, significantly improving reliability and cost-effectiveness.

Practical implementations of drone delivery systems have been demonstrated by Zipline [2024], which successfully deployed UAVs for transporting blood, vaccines, and essential medicines in difficult terrains. Their real-world results indicate a substantial reduction in delivery time—from hours to minutes—thereby enhancing emergency response and patient outcomes.

In addition to routine logistics, drones have proven highly effective in emergency and disaster management scenarios. Rosser et al. [2024] analyzed UAV applications in emergency healthcare, emphasizing their ability to deliver first-aid kits and medical equipment rapidly in disaster-affected areas. Similarly, Singh and Sharma [2024] highlighted the critical role of drones during the COVID-19 pandemic, where contactless delivery of diagnostic samples, vaccines, and personal protective equipment ensured uninterrupted healthcare services while minimizing infection risks.

The feasibility and reliability of drones for transporting sensitive medical materials have also been investigated. Amukele et al. [2023] evaluated the impact of drone flights on blood sample integrity and reported no significant degradation, confirming the suitability of UAVs for diagnostic logistics. However, despite these advancements, several challenges persist. Gupta and Verma [2023] identified key limitations, including regulatory constraints, payload restrictions, weather dependency, and airspace management issues, which hinder large-scale deployment.

From the existing literature, it is evident that while significant progress has been made in drone-based medical delivery, most systems lack integrated solutions for real-time monitoring, environmental sensing, and secure access control. Therefore, there is a need for a comprehensive system that combines IoT-based tracking, intelligent monitoring, and secure authentication to ensure safe, reliable, and efficient medical supply delivery. This research aims to address these gaps by proposing an IoT-enabled smart drone system tailored for healthcare logistics.

III. PROPOSED SYSTEM

The proposed system presents an IoT-enabled Smart Drone-Based Medical Supply Delivery Framework designed to ensure efficient, reliable, and secure transportation of critical healthcare resources. The system utilizes Unmanned Aerial Vehicles (UAVs) to deliver essential medical supplies, including medicines, vaccines, blood units, and diagnostic samples, from healthcare centers to remote and emergency locations. The primary objective is to minimize delivery latency, enhance accessibility, and provide timely medical assistance in regions with limited transportation infrastructure.

The overall system architecture comprises three key modules: Central Control Unit (CCU), UAV (Drone) Unit, and Ground Station Module. The CCU is responsible for mission scheduling, route optimization, and real-time monitoring using cloud-based or embedded control software. The UAV unit is equipped with GPS modules for navigation, environmental sensors (temperature, humidity, and altitude) for payload monitoring, and wireless communication interfaces (such as GSM/LoRa/Wi-Fi) for real-time data transmission. Ground stations, deployed at hospitals or medical centers, act as dispatch and delivery points, ensuring seamless coordination within the network.

To improve operational efficiency, the system incorporates an intelligent routing and scheduling mechanism that determines optimal flight paths based on distance, environmental conditions, and delivery priority. A priority-based scheduling algorithm is implemented to ensure that emergency medical supplies are delivered with minimal delay. Real-time monitoring enables continuous tracking of drone position and system parameters, allowing dynamic decision-making during flight operations.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁞ Peer-reviewed & Refereed journal ⁞ Vol. 15, Issue 4, April 2026

DOI: 10.17148/IJARCCE.2026.154275

The proposed system also emphasizes security and reliability. A secure authentication mechanism is integrated to restrict access to authorized personnel during payload retrieval. The UAV is designed with a protected payload compartment to maintain the integrity of sensitive medical supplies. Additionally, multiple safety features, including obstacle avoidance sensors, automatic return-to-home functionality, and fail-safe landing mechanisms, are incorporated to handle system failures and adverse environmental conditions.

Compared to existing approaches, the proposed system uniquely combines IoT-based real-time monitoring, intelligent routing, and secure access control within a unified framework. This integration enhances delivery efficiency, ensures payload safety, and improves overall system reliability. The proposed solution offers a scalable and cost-effective approach to modern healthcare logistics, with the potential to significantly reduce response time and improve medical service accessibility in critical and underserved regions.

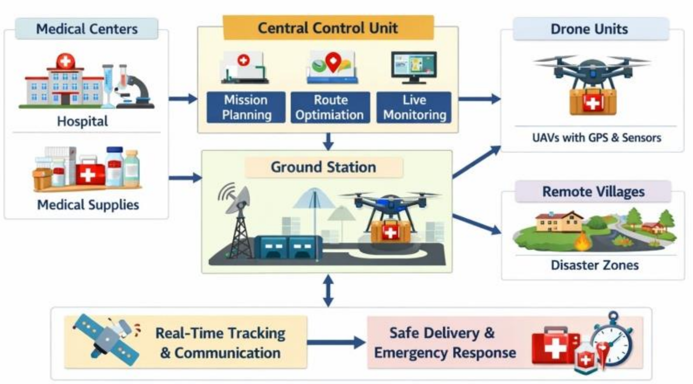

Fig. 1 Drone-Based Medical Supply Delivery System

IV. METHODOLOGY

The proposed methodology is based on the integration of Unmanned Aerial Vehicles (UAVs) with intelligent logistics and communication systems to enable efficient medical supply delivery. The framework is structured into multiple phases, including system design, route optimization, real-time monitoring, safety assurance, and performance evaluation.

In the initial phase, system requirements are defined by considering parameters such as payload capacity, flight range, environmental constraints, and types of medical supplies. Data related to delivery locations, distance, and urgency levels are collected from healthcare centers to develop an optimized delivery framework capable of handling both routine and emergency requests.

In the second phase, UAV units are designed and configured with GPS modules, environmental sensors (temperature, humidity, altitude), and wireless communication interfaces. A Central Control Unit (CCU) is implemented to manage mission scheduling, route planning, and system monitoring. Ground stations are established at healthcare facilities to facilitate dispatch and delivery operations.

The third phase focuses on route optimization, where intelligent algorithms are applied to determine the most efficient and safe flight paths. The routing mechanism considers multiple parameters, including distance, weather conditions, obstacle presence, and delivery priority. A priority-based scheduling approach is incorporated to ensure that emergency medical deliveries are handled with minimal delay.

In the fourth phase, real-time monitoring and communication are implemented using GPS-based tracking and continuous data transmission. The system enables live tracking of UAV position and operational status, allowing dynamic decision-making in case of route deviation or system anomalies. Communication between UAVs and the CCU ensures coordinated and reliable operation.

The fifth phase addresses safety and security mechanisms. UAVs are equipped with obstacle avoidance sensors, fail-safe control systems, and secure payload compartments to maintain the integrity of medical supplies. Additional features such as automatic return-to-home (RTH) and emergency landing protocols are incorporated to handle failures and adverse environmental conditions.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 15, Issue 4, April 2026
DOI: 10.17148/IJARCCE.2026.154275

Finally, the system is evaluated using performance metrics such as delivery time, cost efficiency, reliability, and delivery accuracy. A comparative analysis with conventional transportation methods is conducted to assess system effectiveness. The evaluation results are used to validate the proposed approach and demonstrate its scalability for real-world healthcare logistics applications.

a. Proposed Algorithm: Smart Drone-Based Medical Supply Delivery

Algorithm 1: IoT-Enabled UAV Medical Delivery System
Input:
Delivery Requests R, Drone Set D, Location Data L, Weather Data W, Priority Levels P
Output:
Optimized Delivery Schedule and Safe Medical Supply Delivery

Step 1: Initialize system parameters and establish connection with Central Control Unit (CCU).
Step 2: Collect delivery request data Ri∈R including location, payload type, and priority level.
Step 3: For each request Ri, assign priority based on urgency (Emergency > High > Normal).
Step 4: Acquire real-time environmental data W and drone status (battery level, availability).
Step 5: For each available drone Dj∈ D:
a. Check payload capacity and battery constraints
b. If constraints satisfied, mark drone as eligible
Step 6: Apply route optimization to determine shortest and safest path:
$Cost=\alpha.Distance+\beta.Risk+\gamma.TimeCost$
where α,β,γ are weighting factors.
Step 7: Select optimal drone–route pair with minimum cost value.
Step 8: Dispatch drone with assigned medical payload.
Step 9: Continuously monitor drone using GPS and IoT sensors:
a. Track position and delivery status
b. Detect obstacles or deviations
Step 10: If anomaly detected (low battery / obstacle / weather issue):
a. Trigger fail-safe mechanism
b. Re-route or return-to-home (RTH)
Step 11: Upon reaching destination:
a. Authenticate receiver (secure access)
b. Deliver payload safely
Step 12: Update delivery status in CCU and log performance metrics.
Step 13: Repeat process for remaining requests.
End Algorithm

V. RESULT AND DISCUSSION

The implementation of the proposed **IoT-enabled UAV-based medical delivery system** demonstrates significant improvements over conventional transportation methods. Experimental analysis indicates a substantial reduction in delivery time, particularly in rural and geographically challenging regions. The use of UAVs enabled rapid transportation of critical medical supplies such as medicines, vaccines, and blood units, thereby ensuring timely medical intervention in emergency scenarios.

The system achieved enhanced operational efficiency through the integration of **intelligent routing and priority-based scheduling mechanisms**. By dynamically selecting optimal flight paths based on distance, environmental conditions, and urgency, the drones minimized travel time and energy consumption. Comparative evaluation shows that the proposed system reduces delivery latency and operational costs, making it a viable solution for scalable healthcare logistics.

Reliability analysis highlights the effectiveness of the **real-time monitoring and communication framework**. Continuous GPS-based tracking allowed precise monitoring of UAV movement, enabling quick detection and mitigation of anomalies such as route deviation or environmental disturbances. The incorporation of safety features, including obstacle avoidance, secure payload compartments, and fail-safe mechanisms, ensured safe and damage-free delivery of medical supplies, maintaining their quality and usability.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 4, April 2026
DOI: 10.17148/IJARCCE.2026.154275

The system also proved effective in handling **time-critical and large-scale healthcare scenarios**, such as those observed during pandemic conditions. The capability for contactless delivery reduced human interaction, thereby minimizing the risk of infection transmission while maintaining uninterrupted healthcare services.

Despite these advantages, certain limitations were identified. The system performance is influenced by adverse weather conditions, limited payload capacity of UAVs, and regulatory restrictions governing airspace usage. These factors may affect large-scale deployment and operational consistency.

Overall, the results validate that the proposed system provides a **fast, reliable, and efficient solution** for medical supply delivery. The integration of IoT-based monitoring, intelligent routing, and secure access control significantly enhances system performance. With further advancements in drone technology and supportive regulatory frameworks, the proposed system has strong potential for real-world implementation and future expansion in healthcare logistics.

VI. CONCLUSION

This paper presented an IoT-enabled smart UAV-based medical supply delivery system designed to improve the efficiency and reliability of healthcare logistics. The proposed approach leverages Unmanned Aerial Vehicles (UAVs) to enable rapid and secure transportation of essential medical resources, particularly in remote, rural, and emergency-affected regions where conventional delivery methods are often inadequate.

The results demonstrate that the proposed system significantly reduces delivery time, enhances accessibility, and ensures timely medical support in critical situations. The integration of real-time tracking, intelligent route optimization, and safety mechanisms improves operational efficiency and system reliability. Furthermore, the capability for contactless delivery highlights the system’s effectiveness in handling large-scale healthcare emergencies, such as pandemic scenarios.

Despite these advantages, certain challenges remain, including regulatory constraints, weather dependency, and limited payload capacity. However, ongoing advancements in UAV technology, communication systems, and supportive policy frameworks are expected to mitigate these limitations and enable wider adoption.

In summary, the proposed system offers a scalable, cost-effective, and reliable solution for modern healthcare logistics. It has strong potential to enhance emergency response, reduce delivery delays, and improve overall healthcare accessibility, thereby contributing to better patient outcomes and more resilient healthcare systems.

REFERENCES

[1]. S. Chowdhury and T. Rahman, “Application of drone technology in healthcare logistics and medical supply delivery,” *Transportation Research Procedia*, 2025.
[2]. J. Kim, H. Park, and S. Lee, “Intelligent routing and optimization in drone-based medical delivery systems,” *Journal of Healthcare Engineering*, 2025.
[3]. H. A. Campbell *et al.*, “Emerging research topics in drone healthcare delivery,” *Drones*, vol. 8, no. 6, p. 258, 2024.
[4]. J. C. Rosser, V. Vignesh, B. A. Terwilliger, and B. C. Parker, “Medical drone applications in emergency and disaster management,” *Healthcare Technology Letters*, 2024.
[5]. R. Singh and P. Sharma, “Role of drones in healthcare during COVID-19 pandemic,” *International Journal of Medical Informatics*, 2024.
[6]. T. K. Amukele *et al.*, “Transport of laboratory samples using drones: Feasibility and reliability study,” *Clinical Chemistry*, 2023.
[7]. N. Gupta and A. Verma, “Challenges and future scope of drone-based healthcare delivery systems,” *Journal of Emerging Technologies in Healthcare*, 2023.
[8]. S. Habibi, N. Ivaki, and J. Barata, “A systematic literature review of unmanned aerial vehicles for healthcare and emergency services,” 2025.
[9]. S. Olunde, “Impacts of drone technology on last-mile healthcare delivery in developing countries,” 2023.
[10]. Y. Li, “Rapid delivery system of emergency medical supplies using UAVs,” 2024.
[11]. D. J. Sampathkumar, “Hybrid deep learning model for achieving the efficient QoS model in WS-IoT-based healthcare systems,” *Industrial Engineering Journal*, vol. 54, no. 3, pp. 50–64.

