International Core Journal of Engineering Volume 11 Issue 10, 2025
ISSN: 2414-1895 DOI: 10.6919/ICJE.202510_11(10).0023

Application of Unmanned Aerial Vehicles in Emergency Medical Field

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Abstract

This paper focuses on the application of unmanned aerial vehicles (UAVs) in the emergency medical field. Endowed with characteristics such as easy operation, flexibility and rapidity, UAVs play a crucial role in emergency medical services. They enable emergency delivery to enhance response speed, as exemplified by their assistance in patient transfer during the heavy rain in Zhengzhou and the significant improvement in drug delivery efficiency in Suzhou. Additionally, UAVs optimize medical resources to support remote areas, as seen in their use for transporting vaccines during the epidemic. They also enhance safety and provide telemedicine support. The paper further analyzes the technical and management scheduling challenges faced by UAV applications, including limited battery life and system incompatibility, and proposes countermeasures such as improving battery life and optimizing communication. It points out that UAVs will become a core tool in emergency medical services in the future.

Keywords

Unmanned Aerial Vehicle; Emergency Rescue; Low-Altitude Economy.

1. Introduction

Emergency medical services are of great significance for safeguarding human life safety. However, traditional rescue efforts are restricted by factors like complex terrain and traffic congestion, resulting in limited efficiency and safety. In recent years, UAV technology has matured, showing trends of miniaturization and intelligence. In 2023, the market size of civil UAVs in China reached 165 billion yuan, with a remarkable growth in the number of registered UAVs and operating enterprises. At the policy level, the Chinese government also supports the application of UAVs and the construction of the emergency medical system. UAVs have demonstrated remarkable effectiveness in emergency medical services, such as in the rescue work during the heavy rain in Zhengzhou and the transportation of materials during the epidemic. Nevertheless, challenges still exist. This paper aims to explore the applications, challenges and countermeasures of UAVs in this field, so as to provide references for the development of emergency medical services.

2. Overview of UAV Development

Unmanned Aerial Vehicles (UAVs), also known as unmanned aircraft, are crewless aircraft that can be remotely controlled by a control station or fly autonomously. They feature easy operation, diverse functions, flexibility and rapidity. In recent years, UAV technology has become increasingly mature, gradually showing the characteristics of miniaturization and intelligence, and has been widely applied in various fields such as agricultural production, fire rescue, remote sensing mapping, police security and public entertainment [1]. In terms of the market, the scale of China's civil UAV market increased to 165 billion yuan in 2023, with a year-on-year growth of 37.63%. It is estimated that the market scale of civil UAVs will reach 176.5 billion yuan by 2024. The number of registered UAVs is also

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growing rapidly. In 2023, the number of registered civil UAVs in China reached 1.267 million, with a year-on-year increase of 32.25%. The number of UAV operating enterprises increased from 12,663 in 2021 to 19,825 in 2023, with a compound annual growth rate of approximately 25.1%. It is predicted that the number of UAV operating enterprises will reach 23,161 by 2024 [2].

3. Applications in the Medical Field

In recent years, China has made remarkable progress in the construction of the emergency medical system. The 2024 National Medical Emergency Work Conference clearly stated that continuous efforts should be made to strengthen the construction of the emergency medical rescue system and capabilities, so as to achieve high-quality development of medical emergency work [3]. In addition, public hospitals are faced with higher requirements in responding to public health emergencies and need to establish and improve the emergency command system and emergency plan system [4]. How to better promote the construction of the emergency medical system and improve rescue efficiency has become a persistent concern of the government and hospitals.

With their unique advantages, UAVs have achieved fruitful results in medical rescue, drug delivery, emergency medical assistance and other aspects [5].

3.1 Emergency Delivery to Improve Response Speed

With their fast and flexible flight capabilities, UAVs can easily navigate through complex terrain and traffic congestion, effectively reducing delays associated with traditional ground transportation. This enables UAVs to quickly cover disaster-stricken areas and directly deliver urgently needed medical supplies and emergency rescue materials to designated locations, providing timely medical assistance to the affected areas [6].

For instance, in July 2021, Zhengzhou, Henan Province was hit by heavy rain. The Fuwai Huazhong Cardiovascular Hospital was flooded, with in-hospital equipment cut off from power and signals lost. Patients were in urgent need of transfer. Faced with these circumstances, UAVs bypassed traffic obstacles, temporarily established communication links, continuously monitored the patients' conditions, and successfully completed the patient transfer [7]. On July 19, 2024, a UAV loaded with 10 boxes of emergency heart medications took off from the Suzhou Industrial Park Comprehensive Bonded Zone and successfully delivered the medications to the Children's Hospital Affiliated to Soochow University, which is approximately 7.8 kilometers away, in just 11 minutes. In contrast, under the traditional delivery mode, a freight vehicle would need to travel 14 kilometers, taking about 22 minutes during non-rush hours and more than 40 minutes during morning and evening rush hours. By designing precise air routes, the UAV-based drug delivery reduced the delivery distance by 44% and improved the delivery efficiency by 50%-70% [8].

3.2 Medical Resource Optimization to Support Remote Areas

The application of UAV technology has transformed the traditional medical service model, making the medical service system more efficient and convenient. In addressing the long-standing issues of inconvenient transportation, insufficient medical resources and difficult access to medical care in remote areas, UAVs have built a bridge for people to seek medical treatment. During the COVID-19 epidemic, UAVs were used to transport vaccines and medications to remote areas, thereby effectively cutting off the epidemic transmission chain and reducing the infection rate in hospitals and clinics [9].

3.3 Enhanced Safety and Real-Time Monitoring of Patient Conditions

Owing to their small size and flexibility, UAVs can replace humans in conducting rescue tasks, preventing rescuers from entering dangerous areas. Therefore, in chemical, biological, radiological and nuclear (CBRN) disasters, UAVs can guide people and carry out disinfection work to ensure personnel safety. Moreover, equipped with relevant devices, they can real-time monitor the injured and the surrounding environment, keep track of the vital signs of the injured, and reduce the risk of personnel exposure [10].

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3.4 Technological Innovation for Telemedicine Support

In medical rescue missions, UAVs are equipped with advanced autonomous flight control systems such as the DJI N3 multi-rotor flight control system. This system can realize dual IMU redundancy design and "black box" data recording, ensuring stable flight and precise operation in complex environments. It integrates a variety of sensors, such as thermal imagers and gas detectors, which can obtain comprehensive on-site environmental information and provide key data for rescuers.

In addition, UAVs utilize remote communication technologies such as 5G and satellite communication to achieve high-speed data transmission, ensuring the real-time performance and accuracy of information [11]. For example, the 5G-connected UAV solution replaces the self-built communication link with a 5G cellular network, providing flight supervision and video streaming capabilities to realize remote UAV control and operations. The application of artificial intelligence algorithms enables UAVs to perform intelligent identification, path planning and task execution. For instance, the intelligent UAV AI algorithm solution integrates advanced AI technology and multi-sensor fusion to achieve autonomous flight, intelligent obstacle avoidance, efficient data processing and multi-UAV collaborative operations [12].

Continuous technological progress has driven the continuous development of UAVs in the rescue field. In medical rescue, the application proportion of UAVs is gradually increasing, and they have formed a closer collaborative relationship with traditional medical means such as ground ambulances and air rescue helicopters.

In conclusion, UAVs are developing towards popularization and normalization. This trend indicates that UAVs will occupy a core position in the future medical rescue system and become a key tool for improving rescue efficiency and ensuring life safety.

4. Challenges and Countermeasures

4.1 Technical Limitations

Firstly, limited battery life is a prominent issue. When UAVs perform emergency rescue tasks, they need to fly continuously for a long time. However, the current battery life of UAVs is difficult to meet this demand, which requires frequent battery replacement or landing for charging during tasks, greatly affecting rescue efficiency. Secondly, UAVs face problems of their own safety and poor environmental adaptability. In the wild with harsh environments or urban areas with signal interference, the performance of their batteries and the stability of electronic components will be affected, causing UAVs to lose control, deviate from the established route or even crash. Furthermore, the software functions of UAVs are also limited. Their intelligent obstacle avoidance function is not yet perfect, making it impossible to accurately identify and avoid obstacles in complex rescue environments, increasing the risk of collision and crash. Challenges also exist in video processing. Due to the limitations of signal transmission distance and bandwidth, UAVs cannot transmit the captured videos back to the command center in real time, affecting the timeliness and accuracy of decision-making. Finally, emergency rescue may require UAVs to carry various equipment such as life detectors and rescue materials. However, most current UAVs have limited load capacity, which cannot meet the needs of complex rescue tasks. In addition, the compatibility between UAVs and different professional equipment is poor, which limits the expansion of their functions and the diversification of application scenarios [13][14].

4.2 Improving UAV Battery Life

Notable achievements have been made in enhancing UAV battery life. For instance, renewable energy sources like solar power and hydrogen fuel are increasingly adopted. Solar panels are integrated into UAV structures to convert sunlight into electricity, while wireless charging stations at take-off/landing points enable automatic battery replenishment during long-distance missions. Secondly, helium balloons are incorporated to offset part of the UAV's weight, reducing energy consumption

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for flight. Meanwhile, innovative lightweight airflow-sensing materials are utilized to optimize aerodynamic efficiency without adding extra mass, minimizing drag and energy loss.

Furthermore, researchers have focused on mechanical optimization, refining the design of small propellers and matching them with high-efficiency motors. This approach significantly improves the power system efficiency of electric UAVs, extending operational duration. Such advancements collectively address the critical challenge of limited battery life, driving UAV applications toward longer-endurance and more reliable performance in various scenarios.

5. Conclusion

UAVs (Unmanned Aerial Vehicles) enable precise delivery of emergency medical supplies in emergency medicine by carrying modular medical cabins and intelligent temperature - control systems. In remote -area first aid and disaster medical rescue, they quickly break through geographical barriers to deliver hemostatic drugs, CPR equipment, and other supplies, shortening the golden rescue time. Combined with 5G telemedicine technology, UAVs can transmit vital signs of the wounded, assisting medical staff in remote first - aid guidance. Moreover, disinfection UAVs conduct large - area contactless sterilization in epidemic areas to reduce cross - infection risks. Currently, UAVs are integrating with AI diagnostic systems, gradually upgrading from "material transportation" to "diagnosis - treatment collaboration," providing technical support for building a smart medical emergency response system.

Acknowledgments

Thanks to all who supported this research.

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