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The Application of Artificial Intelligence and Drones in Emergency Medical Care and the Transportation of Medical Supplies

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Abstract. Traditional emergency medical care and material distribution are mostly carried out by vehicle or aircraft transportation. The former is greatly affected by road conditions and has low transportation efficiency, while the latter is fast but has high transportation costs. In recent years, drones have gradually been promoted and applied, as their high transportation efficiency and lack of constraints from terrain and conditions can promote the development of emergency medical care and improve the efficiency of first aid and material distribution. This paper uses the methods of literature analysis and review to explore the application of cutting-edge technologies such as drones, artificial intelligence (AI), and low energy consumption in the medical field, providing new ideas for the future contribution of drones to emergency medical care and material distribution, in order to improve the level of emergency rescue and the efficiency of medical material distribution and transportation. This paper finds that integrating artificial intelligence and drone technology into emergency medical care and medical material distribution can solve the uneven distribution of medical resources and improve the efficiency of emergency response.

Keywords: Artificial Intelligence, Emergency Medical Care, Drones, Material Delivery

1. Introduction

When disasters occur, every minute counts. If there were not a comprehensive and efficient emergency medical system and supplies distribution system, the casualties would only soar dramatically. The existing emergency support transportation methods are mainly land and air transportation. Although the land transportation costs are lower, it's obviously not suitable for disasters such as earthquakes, mudslides, and floods, which significantly alter the terrain. Even if air transportation is fast, it has a considerable cost and slow response. At present, pre-hospital emergency medical care is immature, which can't be quickly respond.

Compared to vehicle transportation, drones have the advantage of being able to adapt to complex terrain. In comparison with airplanes, they are more cost-effective and have a faster response. As drone technology develop continuously and rapidly, the obstacle avoidance and navigation capabilities of drones are constantly improving, and the collaborative cooperation of drones is in the research and experiment stage as well. If artificial intelligence can be applied to optimize the control

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system of drones, which means deeply integrate drone and emerging digital technology, it will be highly conducive to promoting the level of emergency rescue, medical supplies distribution and transportation efficiency. This article will retrieve relevant research and combine it with current development of drone technology, to objectively summarize relevant literature on the integration of drones and artificial intelligence and their application in emergency medical and material transportation, aiming to provide a reference for the development of the medical emergency field.

2. The system architecture of artificial intelligence and unmanned aerial vehicle-assisted medical care

2.1. Overall system construction

The system of artificial intelligence and unmanned aerial vehicle-assisted medical care consists mainly of five parts: Unmanned aerial vehicle (UAV) platform, airborne perception module, communication layer, edge cloud computing layer, and AI decision-making and control layer. The collaborative efforts of each module can meet the real-time, security, reliability and autonomy requirements of medical scenarios.

In terms of hardware platforms, medical drones mainly include multi-rotor, fixed-wing and hybrid-wing types. Multi-rotor drones are flexible to operate, can be lifted and lowered vertically and quickly, and are suitable for short-distance emergency rescue and material transportation in confined Spaces such as mountainous areas. Fixed-wing drones have a long endurance and are suitable for remote areas and long-distance material delivery. The hybrid type combines the advantages of vertical lifting and long battery life, and is universally applicable to various scenarios.

Airborne perception and external data collection are the foundation for achieving intelligent decision-making. In practical applications, various sensors, such as infrared, visual, and multispectral sensors, are used to measure environmental data, providing data support for AI intelligent decision-making.

The communication layer mainly relies on 4G or 5G, satellite communication and other methods to ensure the stable transmission of air-ground data. In the future, 6G mobile communication may be introduced, and 6G has the potential to achieve energy self-sufficiency [1].

The collaborative architecture of edge putting and cloud computing is responsible for real-time inference at the on-board end. In this system, the applications of edge computing include low-latency tasks such as object detection and obstacle avoidance, while cloud computing is reflected in planning and big data analysis. AI technology is a powerful boost for the application of drones in the medical field. Its key technologies mainly include three aspects: obstacle avoidance, path planning, and low energy consumption.

2.2. Core AI technology

2.2.1. Environmental perception and target recognition based on deep learning network

Intelligent visual perception is one of the key technologies for the safe flight of AI medical drones, aiming to achieve functions such as the delivery of emergency supplies, the location of the injured, and the avoidance of dangerous areas without human intervention. Traditional obstacle avoidance methods rely on precise environmental models and known maps, but they have weak adaptability in variable and unknown environments such as disaster sites or mountainous areas, and are difficult to meet the actual needs of emergency medical drones. Deep learning network has powerful

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capabilities in visual feature extraction and for unstructured loops. Commonly used networks include lightweight models such as the YOLO series and MobileNet. At present, scholars have proposed many methods to improve obstacle avoidance. Some scholars have used the Cable News Network (CNN) in the YOLO series and combined it with the binocular ranging principle to improve by comparing the detection data of the left eye and the right eye. There are also those who use the optical flow algorithm and the corner detection algorithm as features for target detection to detect obstacles [2]. Oriented towards medical-specific tasks, AI medical drones should also have proprietary capabilities in medical scenarios, mainly being able to identify specific medical supplies and emergency signs, preliminarily judge the ground conditions through algorithms, and assist the command center in making decisions.

2.2.2. Path planning based on reinforcement learning optimization algorithms

Path planning is the core technology for AI medical drones to achieve optimal paths, efficient scheduling, and multi-machine collaborative work. It mainly addresses issues such as the uncertainty of dynamic environments and the allocation of multi-target resources. Most traditional path planning algorithms are designed for known maps and are difficult to cope with real-time changes. When planning a single machine, reinforcement learning does not rely on the global map. It has the ability to make autonomous decisions, can simultaneously optimize complex tasks with multiple objectives and constraints, and can continuously learn and adapt to the environment. Some scholars have combined Long Short-Term Memory (LSTM) networks with Proximal Policy Optimization (PPO) algorithms to establish relevant models, designed dynamic reward functions and introduced Control Barrier Function (CBF) to ensure safety constraints, and proposed an improved deep reinforcement learning algorithm [3]. When planning multiple machines, reinforcement learning can synchronously conduct collaborative scheduling at multiple points. Some scholars have constructed Dynamic Heterogeneous Graph Convolutional Network (DHGCN) and Deep Deterministic Policy Gradient (HFDDPG), which enhance the efficiency of drone formation and positioning accuracy [4]. It improves dynamically adjusting multi-drone operations and expanding the coverage and response efficiency of medical rescue.

2.2.3. Edge AI and lightweight

The on-board platforms of medical drones generally have hardware constraints such as low computing power, low power consumption, and limited storage, making it difficult to directly deploy high-precision and large-volume deep learning models. Therefore, edge AI lightweighting is also an important technology to accelerate the application of AI medical drones. Edge AI itself is energy-efficient. It doesn't need to be connected to the cloud, which can save a lot of wireless transmission power consumption, and has low transmission latency and energy consumption. Lightweighting is achieved by reducing the number of parameters and computational load, lowering hardware load and inference power consumption. The main model lightweighting methods include pruning, quantization, knowledge distillation, and lightweight structural design. Currently, some scholars have proposed a model compression method that integrates pruning and knowledge distillation, and have applied this lightweight model to the unmanned aerial vehicle detection and counting of wheat ears. It shows that lightweighting can still improve the accuracy of algorithms while reducing parameters [5]. Meanwhile, for remote areas, disaster sites where communication is disrupted and there is no network, the lightweight AI model supports pure offline inference, enabling

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it to complete emergency rescue and delivery tasks without relying on cloud inference, thus ensuring the reliability of medical operations from a technical perspective.

3. Application scenarios

There are three typical application scenarios of AI medical drones: emergency medical rescue and pre-hospital emergency care, remote areas and primary medical services, and medical cold chain and material distribution, which have great potential at present.

3.1. Emergency medical rescue and pre-hospital emergency care

In pre-hospital emergency scenarios, drones mainly undertake the function of rapid response. For example, in emergencies such as cardiac arrest that require automated external defibrillators, drones can quickly deliver defibrillators and first aid kits. This is much more efficient and accurate than manual delivery. At geological disaster sites and the like, drones can carry relevant search and rescue equipment to enter the disaster area in advance to collect information about the disaster area, initially complete the collection and analysis of environmental conditions, the number and distribution of the injured, and quickly provide comprehensive information for the command center to formulate rescue plans. This reduces the risks for search and rescue personnel. Meanwhile, after the search and rescue team enters the disaster area, drones can continue to be arranged for inspection in the disaster area, providing real-time rescue information to the command center.

3.2. Services for remote areas and primary medical

In medical services in grassroots and remote areas, AI medical drones can deliver medicines and provide test kits to mountainous areas, islands, rural areas and other regions with inconvenient transportation and scarce supplies. Intelligent drones can regularly deliver medicines along planned routes, such as those for treating underlying diseases like hypertension and diabetes. Moreover, drones can carry advanced monitoring equipment from urban areas to mountainous regions to achieve remote health checks, chronic disease management, and initial health screenings, providing assistance.

3.3. Medical cold chain and supplies distribution

In the field of medical cold chain and high-value material distribution, AI medical drones have obvious advantages in temperature control, tracking and safety. For instance, items such as blood products, transplanted organs, and biological samples that are highly sensitive to temperature, time, and vibration are too costly to be transported by air, and land transportation is difficult to ensure the vitality of the items. Drone transportation is the best option that balances cost and item value. Additionally, drones can reduce transshipment, which means less contact with people, thereby lowering the risk of contamination and failure. They're particularly suitable for vaccine supply and rapid material replenishment during public health emergencies, providing a solution for contactless delivery in the "last mile".

3.4. Future prospects

Although AI has demonstrated strong application potential in enabling medical drones and significant progress has been made in some functions, it still faces multiple challenges. For instance,

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in terms of technology, the short endurance of drones makes it difficult to meet the long-distance and large-scale delivery of medical supplies. In terms of environmental adaptability, drones are much lighter and smaller than vehicles and aircraft. As low-altitude flying machines, their transportation efficiency is bound to be greatly affected by the wind. In terms of communication, low latency and anti-interference capabilities are difficult to guarantee in remote areas and disaster-stricken regions. These are all points that need to be broken through and improved. Intelligent medical drones will develop in the direction of high autonomy, high reliability and high collaboration. In the future, 6G communication will provide drones with more comprehensive coverage, lower energy consumption and lower latency communication support. The combination of lightweight large language models and edge-side AI further enhances the ability of drones to understand complex instructions and make autonomous decisions. Combined with digital twins, simulating disaster scenarios enables the model to continuously iterate and upgrade, safeguarding the safety and health of people around the world [6].

4. Conclusion

Integrating artificial intelligence and drone technology into emergency medical care and medical supplies distribution can provide solutions to problems such as uneven distribution of medical resources and slow response to emergency rescue, which enhances public health capabilities. AI medical drones have formed a relatively complete technical system in multiple aspects such as system architecture, intelligent perception, autonomous navigation, and edge computing. Some of these technologies have been applied in fields like agriculture and services, and have demonstrated practical value and potential in scenarios such as emergency rescue, primary medical care, and cold chain transportation. Although AI medical drones are currently facing multiple challenges such as battery life, safety, and communication, in the future, with the continuous maturation of AI algorithms, the application and coverage of 6G, and the maturity of energy harvesting models, AI medical drones will play an increasingly important role in the global medical and health system. This article focuses on drone delivery and doesn't delve deeply into the aspect of drone diagnosis and treatment. In the future, there are still areas worth exploring such as 6G air-ground integration, the integration of drones and diagnosis and treatment, and the collaboration between digital twins and clusters.

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