Research on UAV Aided Earthquake Emergency System

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Abstract. As a hot technology in the industry, UAV can play a role in all aspects of earthquake emergency system. In view of the scene of earthquake emergency, according to the characteristics and latest development of UAV, combined with its application in various kinds of natural disasters in recent years, it discusses the design of UAV aided earthquake emergency system. The UAV aerial image processing subsystem focuses on the disaster condition collection, earthquake intensity evaluation and thematic map production after the earthquake. The UAV on-site rescue subsystem focuses on the materials transportation after the earthquake, personnel searching and rescuing, and command and dispatching. The tethered UAV emergency communication subsystem mainly provides emergency communication support after the earthquake. The UAV image return subsystem is designed to deliver images of disaster areas to headquarters and the public, so that they can have an intuitive and vivid understanding of the disaster situation, rescue force deployment and rescue progress in the disaster areas.

1. Introduction
Unmanned aerial vehicle (UAV) is a kind of spacecraft. It is driven by power, unmanned on board, and flying autonomously or remotely. It can be able to carry payload and be reused. Compared with manned aircraft, it has the characteristics of small size, low cost, good maneuverability and simple operation. With the maturity of hardware and software technology of UAV, it is widely used in various industries. Emergency management departments attach great importance to the application and promotion of UAVs in the field of disaster prevention and mitigation. Some competent departments of emergency management have also purchased different types of UAVs, which have carried out beneficial exploration in the field of natural disaster monitoring and prediction, and emergency rescue. Based on the scene of earthquake emergency, according to the characteristics and latest development of UAV, combined with its application in various natural disasters in recent years, this paper discusses the design of UAV assisted earthquake emergency system. It also analyzes its application in different periods, levels and categories in the earthquake emergency system.

2. Design of UAV aided earthquake emergency system
The earthquake emergency command system consists of communication network subsystem, conference subsystem, disaster information transmission subsystem, disaster rapid assessment subsystem, auxiliary decision subsystem, earthquake emergency thematic mapping subsystem, information release subsystem, data management subsystem and earthquake site emergency subsystem [1]. The application of UAV in earthquake emergency system runs through every system and can play...
an active role in different subsystems. The overall design of UAV aided earthquake emergency system is shown in Figure 1.

![Figure 1. Overall design of UAV aided earthquake emergency system.](image)

2.1. **UAV aerial image processing subsystem**

The essence of UAV aerial photography image processing subsystem is UAV disaster area mapping system. It mainly refers to UAV carrying visible light, infrared, radar and other sensors, integrating communication, navigation, positioning, telemetry, remote control and other components to carry out remote sensing operations to obtain images of disaster areas. Traditional remote sensing earth observation mainly uses manned aircraft aerial remote sensing and satellite remote sensing. Remote sensing satellite is limited by flight altitude, return visit period and other factors. So its timeliness is difficult to guarantee. Comparatively speaking, the aerial remote sensing of manned aircraft has high flexibility, but it is easy to be affected by the weather. In the actual operation, there will be provisions for airspace control. The taking off and landing requires a stringent site and costs more [2]. UAV mapping costs less. There is no risk of casualties. The operation mode is flexible and convenient. The effectiveness is good. It can take off and land at any time according to the mission needs, without the limitation of return visit period. It can carry out long-term "gaze" observation on key targets or areas of interest. The flight altitude of UAV is low. It obtains high spatial resolution images. It can shoot vertically, in low altitude and multi angles. UAV technology is an effective supplement to satellite and manned remote sensing.

The UAV aerial image processing mainly includes UAV aerial photography, image processing and information interpretation. The workflow is shown in Figure 2.
Figure 2. UAV aerial photography workflow.

The UAV used in aerial photography after the earthquake usually adopts fixed wing UAV or multi rotor UAV. The multi rotor UAV has low price and lower requirements to the use environment. So it is more practical in severe earthquake and complex environment. Taking DJI phantom 4 RTK UAV as an example, it has centimeter level navigation and positioning system, and high-performance imaging system. Is meets the accuracy requirements of relevant specifications [3]. The maximum take-off altitude is 6000 meters. It can fly continuously for 30 minutes. When RTK is enabled and RTK works normally, the hovering accuracy is ± 0.1 m in vertical direction and ± 0.1 m in horizontal direction. It has obstacle avoidance function and meets the requirements of aerial photography in disaster areas after earthquake.

The UAV aerial images, combined with the understanding of the disaster situation in the earthquake site, can obtain the disaster information of the disaster area through visual interpretation or computer automatic analysis. According to the application experience of remote sensing technology in the earthquake emergency response, the seismic damage of buildings, highway and seismic geological disasters can be accurately identified and judged. The scope and intensity of earthquake disaster area can be produced at the same time. For destructive earthquakes, the output of these products can meet the main requirements of earthquake emergency work. It will play a very important role. The UAV has been applied in Wenchuan M8.0 Earthquake, Yushu M7.1 earthquake and Ludian M6.5 earthquake, and achieved certain results. Taking the M5.5 earthquake in Ta County, Xinjiang in 2017 as an example [4], the staff used the UAV low altitude remote sensing platform to obtain massive high-resolution remote sensing images in the disaster area. The remote sensing image data acquisition of macro epicenter was completed in the shortest time. It provided information to understand the disaster situation in the earthquake stricken areas, and provided scientific decision-making basis for disaster assessment, rescue and post disaster reconstruction.

2.2. **UAV field rescue subsystem**

The UAV has the advantages of no casualty risk, simple operation and low cost. It can replace the manned aircraft in post-earthquake rescue. After severe and catastrophic earthquakes occur in areas with poor environment, complex geological conditions, complex topography and strong geological disasters, traffic congestion will occur in some areas, or the disaster area will become isolated island due to common traffic congestion after the earthquake. It will seriously affect the effectiveness of earthquake emergency command and rescue work. The UAV can be equipped with a thrower to air drop emergency supplies, including purified water, convenient food, medicine, clothes and
communication equipment. Taking Chengying 80e of Yifei Ltd. as an example, it is an electric heavy-duty UAV platform with the function of broken oars protection. Any two oars lose power and can still keep flying posture. It can supply bulk materials in scenic areas, forest areas, mountainous areas, islands, deserts, disaster areas, sentries and ships, with a maximum load of 80kg. It can meet the material airdrop demand in the disaster areas after the earthquake.

It can carry broadcasting and lighting equipment on UAV. The UAV equipped with sound amplification equipment can assist the earthquake emergency scene headquarters to complete the on-site dispatching and command work in the disaster area, comfort the victims with "high-altitude shouting". It can guide the escape route. If the UAV is equipped with strong light source, it can assist and guide the rescue team to carry out rescue work at night or provide a wide range of ground lighting services, which is convenient for on-site rescue work. The UAV equipped with optical camera, pyroelectric infrared identification system, radar biometric system, electromagnetic detection system and navigation and positioning system, can carry out personnel search and rescue work, increase the rescue means and success rate.

2.3. Tethered UAV emergency communication subsystem

The destructive earthquake can cause serious damage to communication infrastructure. The communication interruption has a serious impact on disaster collection and emergency command. It is of great significance to ensure communication in disaster areas. The basic principle of the tethered UAV emergency communication subsystem is to use the UAV to carry a variety of communication loads, such as cluster micro base station, ad hoc radio station, LTE micro base station, antenna and other communication loads, to form different communication application configuration modes. Thus, communication services can be opened in the key areas of the earthquake disaster area [5]. The ultra-short wave communication and broadband video communication can be formed in the command headquarters and rescue teams. It will provide text, voice, video and other communication services. Compared with the emergency communication vehicle, the UAV emergency communication subsystem can be deployed quickly and flexibly. It can avoid buildings, trees and other obstacles, and establish a more reliable communication link. It has low cost and can work all day long. It has an integrated structure and is easy to use.

The emergency communication subsystem of tethered UAV is divided into ground and air parts. The ground part is composed of ground communication relay equipment, ground power supply, generator, tethered cable retraction and release device, antenna system and user terminal [6]. The air part is mainly composed of communication relay and forwarding equipment, UAV with communication antenna load equipment. When the UAV carries UHF radio relay equipment in the air, it can realize fast, real-time, and stable data transmission between mobile map transmission system of individual soldier and command vehicle within 5-10km range in the valley, hill and urban area with little topographic relief [7]. When the tethered UAV carries a small communication base station, the temporary high altitude base station can cover at least 5km area, and the maximum number of users is about 5000. Than will meet the communication needs of the disaster area. The communication coverage area and the number of users that can be accessed are determined by the flight altitude and base station capacity. Taking the Tianshu-A8 tethered UAV provided by Zhuoyi Ltd. as an example, its operation mode can be divided into two categories: direct air to ground coverage and air-to-air relay. When the UAV is equipped with LTE equipment, the communication between outdoor CPE equipment in the air and the ground terminals such as IP camera, mobile phone, backpack station, etc. will be established. Then the HD live image and voice obtained from these terminals will be transmitted to the LTE system command and control center in the ground vehicle through the optical fiber in the tethered cable. Thus to realize the long-distance and wide-range broadband emergency communication [8].
2.4. **UAV image return subsystem**

Accurate understanding of the disaster situation is the key to earthquake emergency command and rescue. At present, the main forms of disaster reporting are text description and picture. The shortcomings are that the expression of the disaster situation is not intuitive enough. It’s difficult to have a concrete, comprehensive and perceptual understanding of the situation in the disaster area. The photos of disaster areas supplement the lack of text description effectively. Its disadvantage is that personnel have to enter the disaster area to take pictures. And the coverage of the pictures is very small, which is difficult to achieve in the complex earthquake field conditions. The UAV based scene aerial photography can obtain the image of the disaster area in a large range quickly without personnel entering the disaster area. The front and rear headquarters can understand the situation of the disaster area intuitively, comprehensively, concretely and sensibly. It plays an important role in determining the severity of the disaster, understanding the disaster types, mastering the mass dynamics in the disaster area, directing the resettlement of the victims and deploying disaster relief material distribution. When the occurrence of a severe earthquake, the preliminary investigation of the epicenter by UAV as the advance team can help to determine the location of the macro epicenter, which is of great significance to scientific rescue command.

The UAV aerial images of disaster areas are transmitted to the operating platform through wireless return system, and uploaded, stored, processed, managed, distributed and played through VOD cloud service. Through cloud service on demand, we can make use of the cloud platform's high-quality distribution network to cover the whole network across regions and mobile operators. It provides the headquarters and the masses with low delay and low stuck smooth playback experience. It provides millions of people to watch at the same time. Thus to meet the people's concern for the disaster area after the earthquake. The design of UAV image return subsystem is shown in Figure 3.

![Figure 3. Design of UAV image return subsystem.](image)

3. **Conclusion**

Earthquake is one of the most severe natural disasters. It has a large impact range, serious casualties and will cause various secondary disasters. There are still many problems to be solved in emergency rescue. UAV, as a popular industrial technology, has been applied to many aspects of natural disaster monitoring and prediction, risk assessment and emergency rescue. According to the characteristics of earthquake emergency, combined with the existing framework of earthquake emergency technology system, the application of UAV is integrated and expanded. The UAV aerial image processing subsystem focuses on disaster collection, earthquake intensity evaluation and thematic map production. The UAV on-site rescue subsystem is aimed at post-earthquake material transportation, personnel search, and rescue command and dispatching. The emergency communication subsystem of tethered UAV mainly provides emergency communication support after earthquake. The UAV image return subsystem aims to transmit images of disaster areas for the headquarters and the public, so that they can have an intuitive and vivid understanding of the disaster situation, rescue force deployment and rescue progress in the disaster area. The establishment of UAV assisted earthquake emergency system
will improve the efficiency of earthquake emergency command, management and rescue. As a kind of load equipment, UAV can be able to carry different sensors or devices. Its application method and depth in the field of earthquake still has a great exploration space.

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