Application of Drones in Nuclear Contaminated Sites

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Abstract. The impact of nuclear radiation following the Japan earthquake has been significant. This article states that on March 11, 2011, a 9.0 magnitude earthquake occurred near Honshu Island, Japan, followed by a tsunami. The Fukushima Daiichi nuclear power plant was severely damaged by the earthquake and tsunami and triggered the Fukushima nuclear leakage event, which had an impact beyond the national boundaries of Japan and caused a global nuclear pollution accident. Nuclear pollution can have severe and long-lasting impacts on the environment and human health. Exposure to radioactive materials can cause radiation sickness, cancer, and genetic mutations. Unmanned aerial vehicle (UAV) technology is the best monitoring mechanical, can carry out monitor and post-quake repairs. This paper explores the application of drones in nuclear contaminated sites from the perspective of drone technology characteristics, the special features of nuclear contaminated sites, and the advantages of drone application in these sites, such as reducing radiation risks, improving operational efficiency, and lowering operating costs. For example, it can be used in nuclear radiation restoration investigation, image collection communication in disaster areas, operational assistance. It improves the nuclear emergency rescue system. Additionally, this paper provides an outlook on the future of drone application in nuclear contaminated sites. Drones can be equipped with more advanced sensors and equipment, enabling more efficient work and restoration.

1 Introduction

Earthquakes can damage nuclear power plants, thereby releasing radioactive material into the environment, which can affect human health. Studies have shown that an earthquake and tsunami combined to cause the Fukushima Daiichi disaster knocked out the plant's cooling systems, allowing radioactive material to leak out. There have been many cases in history where earthquakes have caused structural damage to nuclear power plants, resulting in nuclear leaks. For example, a massive earthquake in Japan in March 2011 triggered a tsunami that devastated the Fukushima Daiichi nuclear power plant. The resulting nuclear radiation has had significant consequences for the environment and human health [1]. Other areas of Japan where nuclear radiation has occurred include the Tokaimura nuclear accident in 1999 and the Goiânia accident in 1987, which resulted from the improper disposal of radioactive material [2]. The impact of nuclear radiation on the human body is irreversible and mainly affects multiple aspects such as the blood system, digestive system, and immune system. The harmful effects of nuclear radiation are divided into short-term effects and long-term effects [3]. In the short term, people may experience symptoms such as fatigue, dizziness, insomnia, skin redness, and ulcers. In the long term, people exposed to radiation will experience a severe decrease in white blood cells, and the incidence of various cancers will increase with the exposure dose. Generally, the more radiation a person is exposed to, the greater the risk of cancer and birth defects in newborns. The remnants of nuclear material after a leak can cause environmental damage, including pollution caused by nuclear radiation and atomic dust. It can also lead to many secondary contamination, such as the harm to organisms and plants caused by water sources contaminated by nuclear material.

The purpose of this paper is to summarize the research results on the effects of nuclear radiation and recovery methods after

Japanese earthquake. And take advance about the future of UAV, there are still some challenges and difficulties at present. For example, how to improve the accuracy and stability of drones in nuclear contaminated sites, and how to ensure the safety and reliability of drones, etc. Therefore, it is necessary to continue to strengthen the research and development and application of drone technology in the future, in order to better cope with the challenges brought by nuclear radiation and make greater contributions to the restoration of the environment and human health.

2 Hazards of nuclear radiation

Nuclear radiation has a long half-life, meaning that it can remain dangerous for hundreds or even thousands of years [4]. It can cause pollution of air, water, and soil, leading to long-term environmental damage. The impact of nuclear radiation on human health includes an increased risk of cancer, genetic mutations, and radiation sickness. The environment is also adversely affected by nuclear radiation, causing mutations in plant

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and animal life, leading to genetic abnormalities and decreased biodiversity. The Fukushima Daiichi nuclear power plant disaster has resulted in the displacement of thousands of people and the contamination of the surrounding environment.The GEOMAR Helmholtz Centre, a top Marine research institute in Germany, conducted a computer simulation exercise on the diffusion of nuclear waste water (Fig.1). Radiation flow chart, blue for light radiation, red for high dose radiation. It turns out that after 57 days, the radiation had spread over more than half of the Pacific; Six months later, high doses of radiation spread widely. In just three years, the eastern Pacific coast of the United States and Canada was polluted.

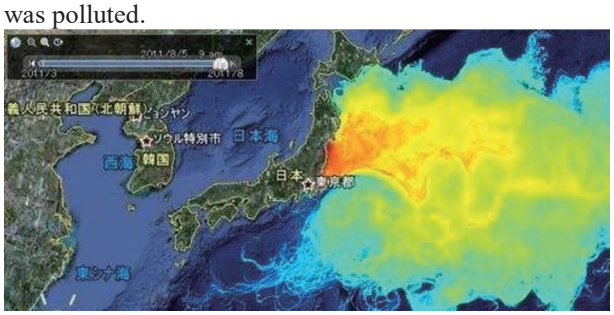

Fig. 1. The nuclear spread in the Pacific ocean [5]

2.1 Environmental pollution

The first is air pollution caused by radionuclides. After nuclear radiation, there is a large spread of radioactive material. The released radioactive material was widely dispersed in the northern Hemisphere by atmospheric circulation. Radioactive iodine-131 caesium-137 has been detected in countries including the United States, Canada, Iceland, Sweden, China and the Philippines. Thus, Fukushima nuclear leakage has caused global pollution

2.1.1 Air pollution

Radioactive substances such as 131-iodine, 137-cesium and 134-cesium have been detected in the air in countries around Japan, as atmospheric circulation has spread widely across the northern Hemisphere [6].

2.1.2 Water pollution

A large amount of radioactive water leakage, due to the earthquake caused damage to the nuclear power plant, coupled with the disposal of reactors in the preliminary cooling caused by a large amount of seawater, resulting in a large amount of radioactive water leakage. According to Japan's Kyodo News on December 26, 2011, because the Fukushima Prefecture government in coastal areas of fish radiation inspection found that fish still has more than the provisional standard level of radioactive cesium. Radiation can also cause contamination of water bodies. When radioactive materials are released into water sources, they can spread and contaminate large areas, affecting both aquatic life and human health. Radiation contamination of water can lead to a range of health problems, including cancer, genetic mutations, and birth defects. It can also damage aquatic ecosystems, leading to declines in fish populations and other aquatic species.

Contaminated water can also have long-lasting effects on the environment, as radiation can persist in water sources for many years. This can make it difficult to restore affected areas and can have significant economic and social impacts on local communities.

2.1.3 Land pollution

Radioactive material from the Fukushima plant can fall to the ground and contaminate the ground, buildings and soil. As a result, some land has been restricted due to excessive amounts of radioactive material [7].

2.2 Human risks

Nuclear radiation can be extremely dangerous to human health. Exposure to high levels of radiation can cause significant damage to cells and tissues, leading to a range of health problems. The severity of these problems depends on several factors, including the level and duration of exposure, the type of radiation, and the age and overall health of the individual. Radiation can cause immediate symptoms such as nausea, vomiting, and skin burns. In extreme cases, it can lead to radiation sickness, which can cause damage to the bone marrow, gastrointestinal tract, and other organs. Over time, exposure to radiation can increase the risk of cancer, genetic mutations, and birth defects. The effects of radiation on the human body are cumulative, meaning that even low levels of exposure over a long period of time can have serious health consequences. This is why it is essential to take precautions to minimize exposure to nuclear radiation in all circumstances, whether it is in the workplace or in the environment. Monitoring and treating potential health effects of radiation exposure is also important. Regular medical check-ups and monitoring can help detect any potential health problems early on, allowing for prompt treatment and management of symptoms. In addition, measures such as decontamination and protective gear can help reduce the risk of exposure to radiation in hazardous environments. In general, the potential dangers of nuclear radiation on human health emphasize the importance of safety measures and precautions in all situations involving radiation exposure.

3 Nuclear radiation remediation technologies

Pollution can be divided into two types: one is the production of radioactive aerosols and other radioactive pollutants that can damage the respiratory system and the human surface; the other is spread by the wind, in the nuclear accident, nuclear fuel formed smoke and dust in the air during the explosion, causing widespread damage. It caused a certain degree of pollution to the surrounding soil, atmosphere, and water [8].

For the direct contamination caused by nuclear leaks can be addressed through various methods. One such method is the use of decontamination equipment, which

can remove radioactive particles from surfaces. Another technique is the use of radiation-resistant materials in construction. In addition, there are several nuclear radiation prevention techniques that can be used, including the use of radiation detectors, radiation shielding, and radiation monitoring.

To prevent secondary pollution from continuing to increase, physical, chemical, and biological methods are generally used to remove the surrounding media, including isolation and restriction methods, soil excavation methods, deep plowing methods, peelable film methods, forest restoration methods, and solidification and stabilization methods (Table 1).

Table 1. The technology contrasts

Technology	Advantage	Shortcoming	Applying
soil excavation methods	Effectively remove surface pollution	The removed soil requires secondary treatment; The cost is higher;	soil
peelable film methods	Blocking the transmission of pollutants	Not completely removed	soil
forest restoration methods	Green ecology，Lower cost	Plants grow slowly and take too long to repair	Soil; water
solidification and stabilization methods	The technology is mature and the cost is low	The pollution has not been fundamentally removed; The site cannot be reused; Waste of resources	soil
Monitoring method	Low cost, monitoring function	As an auxiliary means only,	Soil; water; air

4 UAV radiation detectors technology

Radiation detectors can be used to detect the presence of radioactive material, while radiation shielding can be used to protect against the harmful effects of nuclear radiation. Radiation monitoring involves the regular monitoring of radiation levels in the environment to identify any changes in radiation levels. Basic structure of UAV is represented in the Fig. 2. drones are the best monitoring mechanical drones include both the drone and drone system. Personnel are generally unable to enter nuclear contaminated sites. Technicians can control the drone through the drone system to reach specific goals. During this process, specific designs can be made for flight altitude, flight range, and drone type according to application requirements. For example, the mission altitude of high-altitude drones can reach up to 18,000 meters, while the mission altitude of ultra-low-altitude drones can be controlled within 100 meters. At the same time, the drone remote sensing system can also achieve information collection through ground auxiliary equipment. During collection, high resolution can be achieved. In addition, compared to satellite remote sensing, the information transmission speed of drones is faster and can transmit exploration information in real-time [9].

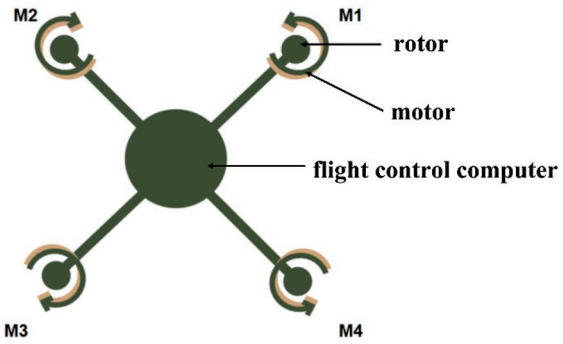

Fig. 2. Basic structure of UAV [9]

5 Use of uav in nuclear radiation restoration

Drones are increasingly used in nuclear radiation restoration efforts. They can be used to survey contaminated areas and assess the extent of the damage. They can also be used to deliver supplies and equipment to areas that are difficult to access. There was a nuclear accident in Fukushima, Japan. Drones can be used to investigate nuclear reactors under the control of technicians outside the site. At the same time, corresponding radiation sensing devices can be equipped on the drones to monitor the radiation level at the accident site, and the measured radiation information can be uploaded to the ground operation terminal or the command center. Based on the investigation results, medical personnel can carry out targeted treatments. At the same time, drones can also serve as relay stations to provide convenience for network communication. With

the cooperation of drones, nuclear emergency rescue can be developed in an orderly manner [10].

5.1 Investigation and image collection

Drones can carry high-definition cameras for image collection, providing comprehensive recording of nuclear contaminated sites. Drones can carry radiation measurement equipment for real-time monitoring and recording of radiation levels in nuclear contaminated sites. At the same time, the UAV can also act as a relay station to provide convenient network communication. With the cooperation of the UAV, it can promote the orderly development of nuclear emergency rescue.

5.2 Communication in disaster areas

Rescue workers can use drones to communicate with people in the vicinity of nuclear accidents and publicize radiation protection measures. At the same time, when a nuclear accident occurs, if the people around the disaster area do not know enough about the nuclear accident, it will lead to the spread of nuclear pollution [11]. Therefore, the rescue team can calm the people through drones, gain their trust, and effectively control the spread of the accident. In addition, when a nuclear accident occurs, the public should be organized to go back indoors as soon as possible to avoid deep nuclear radiation. However, the speed of information transmission of rescue is difficult for workers to guarantee, and the actions of the public can be controlled efficiently and widely by UAV.

5.3 Operational assistance

Drones can assist in nuclear contaminated site operations, performing hovering, fixed-point operations, and other precise work. It can reduce the casualty rate of rescue workers. Due to the spread of nuclear accidents on human beings, the physical and mental health of rescuers may be endangered if no protective measures are taken. However, drones can accurately understand the situation of the site without the need for rescuers to enter the site, so as to make appropriate rescue preparations [12]. The application of UAV can minimize the direct contact between rescuers and the disaster-stricken people, and help within the safe range. For example, when handing out protective materials, rescue personnel can operate unmanned aerial vehicles to drop them on site, thus comprehensively improving the safety of nuclear emergency rescue.

5.4 Improving the nuclear emergency rescue system

As a science and technology of high practical value, UAV can collect information more quickly, arrive at the site of nuclear accident in the first time, and have an in-depth understanding of the whole process of nuclear accident. When establishing a nuclear emergency rescue team, it is necessary to collect site information as soon as possible and communicate the information. The flight speed and height of UAV has certain controllability. In this process, the image data collected by UAV has high resolution, accuracy and reliability [13]. At the same time, the relatively small UAV can also observe the site information closely and conduct detailed investigation on the nuclear accident site, so as to further improve the nuclear emergency rescue system.

6 Conclusion

The impact of nuclear radiation following the Japan earthquake has been significant. It has had a devastating effect on the environment and human health. The use of drones is an exciting development in nuclear radiation restoration efforts and has the potential to play a significant role in future restoration efforts. UAV can effectively improve the emergency rate in nuclear emergency rescue, and collect on-site information more accurately and quickly, thus improving the pertinence of rescue. At the same time, the rescue team can also use drones to publicize the nuclear accident response measures, maximize the protection of the disaster area people, reduce the impact of nuclear accident on people's personal safety. In addition, in nuclear emergency rescue, the flexible performance of UAV is also relatively high, which can effectively increase the disaster relief efforts and comprehensively improve the rescue level. Although the application of drones in nuclear radiation recovery work has broad prospects, there are still some challenges and difficulties at present. For example, how to improve the accuracy and stability of drones in nuclear contaminated sites, and how to ensure the safety and reliability of drones, etc. Therefore, it is necessary to continue to strengthen the research and development and application of drone technology in the future, in order to better cope with the challenges brought by nuclear radiation and make greater contributions to the restoration of the environment and human health.

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