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Review of Varied Types of Rescue Robotics with Their Functions and Shortcomings

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Abstract: It is an undoubtful phenomenon that earthquakes are still affecting humans' lives and causing a dramatic amount of death. Therefore, with the popularity of rescue robotics in recent years, varied types of rescue robotics appear to assist humans in the rescue process. Using the literature reading and review method, 4 types of rescue robotics will be discussed with their functions examples and future improving aspects. The research robotics mentioned are analyzing robotics, locating robotics, rescuing robotics, and medical robotics, which can primitively use the related data to analyze the happening of earthquakes as well as the environmental situation after earthquakes. Next, the system will locate the injured and dispatch them to the rescue center. With diverse assistance provided by rescuing robotics, the operation of rescue will be much more efficient. Eventually, some simple diagnoses and surgeries will be performed through medical robotics, increasing the possibility for the survival of the wounded. While the rescue robotics have gained the basic capability to act, more improvement in precision and multifunction will be given to them.

Keywords: rescue robotics, earthquakes, artificial intelligence, survivors rescue.

1. Introduction

Earthquakes nowadays are still a severe question for humans because of their randomness [1], the increased possibility of occurrence, the extremely high fatality rates, and the casualty rates with the collapse of buildings. For example, in 2001, more than 20 thousand people were killed as well, and 167 thousand people were injured in Gujarat [2]. In 2008, sixty-nine thousand two hundred and twenty-seven people were killed and more than fifteen million and one hundred thousand people were injured in Wenchuan [3]. As there are a huge number of people who died because of the late rescue, it is of great importance for humans to improve their rescue efficiency to save more lives of survivors. Thus, to assist humans in responding to disasters and rescuing the injured during the earthquake, a huge amount of rescue robotics has been invented recently, which has been proven to have a positive effect on rescue after the earthquake. In this essay, using abundant related models and documents, varied kinds of rescue robotics will be introduced in detail, firstly with explanations of their applications, their functions, and eventually their future direction in improvement, which will show the process and progress of the existing rescue robotics, helping people to get a better understanding of them. Besides, this essay will also provide evidence and a theoretical foundation for further learning in rescue robotics and methods to combat extreme natural disasters.

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2. Necessity Analysis of Rescue Robots

The rescue robotics used can be divided into 4 types, including analyzing robotics, locating robotics, rescuing robotics and medical robotics. Each type of robotics can provide efficient assistance to humans in saving the lives of the injured in earthquakes.

While the happenings of earthquakes and other disasters often have the same characteristic that their happenings and caused situations are complicated, which will definitely inhibit humans from responding quickly, leading to high fatality and casualty rates. Therefore, the application of robotics is essential. Robotics often works before and during the whole process of rescue. As the seismic wave and other pieces of evidence that are related to the happening of earthquakes are caught, the analyzing robotics can help researchers in analyzing the data and estimate the time and centre of the earthquakes, sending warnings to the government to evacuate the masses, reducing the possibility of causing the huge amount of death. Besides, they can also be applied during the rescue to provide more suggestions for rescuers to act more efficiently. Rescue robots can directly determine the center and magnitude of an earthquake and measure the severity of building collapse. At the same time, the application of such robots can plan routes based on factors such as population density, danger level, and distance, allowing rescuers to take priority actions and save as many casualties as possible.

It is extremely significant for rescuers to obtain the location of the survivors to react and save them. Thus, the locating robotics are acting an essential role during the process of rescue. Unfortunately, after the disasters, especially the earthquakes, the situation of the environment is poor, leading to the difficulties and challenges for researchers to overcome to discover the location of the injured. However, while the positioning system and technology have been improved dramatically, the locating robotics nowadays can be applied to find the survivors and give their locations back to humans efficiently. For example, with the use of specific radio networking, the locating robotics can quickly respond, collect coordinates aerobatically and send messages with data included to improve the rescuing efficiency, which has been proved by the ICARUS project [4]. The application of rescue robotics here truly can save more people's lives through reducing the dangerousness of rescue greatly with precise locations.

The rescue in earthquakes can be risky, for the reason of the random happenings of aftershocks and the instability of ruins. Hence, it is safer and more efficient to use rescuing robotics to assist humans and eventually replace their work. The rescuing robotics can have different functions, such as removing the blocks on the injured, carrying the survivors, protecting the security of the rescuers and providing various assistance. The rescuing robotics can widen the openings in the ruins to provide an entrance for both people and robotics to operate further, similar to the robotics reported in 2014. Additionally, they are capable of bearing a significant portion of the collapse's weight, which will allow the other robotics to enter and rescue the survivors [5].

After analyzing, locating, and rescuing, the survivors can be saved from the ruins. However, heavy bleeding and wound infection could lead the survivors to pass away right away if proper, timely treatment is not received. Thus, the medical robotics should also be deployed during the process of rescue. Using the special network, the medical robotics can be connected to the hospitals even if the surrounding signal stations are destroyed, which can diagnose the health situations of survivors, perform simple surgery while returning to the safe zone and develop a follow-up treatment plan in advance. One type of medical robotics, assembled with the system called focused assessment with sonography for trauma (FAST), can be attached to the body of the injured and make simple diagnose to them to greatly improve the prospects of survival [6], which has been proved to be practical with further experiments.

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3. The Applications of Rescue Robotics

Through the applications of varied types of rescue robotics, rescue efficiency and safety have been improved dramatically with those intelligent inventions. Besides, the percentage of survival has also increased due to the timely diagnose and treatment. As some of the rescue robotics have been used practically, the success they achieved can provide further evidence to prove their usefulness.

Because robotics analysis, robotics location, and robotics rescue are closely related, they typically operate in tandem to remove survivors from the wreckage and transport them to a safe area. In order to identify the location where other survivors might be found, robots analysis will first gather all the data and information. Rescuers and other robotics will then be sent to search. Then, the location of the injured in the ruins and the designed routes that have the highest efficiency and safety to reach the destinations will be discovered and sent to the rescuers with the assistance of the locating robotics. Eventually, the rescuing robotics will carve out a way, support the ruins, create a safe environment for rescuers to perform and then move the injured out of the ruins.

After the process of analyzing, locating and rescuing, the medical robotics will make personalized diagnose to the survivors with simple surgery. The results will be sent to doctors to increase the efficiency of healing.

As the rescue robotics have had enough theoretical evidence, they have been invested in testing and performing actually in reality. In 2008, the National Training Base for Search and Rescue (CNTBSR) was settled in China to make experiments on their rescue robotics [7]. After 2 years of testing, their rescue robotics proved to be efficient successfully and were put into use in 2013, providing assistance to the rescuers and finally saving much more injured in a magnitude 7.0 earthquake.

Besides, in 2024, a new evaluation method was created and put into practice to enhance the adaptality of rescue robotics in complex environment when performing [8], which was tested, evaluated and ranked through the DEA model

These example truly demonstrates the feasibility and the possibility in perspective development of the nowadays rescue robotics.

4. Future Research Direction of Rescue Robotics

While the existing rescue robotics have accomplished the tremendous achievement, they still have a mount of shortcomings that need to be overcome in the future.

It is of great importance for engineers to provide further improvement for the precision of the operation of rescue robotics, though they have a degree of accuracy nowadays. The environmental situation after earthquakes can be severe and complex; the small error in the operation may lead to the re-collapse of the ruins and cause excessive death or injury. Besides, during the performance related to the survivors, the inaccurate operation may hurt them, further aggravating the condition of the wounded. Thus, the precision of the operation of rescue robotics should get more attention in its development in the future.

After the happenings of the earthquake, the surrounding signal stations are considered to be destroyed, leading to the communication outage without essential signals, which will definitely influence the process of rescue badly. In that case, as the rescue robotics may lose connection to the manipulators, they may stop their operation and get stuck in the ruins. Therefore, the signal receivers of the robotics should be developed so that they are able to receive signals even when the stations are not working, which can be realized through the 5G technology. What's more, while improving their receivers is only one method to keep connection to the manipulators, some rescue robotics should also be set to act as simple signal stations or fix the surrounding signal stations to prevent the accidence and recover the area communication quickly.

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The ruins of the buildings in the disaster area are unstable and dangerous for humans to perform. With the severe environmental situations, the mortality of the rescuers is high, causing extra casualties to society. To better reduce the casualties of humans, future rescue robotics should gain the capability of replacing more artificial work with advanced intelligence. For example, while the process of rescue can be regarded as teamwork, rescue robotics can be more self-operated with the connection to the others, forming a collecting-analyzing-operating system, which will reduce the number of rescuers dispatched to the spot. Besides being removed from the ruins, the survivors are desperately in need of emotional care. In the past, emotional care was provided by related professional rescuers. With the development of artificial intelligence, emotional care nowadays can also be produced through trained rescue robotics. After multiple simulation pieces of training with daily conversation and special dialogue, they will be able to supply appropriate emotional value to the injured and reduce their pressure and desperation greatly.

5. Conclusion

In conclusion, the happening of earthquakes nowadays is still a severe problem for humans, especially the rescue of survivors after the earthquakes, which is influenced by many factors. To overcome this, rescue robotics are created to assist humans to save more injured with high efficiency. The types of robotics are diversified, including analyzing, locating, rescuing, and medical robotics. These types of robotics all have their function in the process of rescue, and they can also operate as a cooperating system to work in sequence, which can not only improve the efficiency of the rescue process but also reduce the risk acted on by human rescuers. Unfortunately, the technology of rescue robotics is still immature, with many unsolved problems and weaknesses that may impede the process and even cause the extra death and sacrifice of humans. As the further direction has been discovered and settled, rescue robotics will have a brighter future and save more lives in reality in the future.

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