Development of an Unmanned Ground Vehicle for Prevention of Radioactive Disasters by Providing Outdoor Radiation Information in Nuclear Facility

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1. Introduction

Nuclear facilities are safely managed to prevent radiation leaks. Furthermore, a government-level response system is in place to prepare for any potential emergency. Nuclear facilities conduct annual mandated drills to prepare for nuclear emergencies. In the event of a nuclear emergency, human workers are often the primary focus. However, if human workers are deployed to perform initial response before a radiation leak is confirmed, radiation exposure can cause harm. To address this, it is advisable to utilize robots in the early stages of a radiation emergency to assess the extent of damage and radiation levels in the disaster area. Recent advancements in drone technology have led to its use in various industries and the creation of radiation maps for nuclear emergencies. However, measuring radiation from the air can be difficult due to the inverse square of the distance, making it difficult to measure radiation distribution.

The stakeholders of nuclear power plant has been tried to adopt smart technologies for safety management. Various types of robots has been studied to applied to nuclear facility [1-3].

This paper describes the development of an unmanned ground vehicle that provides outdoor radiation information at nuclear facilities.

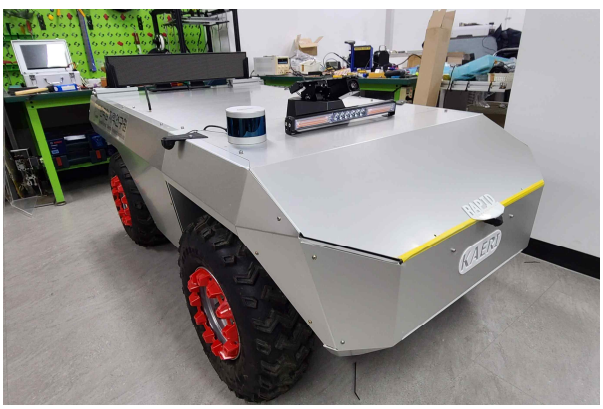

Fig. 1. The developed unmanned ground vehicle for prevention of radioactive disasters by providing outdoor radiation information in nuclear facility

2. Development of an Unmanned Ground Vehicle for Prevention of Radioactive Disasters

2.1 Design of an unmanned ground vehicle

By using robotic technology, an unmanned ground vehicle was developed for outdoor patrols of nuclear facilities during emergencies. The design requirements for the robot were established as follows:

- Unmanned driving capability via remote control
- A top speed of over 40 km/h
- High-brightness LEDs for nighttime driving
- Broadband data transmission and reception via wireless LAN and LTE
- Video transmission to monitor on-site conditions
- Lidar sensors for driving safety
- Equipped with an electronic display board to provide disaster and evacuation information
- A voice transmission function capable of broadcasting announcements

To implement these design requirements, the unmanned ground vehicle was developed, as shown in Fig 1.

2.2 Teleoperation control system for the unmanned ground vehicle

The developed unmanned robot is primarily controlled remotely, taking into account responsibility for tasks. Its functionality has been expanded to include partial automation and autonomous driving within delegated authority. The remote control system's user interface consists of two screens to effectively display robot information, image data, map location, and sensor data such as radiation and lidar.

As shown in Fig. 2, front and left/right camera screens monitor the robot's path and provide a field of view for remote control. The main zoom camera, with its pan/tilt mechanism, can be adjusted up, down, left, and right, allowing for detailed observation of the disaster site, such as observing ground debris and identifying victims. The robot's current location is

displayed based on a satellite map, allowing for immediate navigation to the location in the event of unusual events, such as abnormal radiation levels or the discovery of injured individuals. The measured radiation is displayed numerically, and the presence of surrounding obstacles is indicated by point clouds using lidar. It is designed to display robot status and malfunctions, such as remaining battery level, blinking lights, and an electronic display.

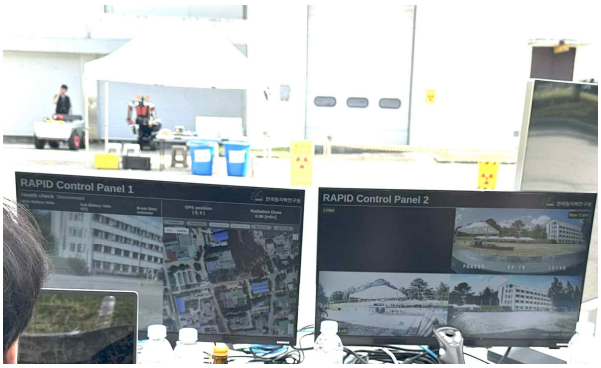

Fig.2. User interface for teleoperation control of the developed unmanned ground vehicle

3. Application to Actual Drill at Nuclear Power Plant

The developed unmanned robot was deployed in a statutory disaster prevention training exercise at a nuclear power plant, demonstrating its utility. The training scenario assumed a complex disaster situation involving an earthquake and a fire, and involved a human-centered disaster response, including the deployment of firefighters to suppress the fire, while allowing the robot to participate alongside the situation.

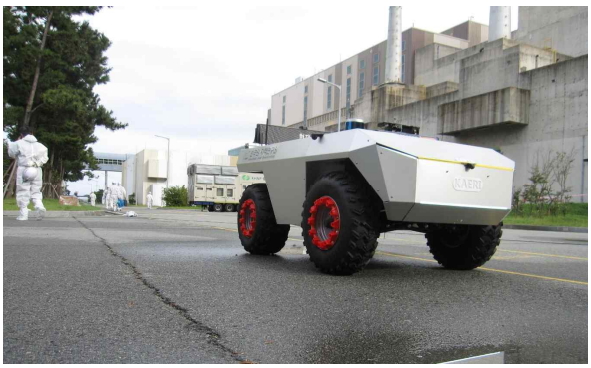

Fig. 3. Mandated drill at NPP with the developed unmanned ground vehicle.

As shown in Fig. 3, the developed robot was deployed to detect areas of high radiation levels following the fire and in the event of a radiation leak. It patrolled the outdoor nuclear power plant site unmanned, and if an area with high radiation levels was detected, it immediately reported it to the command center, preventing disaster response workers from approaching the area..

4. Conclusions

In this research, an unmanned ground vehicle was proposed for prevention of radioactive disasters by providing outdoor radiation information in nuclear facility. The unmanned ground vehicle provides radiation information to help avoid radiation exposure risks during the initial response to a radiation emergency, which is typically conducted primarily by human personnel. The developed robot is also able to provide real-time video information on the scene of a radiation disaster and detect high-radiation risk areas. The teleoperation control system was integrated to remotely control the unmanned ground vehicle, enabling it to be controlled from a safe remote location via high-bandwidth Wi-Fi and LTE. Furthermore, evacuation information was provided via electronic displays and broadcast announcements, guiding victims still present on site to evacuate. The developed system was deployed at a law mandated drill in an actual nuclear power plant, and the usefulness of the developed system was verified.

ACKNOWLEDGEMENT

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