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An Aerial and Ground Monitoring System for Nuclear Accidents

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1. Introduction

Nuclear accidents have been a public concern since the first nuclear reactors were constructed. Nuclear accidents involve radioactivity leakage, which can cause a catastrophic environmental disaster. Therefore, the emergency response to nuclear accidents is crucial in the early stages.

A variety of robots and automation machines has been used to identify accident situations on behalf of human workers. In Fukushima, various types of robots have been being used for radiation measurement, identification of accidents and decontamination [1].

Among the unmanned tasks, our concern is how to quickly identify the vast power plant site efficiently. Generally, nuclear power plants are huge and consists of many auxiliary buildings. In addition, the individual buildings are high, large and complicated. Therefore, it is practically difficult to acquire information of the accident with the existing robot systems in a quick manner. To deal with the problem, we propose a robot system that combines a ground and aerial vehicles to monitor the accidents.

2. Remote Control System for Accident Monitoring

In this study, we propose a joint operation system of unmanned ground vehicle and unmanned aerial vehicle to perform rapid ground to aerial accident monitoring.

2.1 Unmanned Ground Vehicle

An unmanned ground vehicle (UGV) should be capable of traversing various terrains such as inside / outside of nuclear facilities and surrounding areas. In addition, the ground vehicle should be easily controlled, durable, highly mobile and capable of carrying a sufficient payload for mounted sensors and instruments. To meet these requirements, an all-terrain vehicle (ATV) was selected as the UGV [2].

The ATV has excellent maneuverability and can quickly access to the nuclear reactor building in a distance. The ATV was robotized to be controlled. The overall ATV system mainly consists of a communication unit, a control unit, and an actuation unit.

The communication unit transmits the control command remotely and utilizes the frequency band of 400 MHz. The control unit is composed of a microcontroller and control algorithms, and generates control commands for the actuators. Finally, the actuation unit performs the operation of the ATV mechanisms.

2.2 Unmanned Aerial Vehicle

Unmanned aerial vehicles (UAV) are divided into fixed-wing and rotary-wing aircrafts depending on the type of wings. Rotary-wing aircrafts are relatively slower and less efficient than fixed-wing aircrafts. However, it is suitable for acquiring data in a stable position thanks to its attitude control algorithm and hovering ability.

Quadcopters are the representative type of fixed-wing aircrafts and have excellent maneuverability and flight stability. For the aerial monitoring tasks, we chose a quadcopter as an UAV.

2.3 Power Transmission System

A quadcopter has a short operating time due to the limit of battery capacity. Therefore, it is inappropriate to carry out a long time or large area flight missions. To deal with the critical problem, the power transmission system (PTS), which includes a wired power transmission, winding device and a landing platform, was designed to increase the operation duration and area.

As the power transmission device, wired system was adopted because, it can constantly supply electric power stably. The electricity generated by the engine of the UGV is stored in a large battery located in the UGV, which is then transferred to the quadcopter through PTS. The power transmission capacity of the current model is 300 Watt.

The quadcopter should be able to fly freely in the air with least disturbance generated by the PTS, while receiving constant power. Therefore, a winding device was designed to keep the tension of the power line between the quadcopter and UAV at a proper level and to maintain the flight stable.

The landing platform is the structure for the quadcopter's takeoff and landing. It is located behind the UGV so that the quadcopter does not interfere with the UGV, and is made of a shock-absorbing polymer for safe landing and stable traveling while the UGV is running.

Fig. 1. Remote control system for accident monitoring (RAM)

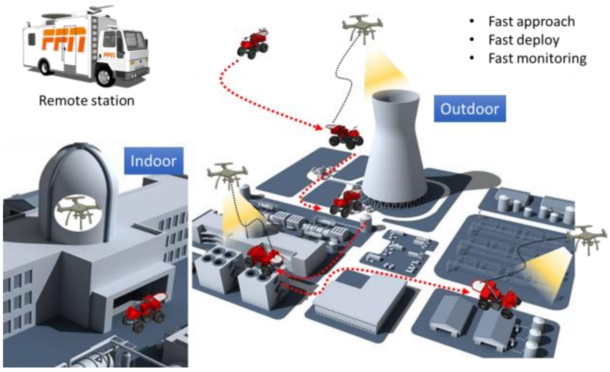

Fig. 2. Remote monitoring operation scenario

2.4 Specifications and Operation scenario

The proposed UGV-UAV combined system, RAM (Remote control system for Accident Monitoring) was built as shown in Fig 1. The RAM runs at a maximum speed of 60 km/h with a payload of 160 kg. Operation duration is over 5 hours in the distance of 1 km. Thanks to the PTS, the quadcopter can fly continuously without any restrictions to the operating time and can fly within a radius of 50 m from the UGV

The RAM can be operated as the scenario shown in Fig. 2. When a nuclear accident occurs, the RAM will acquire information by approaching to the accident site rapidly, and then the quadcopter will be deployed to monitor accident consequences in the air. The collected data from the ground to the air will be sent to the operator to make crucial initial decision-makings.

3. Conclusions

In this study, we discussed an aerial and ground remote control system, which can be applied to the nuclear accidents. Based on the characteristics of the nuclear power plant, we selected the specific types of UGV and UAV, which can be used for accident site monitoring. In addition, PTS was designed for an effective operation of the quadcopter. In the future, we will verify the performance of the RAM through the mock-up environment, and improve the sensor and control systems.

REFERENCES

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