Development of a Virtual Simulation Environment and Control System for a Nuclear Incident Response Robot

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1. Introduction

Following a nuclear accident, the surrounding environment becomes highly radioactive and inaccessible to humans due to the associated hazards. To address this critical challenge, there is a growing demand for advanced emergency response robotic technologies. At nuclear incident sites, emergency response robots play a crucial role in tasks such as debris removal and the establishment of access routes, often involving heavy payloads. However, real-world robot experiments have many limitations such as time and resources. This paper introduces the development of a virtual simulation environment and control system for a nuclear incident response robot. In this paper, we discuss the hardware requirements and the software framework for virtual simulation.

2. Hardware Requirements for Virtual Simulation

Among various hardware configuration options, our particular focus is on Unity, Nvidia's Omniverse, and ROS as potential software platforms. It is worth noting that Nvidia's Omniverse platform, in conjunction with its associated robot development platform, Isaac Sim, places relatively high demands on computational resources. Consequently, we have defined the hardware requirements with these considerations. Specifically, when configuring the hardware with Nvidia's Omniverse Platform as the benchmark, our goal is to achieve the highest possible CPU and GPU performance.

The hardware requirements entail the use of either Ubuntu 18.04/20.04 or Windows 10 as the operating system, the deployment of a 12th Generation Intel Core i9 processor, a minimum of 64 GB of RAM, the utilization of a 2 TB SSD for storage, and the adoption of an Nvidia Geforce RTX 3090 graphics card with 24 GB of memory. With these specifications in place, we have established the appropriate hardware prerequisites for the development of a virtual simulation environment designed for unmanned disaster response in diverse accident scenarios.

3. Software Framework

The primary objective is to develop software for virtual simulation environment capable of effectively responding to various accident scenarios. This software must incorporate response protocols customized for different emergency situations, allowing for the rapid and efficient utilization of robots. To accomplish this, the system needs to be proficient in coordinating a diverse set of robots with varying forms and configurations, enabling the formation of teams that can collaboratively execute missions.

Furthermore, the system should support the heterogeneous operation of the robots, including real-time monitoring of their individual statuses and facilitating maintenance as needed. Efficient data management is also paramount, necessitating the seamless sharing and management of data collected by the robots, encompassing visual data and environmental information such as terrain data, temperature, and radiation levels.

Moreover, the system should allow for data reconstruction and effective visualization, empowering comprehensive situational assessment. In the event of communication breakdown or robot malfunction, the system must ensure secure handling following predefined protocols, with minimal impact on the overall operation of the robots.

Considering the challenges posed by environments with limited accessibility, particularly in scenarios like nuclear power plants, the system should provide the capability for comprehensive training and validation in virtual environments to effectively prepare for diverse accident scenarios. To meet these requirements, our software architecture includes local coordinator

software for individual robots and global coordinator software for overseeing both individual robot operations and the overall system operation efficiently.

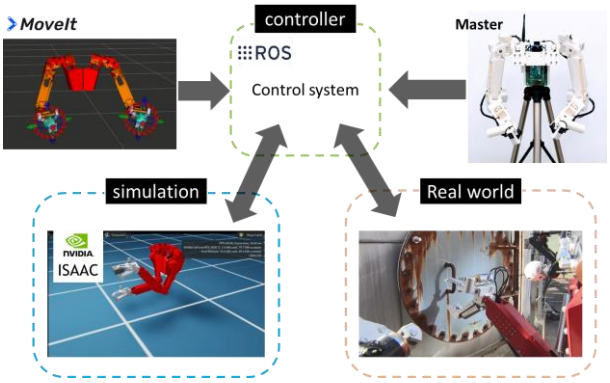

Fig. 1. Virtual simulation software framework for nuclear accident response robot

4. Conclusion

In this paper, we have derived the hardware requirements for a virtual simulation environment and control system for a nuclear incident response robot Additionally, we have presented the software framework. In the future, we plan to simulate disaster response robots in various nuclear incident scenarios within the virtual simulation environment.

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