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An estimation to measure and to evaluate the work times following the trajectory of workers during decommissioning of nuclear facilities

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ABSTRACT

This paper is intended to suggest an approach to an estimation of the work time to optimize the trajectories of workers during decommissioning of nuclear facilities. The working times during decommissioning for nuclear facilities have a great effect on safety and costs. The key feature of this work is to analyze and to evaluate the working times in virtual decommissioning environments. The measured data are statistically analyzed into the mean and variance work time and radiation exposure dose. It is expected that the safety of decommissioning will be improved and decommissioning costs can be reduced. It can be concluded that this work will make it possible to efficiently establish the ALARA plan for decommissioning of nuclear facilities.

1. Introduction

Decommissioning of nuclear facilities has to be accomplished by assuring the safety of workers because the decommissioning activities of nuclear facilities are under high radioactivity and work difficulty (IAEA, 1999, 2008, 2013, 2014). 'External exposure' is the most potential hazard to workers during decommissioning of nuclear facilities other than hazards and is an occupational exposure to workers during decommissioning of nuclear facilities (IAEA, 2013). It is necessary that before decommissioning, the radiation exposure dose of workers is analyzed and assessed under the principle of ALARA (as low as reasonably achievable).

This work is intended to suggest an approach to an estimation of the work time to optimize the trajectories of workers during decommissioning of nuclear facilities.

2. The methodology of estimation on work time to optimize the trajectory

To optimize the occupational exposure doses to workers during decommissioning of nuclear facilities, a systematic approach to estimate the work time during decommissioning of nuclear facilities is presented in Fig. 1. As shown in Fig. 1, first, a decommissioning scenario as designed. The decommissioning scenario is converted using 3D data. The converted data are input into the virtual decommissioning environment. Based on the virtual decommissioning environment, experiments were carried out and the work time of workers is measured. In the end, to optimize the occupational exposure dose, the work time of a decommissioning scenario is estimated.

The virtual environments of decommissioning were developed with Unity3D and were composed of three design phases. The three design phases consist of 3D mapping, scenario development, and radiation mapping. Fig. 2 shows that a reactor is being mapping as 3D data and illustrates the scenario development of fulfilling a reactor pool. And Fig. 3 presents radiation mapping of a reactor. The radiation mapping means the amount of dose distribution in a reactor. The raw data of dose distribution can be gained from MCNP (Monte Carlo N-Particle Transport) code.

3. Experimental method to optimize the trajectory of workers during decommissioning

3.1. Experiment in virtual decommissioning environments

The experiment was accomplished using the scenario-based system as shown in Fig. 4 (Jeong et al., 2014). On-the-job training of decommissioning works could effectively train decommissioning workers but this training approach could consume much costs

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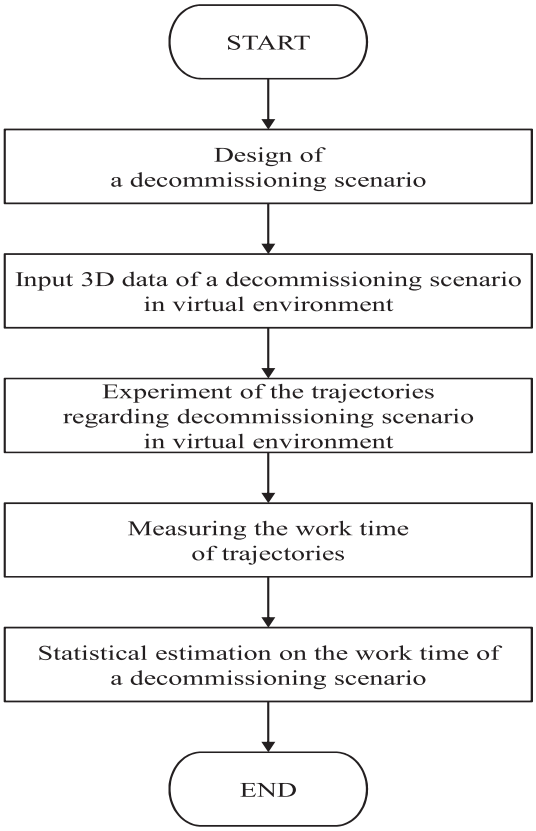

Fig. 1. The procedure of work time estimation.

and poor modifications of scenarios. The efficiency of virtual training system could be much better than that of physical training system (Freitas et al., 2014; Mol et al., 2009). When a subject puts a head-mounted display (whereafter 'HMD') on their heads, the graphic server of the virtual training system is operated. The graphic server receives data of the worker's changes in direction. The graphic server exchanges the data management unit with the detected numerical data. The graphic server provides the HMD with pictures of the direction response, and the monitoring device with pictures of the worker's location and behavior. In this situation, the worker is in first person mode and recognizes the decommissioning scenarios with the HMD as those of working in place. On the other hand, the manager is in third person mode and can keep up with the location of the worker and the working situation.

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3.2. Statistical analysis

On the basis of the scenario-based system, data of the measured work time are analyzed and evaluated through a program evaluation and review technique (whereafter 'PERT'). Data of the

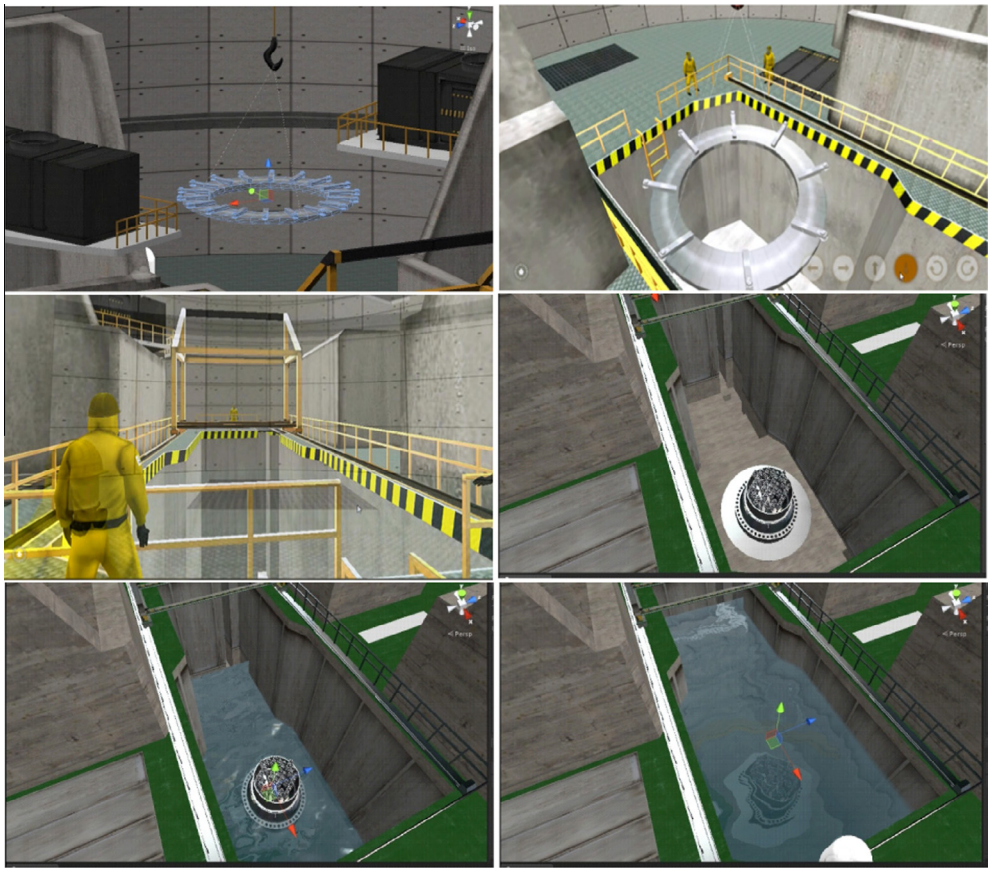

Fig. 2. The 3D mapping in a reactor.