3-D Virtual Reality Based Radiological Exercise System Phase 1 Study: Basic Modelling of Implementing Virtual Reality

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1. Introduction

Currently, Act on Physical Protection and Radiological Emergency (APPRE) of Nuclear Safety and Security Commission (NSSC) stipulates that a full scale radiological exercise shall be conducted where emergency response organizations under the national emergency prepared and response system and the public shall be participated in and emergency planning zones are expanded by the stipulation of reinforced legislation of APPRE [1]. On the other hand, the situations of exercises have been evaluated as in low efficiency levels and personnel participations by the public in exercises as poor [2,3]. To overcome these issues, there have been increasing demands of new concept such as virtual reality (VR) technology for a radiological exercise system. And varieties of the VR based systems have been developed and applied to the nuclear power plants and related areas in abroad [4, 5]. Now it is believed that the VR based radiological exercise system would be a practical alternative system for the solution to increase the public participation. Thus, we proposed an exercise scenario structure applied with event tree methodology, which might be suitable for the VR based radiological exercise system [2, 3].

Concurrently, as a more concrete stage, we conducted phase 1 study during the development of the 3-D VR based radiological exercise system to enhance the efficiency of the VR implementation, which is the core content of the proposed exercise system, and expand the comprehension about an exercise by the public. The objectives of this phase 1 study are as follow:

- To utilize the outcome of the study as basic data in the implementation of VR by thorough grasping of the overall exercise situation including scenario, and
- To derive prospective tasks to be overcome through the basic modeling of 3-D VR implementation.

During the initial stage in the development of the conceptual design of the system we had success in producing two types of primitive study results. One is a video file with contents of public response actions during an emergency. The other is a prototype VR based exercise system with series of success events.

2. Video File with Contents of Public Response Actions

The aim of this video production task is intended to obtain the followings:

- To understand the objects and scopes of VR implementation;
- To plan the parts in the VR implementation that shall be emphasized and/or skipped;
- To plan the areas where the public reactions are required; and
- Develop the operational logics for the VR implementation with the basic data obtained.

Fig.1 to Fig. 6 in the video file shows some scenes of the public response actions as examples when a site area emergency is announced and the emergency management authority advises indoor sheltering for the public and moving to assembly posts. It also demonstrates the public response actions when a general emergency is announced and the emergency management authority advises evacuation of the public and moving to a shelter. In the clips, the public response actions ought to be taken by step-by-step methods for individual events are introduced. Events include announcement of an emergency, perceiving an emergency, indoor sheltering, preparation of moving to assembly posts and moving to a shelter for evacuation when a general emergency is announced.

The video file was recorded with a smartphone and edited for sound effects and captions by a BEES' staff member. He produced 4-minute running time file focusing on the two major points. Staff member recorded images of tutorial type training mode scenes for the public based on the events with successes. He chose the simplest scenario among the event tree structured exercise scenarios. We also had to convince a person who participated in the motion pictures for emergency response actions and selected a resident person to enhance the sense of realism. Few video clips are listed for reference:

Fig. 1. VR based radiological exercise system: Basic scenes of an exercise

Fig. 2. Event of perceiving a site area emergency

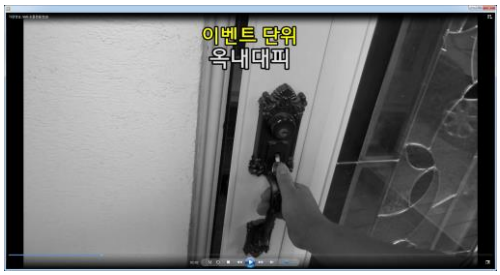

Fig. 3. Event of an indoor sheltering

Fig. 4. Event of perceiving a general emergency

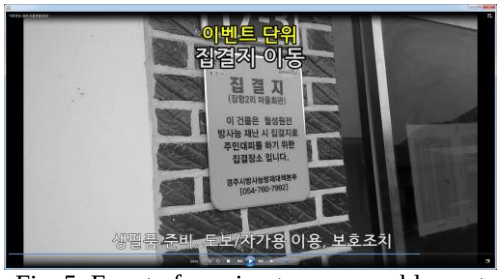

Fig. 5. Event of moving to an assembly post

Fig. 6. Event of moving to a shelter

3. 3-D VR Modelling for an Exercise System with Series of Success Events

The 3-D VR modelling aims at achieving the followings:

- To obtain a ground work for the VR implementation for the head mount displays (HMDs) device in the future;
- To examine the prospective problems when VRs are implemented and preparing countermeasures;
- To conduct a basic survey to determine the work scope, resolution of the modelling image, and so on; and
- To develop the operational logics for the VR implementation by obtaining the basic data from the 3-D modelling.

A prototype VR based exercise system with series of success events was developed and tested to identify any possible difficulties in the future and to reduce the number of trial and errors during the phase 2 study of 3-D VR Based Radiological Exercise System. From this primitive attempt the weak points in the emergency arrangements and strategies which we now have were identified and deduced. Among the weak points identified, no arrangements are provided for failures in the response actions by the public during a complex disaster and no consideration made in case of individual arriving at a shelter instead of moving as groups of evacuees by public transportation vehicles.

The 3-D modelling task was undertaken by our coworkers at TIUM solutions. They used computer graphic software such as CADs and/or CAMs and employed various algorithms to materialize the VR implementation. They also produced 4-minute 3-D VR program. Few video clips are listed from Fig. 7 to Fig. 13 for reference:

4. Results and Discussion

Urgency from a Radiological Disaster: During the phase 1 study we had experienced a lot of difficulties in implementing VR into the radiological disaster

which humans are not able to recognize with their five senses contrast to natural disasters such as flood, Tsunami, or earth quake.

Fig. 7. Identify an emergency message on a cell phone

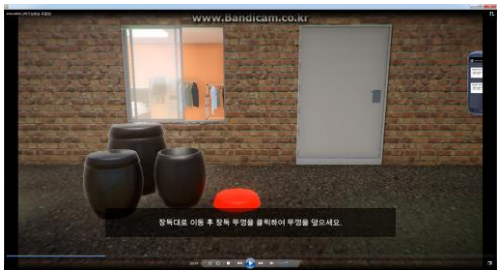

Fig. 8. Cover a pot with the lid

Fig. 9. Shut the windows and doors in a house

Fig. 10. Put the contaminated clothes in a waste bag

Fig. 11. Turn on a TV to watch news

Fig. 12. Announce a site area emergency at WSN

Fig. 13 Announce a general emergency at WSN

We employed the implementation of the urgency and tension caused by the nuclear power plant accident during the introduction period with few vivid video clips of serious calamity scenes.

Sense of Realism: We also realize that there is a great need to catch the participants' eyes and provide them senses of realism by introducing the prominent geographical features near their residential areas.

Importance of Protective Actions: The main goal of a radiological exercise is to educate the public with technical know-how to take response actions to protect themselves from radiation during an emergency where massive amount of radioactive materials released from the nuclear power plants. However, there are high possibilities to deteriorate the efficiency of an exercise and reduce the public interests by the negligence of delivering the real meaning of emergency preparedness and response due to the heavy concentrating on the know-how of the protective actions. To eliminate these kinds of mistakes and enhance the efficiency of an exercise, there should exist simultaneous delivery of real meaning on individual protective actions along with know-how according to each emergency situation. To achieve this goal, it is required that the public fully understand the mechanism of radiation exposure (external and internal) and that of diffusion of a radioactive plume when we implement contents of VR.

Self-Evaluation of Performance: During the early period of phase 2 we studied to set up ground rules for evaluating the self-performance level of participants when conducting an exercise. Based on these rules we will derive factors required for

exercise evaluation such as times consumed for exercising, accuracy, and exposure doses and method(s) how to evaluate the performance. Then, we might need the practical application plan for these factors and method(s).

Mobile Vehicle Installed with the Radiological Exercise System: Because there are some difficulties in calling the public involved in economic activities for an exercise to the assembly posts, there is a need to consider a mobile vehicle installed with the radiological exercise system for multi users to resolve this issue. For example, first we deliver network servers and personal computers (PCs) to the assembly post such as a townhouse where prospective trainees are waiting and then connect servers and PCs with cables from a mobile vehicle installed with the exercise system or provide the public a vehicle with servers and PCs on board to manipulate the exercise system. However, we have to discuss the matter with local governments who are the prospective buyers of the exercise systems.

Determination of the Session Length of and Number of Participants in an Exercising: Because the speed of image processing of VR is limited, there is a need for the proper session length of an exercising due to the possibility of the occurrence of participants' simulation sickness from a long exercising session and limitation of the personal concentration period in an exercising. In determining the session length of an exercising, there are needs to search for reference materials and experts' comments in making-decision on the session. Because the local governments are responsible for educating and training the resident public, there is also a need to find the effective plan for an exercising. In other words, even though it is a very effective way for local governments to arrange large number of participants in the training and education program but they have to consider the venue, contents, and optimized number of participants of a training and education session (need discussions with a local government).

Determination of the Processes and Modes of an Exercising according to the Participants: Determine the proper processes and modes of an exercising for individual groups of participants such as juvenile, male or female adults, seniors.

5. Conclusions

As discussed earlier, the VR exercise system to be developed aims at exercising large number of the public, and it is believed to have a huge effectiveness in the radiological exercise where an exercising of the personnel mobilization type is not readily available. We conducted this study during the period of phase 1 of developing the 3-D VR based radiological exercise system for the public, and won successes both in production of a video file for the radiological emergency exercise of a rudiment type and 3-D VR modelling of an exercise system based on contents of the video file. We are planning to utilize these results as the basic data in developing concrete VR contents in the future. Even though the 3-D VR exercise system introduced here is intended for only the public, other VR based exercise systems customized for the personnel in various response organizations under the national emergency preparedness and response system are expected to be developed according to their specific needs in the near future, if needed.

Acknowledgements

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