

Review of Virtual Reality Technology Application in Fire and Medical Exercise for Development of VR based Radiological Emergency Exercise System

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1. Introduction

After Fukushima accident, importance of radiological emergency exercise system has been emphasized. The article of Act on Physical Protection and Radiological Emergency (APPRE) was amended as "A nuclear licensee shall formulate a radiological emergency exercise plan as prescribed by the Ordinance of the Prime minister and execute such plan with the approval of the Nuclear Safety and Security Commission (NSSC)." [1] According to APPRE, NSSC notified that annual radiological emergency exercise once a year for a nuclear power licensee and biennial exercise for a small scale nuclear licensee [2].

Current radiological emergency exercise is basically conducting in the field. The field exercise essentially requires participation of mass population. Due to lack of time, cost, communication and participation, the field exercise necessarily causes several limitations in an aspect of effectiveness. The field exercise needs a well-organized collective action with active participation. However, it is not easy to encourage the residents for enthusiastic participation. The public participants often misunderstood the situation as real though it is just an exercise so several conflicts are occurring. Furthermore, the exercise program is too ideal to reflect the real accident situation.

In this point of view, application of virtual reality (VR) technology is highlighted with its many advantages. VR technology is expected to resolve those existing problems. Our research team is currently developing VR based radiological emergency exercise system.

Before applying VR technology to radiological emergency exercise system, we would like to evaluate and expect of the potential of it. In this paper, we reviewed research papers about real applications of VR in the other fields. The VR based radiological emergency exercise system of which we're developing now is briefly introduced.

2. Review: VR Application in the Other Fields

In this section some examples of the VR application are described. The VR technology has been briskly applied in the field of fire and medical exercise application. In future, the prospect of VR application is promising and growing more with technology development.

2.1 Application in the Field of Fire Disaster Exercise

The applications of VR in fire disaster are usually classified into evacuation and rescue. Those applications are mainly focused on reaction and response of users in fire emergency. With understanding the human behavior in the emergency, the ultimate goal is to improve safety.

M. Kinateder et al. [3] did SWOT (Strength, Weakness, Opportunity and Threat) analysis on VR application for fire evacuation research. They suggested that strengths of VR were maximum experimental control, replicability, relatively high ecological validity, and safe experimental environment. Lower ecological validity compared to field studies, ergonomics, and technical limitations were suggested weaknesses.

The spatial navigation training for firefighters was conducted by virtual reality [4]. Three experimental training groups were examined, training from blueprint, VR, and no training. The performance was measured by total navigation time and number of wrong turns during field exercise in the actual building after training. The performance of VR trained group was better than the group of no training and similar with the group of trained by the blueprint.

Response measurement in fire emergency utilizing virtual environment was conducted by L. Gamberini et al. [5]. When the sudden appearance of a fire emergency occurs, participants' action and their patterns were measured. By quantitative and qualitative analysis, they concluded that virtual environment was suitable enough to simulate emergency and train participants effectively.

An immersive virtual reality system for emergency rescue training is developed by Li et al. [6] They abbreviated their training system as ERT-VR (Emergency Rescue Training – Virtual Reality). The system was originally designed for the situation of earthquake. With their 3D scenario creator, trainees can be assigned a specific scenario. The trainees should take a role in the each training scenario and control their actions.

Recently, discussion on VR for emergency evacuation training and its theoretical approach was reported [8]. They concluded that virtual reality can be utilized a valuable evacuation training tool because the trained individuals by VR can produce better responses in such situations. Furthermore, VR is also cost effective.

2.2 Application in the Field of Medical Exercise

The field of medicine is one of the most VR friendly domains. VR technology has been traditionally utilized in the training of emergency room and various surgery techniques.

The effectiveness of VR training on operating performance was proved by Seymour et al. [9] With surgical residents, the proficiency of laparoscopic cholecystectomy was compared in between VR-trained and non-VR-trained. They found that the progress of gallbladder dissection for VR-trained group was 29% faster than that of non-VR-trained group. Non-VR-trained group has nine times more chance to transiently fail to make progress. Furthermore, Possibility of injuring the gallbladder or burning nontarget tissue was five times higher for the non-VR-trained group than VR-trained group.

VR training also helped the performance of laparoscopic surgery [10]. Compared to the non-trained group, VR training decreased the total time consumed for completion of the surgery, and increased accuracy and decreased errors. The group of VR-trained reported better performance in an aspect of accuracy than the video trained group. With the participants of limited laparoscopic experience, VR training resulted in a greater reduction of operating time, unnecessary movements and error in comparison with standard laparoscopic training.

Andreatta et al. [11] proposed that VR technology can be utilized a promising alternative for training emergency medicine (EM) in mass disaster triage. The mean scores for standardized patient (SP) drill and fully immersed VR were similar. However, with the advantages of VR, flexibility, consistency, capability of on-demand training, stability, and repeatability, it can be utilized for the development of standardized assessment protocols.

Effective disaster education should be backed up by andragogic and pedagogic evidence. Farra et al. [12] applied Ace Star Model for putting findings of virtual reality simulation in disaster training into education practice especially for nursing education. This translation model can be a good model for subsequent relative studies.

For the nursing student in a disaster course, VR simulation was applied to learning outcomes and retention of the training [13]. One group utilized only web-based module, and the other group utilized web-based module and VR simulation, together. After 2 months training, the effect of VR simulation was identified significant. It reinforced learning and improved learning retention.

3. Development of VR based Radiological Emergency Exercise System

With the advantages mentioned in the previous section, VR based radiological emergency exercise system is currently being developed. Furthermore, we would like to solve the problem and overcome the limitation of existing VR exercise system learned from prior researches.

For the very first step, the radiological emergency exercise system targets the residents near the site of nuclear power plant. With the VR technology, the problems of current exercise system, low participation of residents, an ideal and simple scenario, and low repeatability are expected to be resolved.

To solve the problem, physically the system will be composed of various interactive systems, like immersed virtual environment with glass, haptic helped experience, walk on treadmill, etc.

The contents of the system will be also filled with interactive scenario. Furthermore, to overcome the limitation of success-based ideal scenario, fail-concerned realistic scenario will be adopted. Particularly, the event tree structure of which was usually used in the probabilistic safety analysis (PSA) will be applied to make the structure of scenario. It will provide a lot of fun and interactivity.

With various features mentioned above, the VR based radiological exercise system will be game-like edutainment solution. The participants are expected to join the exercise spontaneously and sustainably. Ultimately, with effective learning and participation on radiological emergency exercise, we are aiming a safe evacuation without any casualty in case of radioactive accident.

4. Conclusions

In this paper, the advantages and actual application of VR based training were introduced. With those advantages and improvement of existing disadvantages, our VR based radiological emergency exercise system will be developed. Not only physical interactive features, but also interactive fail-considered real-like scenarios will be adopted in the system. The ultimate goal of the system is safe and perfect evacuation of residents in case of radioactive accident. The residents will be encouraged to get familiar with emergency and enhance the capability on emergency response.

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