Development of Virtual Reality Training Content for Security Screening at Nuclear Facilities

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1. Introduction

In March and April of 2023, serious security incidents occurred at Incheon International Airport, a facility designated as 'Category A' and a critical national security objective, where live ammunition and knives successfully passed through the screening process [1]. Fortunately, these incidents did not lead to further accidents; however, they significantly heightened awareness regarding the security vulnerabilities at key national infrastructures. Alongside airports, nuclear power plants are also considered crucial national facilities, necessitating the establishment of robust physical protection systems. These systems are designed to proactively prevent threats to nuclear materials and facilities, ensure rapid detection and response to any arising threats, and minimize the potential damage resulting from such incidents.

The Korea Institute of Nuclear Nonproliferation and Control conducts over 50 physical protection training sessions annually for security personnel. However, most of these training sessions are classroom-based, focusing on theory and concepts, leading to issues with diminished interest and concentration among participants. Despite having trained 2,415 individuals across 51 sessions in 2023, the traditional training methodologies have limitations in fully reflecting the diverse scenarios encountered in the field. Notably, "access control and security screening," critical components of the physical protection system at nuclear power plants, are not adequately covered in the in-house training provided by nuclear operators. Security screening requires adaptable response procedures for various items and scenarios, emphasizing the need for vigilance and repetitive familiarization with procedures in recurrent situations.

In this study, we developed educational Virtual Reality (VR) content aimed at providing practical training on security screening procedures, to enhance the situational and item-specific security screening capabilities of personnel engaged in the protection of nuclear facilities.

2. Methods and Results

In the wake of the Fourth Industrial Revolution and the COVID-19 pandemic, the world is witnessing a rapid digital transformation based on new technologies, leading to efforts to secure competitiveness across various sectors, including education and healthcare. Particularly in the field of education, a swift transition towards the EdTech industry is being observed. EdTech, a portmanteau of education and technology, signifies an innovative era of education that applies ICT technologies to deliver both traditional and new educational services. This shift is focused on maximizing educational outcomes by leveraging key technologies of the Fourth Industrial Revolution, such as the Internet of Things (IoT), blockchain, artificial intelligence (AI), big data, and virtual reality [2].

Among various technologies, Virtual Reality (VR) is responding most rapidly to environmental changes, achieving radical advancements. Particularly in the industrial sector, it demonstrates significant potential through the creation of simulated environments that replicate real-world work settings, enabling education and training in diverse scenarios without actual risk. This offers the possibility to ensure the safety of individuals working in high-risk industries (e.g., construction sites, chemical laboratories) and to enhance practical skills through hands-on education. This suggests that VR technology is establishing itself as an innovative tool in the fields of education and training.

2.1 Hardware

The primary equipment utilized in the implementation of VR content for nuclear facility security screening training is the VR headset. This device facilitates a standalone VR experience, designed to allow users to enjoy high-quality VR content without the need for external sensors or cable connections to computer. A key innovation during the development process was the application of hand tracking technology. This technology tracks the user's hand movements and positions in real-time, enabling interaction with the virtual environment. It has made the user interface more intuitive and natural, contributing significantly to the advancement of the VR experience.

Fig. 1 Virtual Reality Head Mounted Display and Controller

2.2 Planning of VR Content

The initial phase of developing VR content was based on research related to security screening, followed by interviews with experts who have extensive experience in the field of security screening and visits to nuclear facility sites to create flowcharts outlining the sequence of item-specific security screening procedures. This groundwork laid the foundation for the content's structure.

Subsequently, the development of detailed scenarios began, encompassing the creation of characters, situation descriptions, and dialogues, which are the core components of content planning. The developed scenarios underwent continuous revisions and enhancements based on feedback from relevant stakeholders to accurately reflect the terminology and environment of nuclear facilities.

In the final stage, storyboards were created to meticulously review the components needed for content development, such as scene descriptions, narrations, and subtitles, and to ensure the natural transition between scenes. This process aimed to enhance the quality of the VR content and establish a foundation for transitioning to the final production stage.

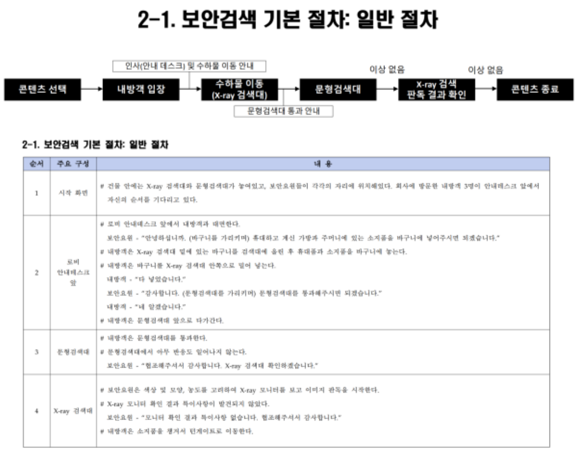

Fig. 2 Flowchart & Scenario of Security Screening Procedures at Nuclear Facilities

2.3 Results of VR content

The VR content for nuclear facility security screening training is categorized into three main areas: operation of security screening equipment, basic security screening procedures, and item-specific security searches. For the operation of security screening equipment, content includes the use of walkthrough metal detectors and portable metal detectors, as well as the operation of X-ray screening systems. The basic security screening procedures are divided into general procedures, entry authorization, entry restriction, and suppression of visitors, enabling users to familiarize themselves with the processes according to different scenarios. Due to the challenge of creating content for a vast number of items, a selection was made to produce content for eleven typical prohibited items (firearms, smoke grenades, drones, etc.), four hazardous items (lighters, acidic substances, etc.), and five restricted items (laptops, cameras, etc.). The content is designed to simulate various situations encountered at walk through metal detectors and X-ray screening, starting from the perspective of a security officer at the reception desk welcoming visitors.

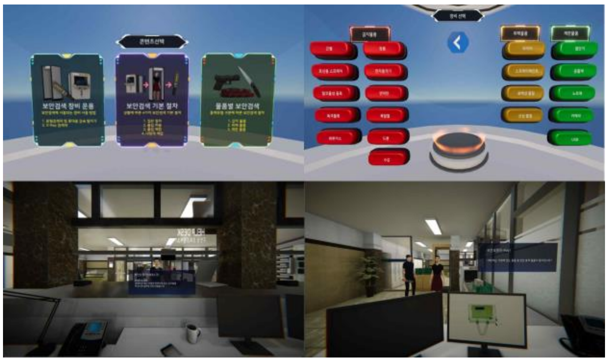

Fig. 3 VR Content for Security Screening Training at Nuclear Facilities

3. Conclusions

In this research, VR content for security screening training was developed to enhance the competencies of protection personnel with the aim of strengthening the physical protection system of nuclear facilities. The active utilization of this VR content is expected to enable practice-oriented education, allowing security personnel to repetitively learn security screening procedures and improve their ability to respond to various situations, which will significantly contribute to the reinforcement of the protection system at nuclear facilities.

When education utilizing the currently developed security screening VR content is conducted, there is a need for additional content to cover the entirety of security screening training. For example, additional content on vehicle search procedures and undercarriage inspections for a specific area of security screening, as well as the development of multilingual versions of the content for international training programs, are required. It is anticipated that further additions and improvements to the content will establish this training program as a standard textbook for security screening education and training.

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