Development of Nuclear Security Training Program Based on Motion Tracking VR Technology

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1. Introduction

With the expectations of the fourth industrial revolution recently, there are many attempts to use Virtual Reality technologies in relation to various fields including defense, health and education industries. In particular, high risk and high cost hands on training is being replaced by VR-based education owing to its low cost and low risk features. VR-based training can provide some situations that are difficult to experience in reality and also increase trainee's immersion. It also enhances trainee's motivation and transfer of learning.

In order to take these advantages of VR-based training for nuclear nonproliferation and security education, KINAC/INSA (Korea Institute of Nuclear Nonproliferation and Control/International nuclear Nonproliferation and Security Academy) has developed VR-NET system (VR-based Nuclear Education and Training system) since 2016 and made one pilot content related to the physical protection contingency situation at 2017. To maximize the advantages of VR-based training, INSA has adopted the motion tracking technology which can reflect the trainee's movements into the VR simultaneously in real time. When using this VR technology, trainees can move freely within 6mX6mX3m space. And it has also distinct advantages over 360° VR that causes human factors like motion sickness, dizziness, and so on. In addition, the pilot content was test-operated for guards of nuclear power plant, public, and so on [1].

This paper describes the development process of VR-NET system including hardware, software, system configuration, pilot training course operation and analysis of educational effectiveness.

2. VR-NET System Development

VR-NET based on the motion tracking technology enables real-time interaction among participants, so it creates the best immersion for trainees. Therefore, this system is effective to train the trainees to achieve some goals using brain recognition technology within the current level of VR technology available.

The VR-NET system developed by INSA is divided into three sub-systems - the motion tracking system, contents operating system and interaction system between VR and reality.

2.1 Hardware Development

The H/W of the VR-NET system consists of motion capture cameras, a server, and other accessories to connect each system. The amount of space that trainee can move in VR depends on the number of cameras, and VR-NET has built the VR training space of 6mX6mX3m using a total of 12 cameras (based on Opti-Track Company Prime 17W). If more motion tracking cameras are used, VR training space can be expanded. In addition to cameras, other equipment such as a calibration kit, cables connecting cameras and servers, stands and clamps for camera installation are also needed. Besides markers for object detection are essential because cameras use infrared light to collect trainee's motion and location information.

Figure 1. Main H/W components of VR-NET system

Once the motion tracking system has been configured using the above products, servers and S/W (such as motion tracking programs and content game engines) are required to interconnect the motion tracking system and training contents.

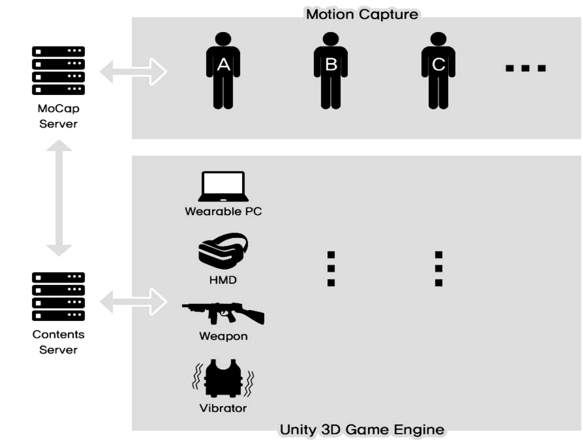

Figure 2. The H/W and S/W connection configurations

2.2 Contents development

VR contents are usually produced through the following process: 1) Planning and researching VR content, 2) Scenario configuration, 3) Planning storyboards and storyboards, 4) Virtual training environment creation using 3D production, 5) 3D character creation and programming, 6) Testing and publishing [2].

INSA continuously has cooperated with "Dongguk University Graduate School of Digital image and Contents" to develop VR-NET pilot content related to physical protection, and it was completed in 2017.

Pilot content was developed as a scenario that assumes a terrorist attack with vehicles and explosives on the main gate of a nuclear power plant (Gori) during the day. Trainees must counteract all six terrorist attacks armed with gun in front of a virtual nuclear power plant, and the aim of the trainees is to protect the nuclear power plant with four AI (Artificial Intelligence) allies for up to four minutes against terrorist attacks.

This pilot content can be used to train and assess an individual's tactical ability to protect a nuclear facility in the event of a contingency situation.

Figure 3. Pilot content operation

3. Effectiveness Analysis of VR based Education (VR-NET)

Since 2017, INSA has been piloting VR-NET based training and a total of 1,188 trainees have experienced VR-NET content over three years until 2019.

INSA conducted a survey to analyze the educational effectiveness of the VR-NET system on 39 trainees who participated in 2017. The purpose of this survey was to measure the satisfaction score of VR based training and then to analyze which education method is more effective compared to other traditional education methods using PPT and CBT.

[Comparison of 3 types of education courses]
- VR-NET based education
- Physical protection education (usually in classroom)
- X-ray reading exercise (computer based training)

The results of analysis show that satisfaction score of VR-NET based training was much higher than traditional education's score. This means that VR-NET-based education draws a higher level of educational satisfaction than the general types of education using video and images in the classroom [3].

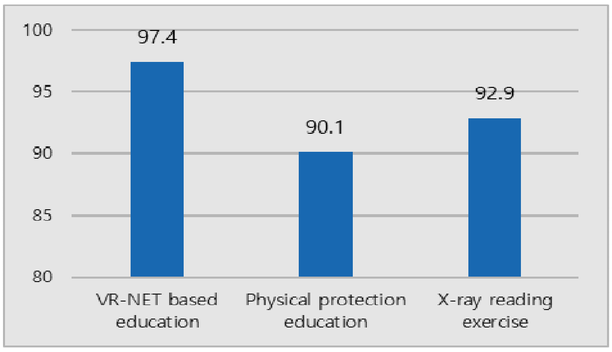

Figure 4. Education Satisfaction Score

In addition, the NPS (Net Promoter Score) for VR-NET based education scored 9.6 points. The NPS is measured from 0 to 10, indicating the intensity that a trainee recommends a particular course to a colleague. In general, if the NPS is measured 9 or higher, that means that the trainees are likely to recommend a particular course to colleague. NPS of VR-NET system shows that the trainees are highly likely to recommend to their colleague because the NPS for VR-NET-based education was measured at 9.6.

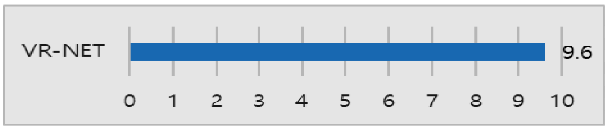

Figure 5. NPS of VR-NET based education

4. Conclusions

VR-NET system has been developed by KINAC/INSA, can provides more effective education through customized training for high-risk events that are usually difficult to experience in reality like nuclear industry. In addition, VR-NET based education can achieve high education satisfaction score compared to traditional types of education or exercises, and is also highly likely to be recommended to colleagues.

KINAC/INSA will continue to develop and operate various VR-based training courses in the areas of nuclear nonproliferation and security including safeguards, strategic materials control, nuclear forensic and physical protection to strengthen human resources capacity and develop the nuclear nonproliferation and security culture.

REFERENCES

[1] Annual Report for Implementation of Compulsory Training Programs on Nonproliferation and Security in 2018, KINAC, 2019
[2] A study on Development of HMD Interactive Contents Based on Virtual Reality, Jungyeob Han, 2016
[3] Result Report for Implementation of Compulsory Training Programs on Nuclear Nonproliferation and Security in 2017, KINAC, 2018