

Utilizing Virtual Reality for safety training in construction sites

Penta-Ocean Construction Co. Ltd., Sivaranjani Jayaprasad
Penta-Ocean Construction Co. Ltd., Tsuyoshi Kotoura
Penta-Ocean Construction Co. Ltd., Kazuhisa Teramura

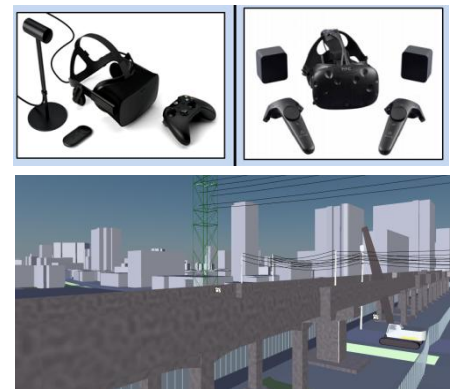
1. Introduction

Workforce safety is a global concern. The engineering industry especially the construction sector has the highest rates of injuries. Making the construction site as safe as possible requires concerned effort by the owners, designers, construction companies at all levels of management, construction workers, regulators and educators. Construction workers play an important role in identifying the risk factors at the work site and the ability to identify and assess risks is acquired through training and experience and is among the key factors that determine their behavior and thus their safety. Improving the traditional method of classroom training using videos and replacing with the advanced training sessions like utilizing the 3D model of the construction site and the virtual environment would be effective.

In this paper, we have adopted the method of providing safety training in virtual interactive 3D environment. The contents of the training are identified based on the work site environment and the target people. This method of safety training is given to the site workers and freshmen employee in order to increase awareness of the potential hazards and visualize the construction site that enhances the ability to understand the safety measures.

2. Virtual Reality – Immersive Environment

Virtual reality is a technology that uses computers, software, and peripheral hardware to generate a simulated environment for its user. It simulates a real or an imaginary environment. An immersive virtual environment is a computer generated environment that gives a person a sense of being within it by engaging the persons senses and reducing/removing their perception of real life environment. Virtual reality (VR)-based approaches have been used widely in a variety of industries. It facilitates safety knowledge transfer and increase hazard awareness by providing safe and controlled experiences of unsafe scenarios for construction safety training applications. Some of the widely used VR devices are Oculus rift, HTC Vive as shown in Fig.1. The set up for VR devices doesn't take much time, even a person with basic exposure in handling computers could do VR setup.



3. CIM Model Utilization

The Ministry of Land, Infrastructure, Transport and Tourism has implemented CIM (Construction Information Modeling / Management) program that utilizes a three-dimensional model to improve productivity and efficiency of construction site works. It involves planning of the project right through to the construction, operation, and the maintenance. It extends beyond the construction process, taking into account the management of the cost, operations, and project as a whole. One of the CIM applications involves the effective utilization of the 3D model in the safety training/education. Traditionally, construction safety training is provided in a classroom setting with slide presentations or videos, which do not represent real construction site conditions. So, using a 3D model that represents the construction site conditions in an interactive environment would be effective in engaging trainees to improve their training performance.



Fig.1 VRDevice, CIM Model, Training conditions in an interactive environment

4. Training Materials

(a) Case study One: Excavator in a construction site.

Work sites in urban areas usually have a large number of high rise buildings which will restrict the movement of the construction vehicles and there arises the necessity to pre check the safety precautions of the work site. One of the work sites "Canal embankment" in a major metropolitan city had a similar kind of situation because of its presence in between the high rise building areas. The operation of the construction vehicle in this site has to be managed careful because of the narrow danger zone area.

Integrating the 3D model of the work site with the 3D map (Zenrin), the surrounding environment of this project could be visualized as shown in Fig.2. Importing the integrated model in VR environment and adding a work scenario of using excavator (as in current case), could assist in finding the safety precaution point. Excavator used at this site as in Fig.3 is animated and safety training video of how dangerous it would be if we get into the danger zone area of

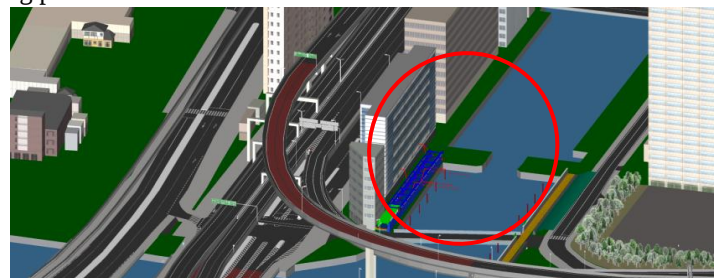


Fig.2 Canal Embankment site (3D model + 3D map)

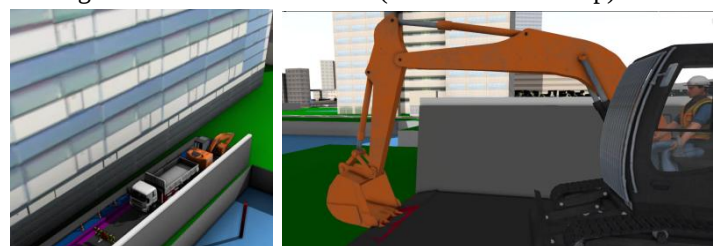


Fig.3 Excavator safety training video at Canal embankment site

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Contact: 〒329-2746 Tochigi, Nasushiobara, Yonkucho 1534-1 Penta-Ocean Institute of Technology TEL 0287-39-2100

the working excavator. This would increase the awareness in identifying potential harms while working in construction site.

(b) Case study two: Mobile Crane in construction site

Work sites that involves works like lifting heavy objects to taller places, mobile cranes are used. The work should follow the safety measures as mentioned in Working manual, one of the major step includes restricting danger zone off-limits around the crane working area. One of the work sites, “Elevated structure construction”, had a situation where work site was in city residential areas with large number of electric wires and poles. The operation of the mobile crane has to be managed carefully because of the above mentioned complexities.

Integrating the 3D model of the work site with the 3D map (Zenrin), the surrounding environment of this project could be visualized as shown in Fig.4. Importing the integrated model in VR environment and illustrating a work scenario of using mobile crane (as in current case) could assist in finding the safety precaution point. Mobile crane used at this site as in Fig.5 is animated and safety training video of how dangerous it would be if we get into the danger zone area of the working mobile crane. This would increase the awareness identifying potential harms while working in the construction site.

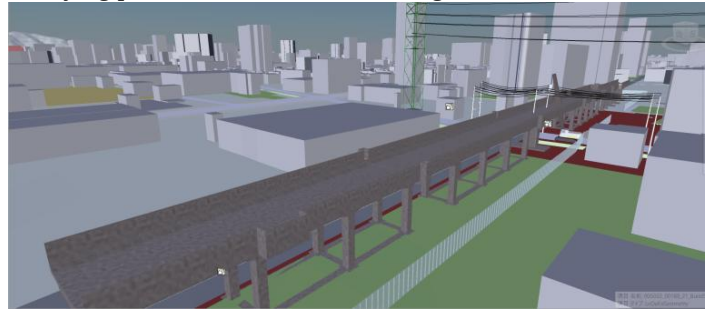


Fig.4 Highly elevated structure work site (3D model+3Dmap)



Fig.5 Mobile Crane safety training video at work site

5. Safety Training

(a) Training at Construction sites

There is a serious need for reducing the occurrence of accidents. Several critical factors are leading to an increase in the rate of accidents in the construction industry. Proper training and awareness are the foremost steps to be taken while undertaking any task. Workplace safety training will provide employees with the skills and knowledge they require to protect themselves and others from accidental deaths and injuries. It will also help in protecting facilities and equipment and in reducing the costs associated with it as well. In response to the shortcomings of traditional safety training, we have explored the use of virtual reality to create active learning experiences that engage the learner. Providing Virtual Reality training opportunities for dangerous tasks in the jobsite, allowing users to avoid exposure to potential harm. Fig.6 shows the safety training conducted for Site workers at one of our work site in last year. There were active participation of the site workers that paved way for the interactive discussion on the safety measures to avoid potential harms.



Fig.6 VR Safety Training at Construction site.

(b) Freshman Training

Education to the freshman employees working in the construction site is very important in helping the freshman identifying the potential hazard and respective preventive measures to be taken. We have started including Virtual Reality safety training programs as a part of our freshmen training. The Fig.7 shows the safety training conducted at Freshman Training in last year. The safety precaution point at each construction site has been illustrated in the virtual environment with the voice controlled guidance that helps learners to identify the potential harms and avoid exposure to these harms in the work site.



Fig.7 VR Safety Training at Freshman Training

6. Further developments and Conclusion

Virtual reality safety training has given a good opportunity to the site workers and freshmen to visualize the critical conditions while working with different construction vehicles. Safety training in Virtual reality interactive environment could be made more realistic by importing SFM data from the drone survey. Other benefits of using virtual reality technologies are broader like (1) 3D Visualization of the work site like Structure model with surrounding terrain, subsurface model along with the prevailing environmental conditions, (2) Understanding the complex structures easily, (3) Real time monitoring of the work site with 360deg photos, (4) Interactive meeting and training sessions.

7. References

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