

ADVANCEMENTS IN UTILIZING VIRTUAL REALITY FOR SAFETY TRAINING AT CONSTRUCTION SITES

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1. INTRODUCTION

Workforce safety is a global concern and the construction sector has the highest rates of injuries. Ensuring safety in the construction site requires concerned effort by the owners, designers, construction companies at all levels of management, construction workers, regulators and educators. So, improving the traditional method of classroom training, with advanced training sessions like utilizing 3D model of the construction site in the Virtual environment would be effective. In this paper, we have adopted the method of providing safety training in Virtual immersive 3D environment. This method of VR safety training will help all workers at the construction site to understand safety points from different viewpoints, which will increase the awareness of identifying the potential hazards.

2. VIRTUAL REALITY – AN IMMERSIVE ENVIRONMENT

Virtual Reality uses computers, software, and peripheral hardware to generate a simulated immersive virtual environment engaging the persons senses and reducing/removing their perception of real life environment as in Fig.1. In construction industry, Virtual Reality based approaches facilitates safety knowledge transfer and increase awareness of potential harms by providing safe and controlled experiences of critical scenarios. Some of the widely used Virtual Reality devices are manufactured by Oculus and HTC Vive.

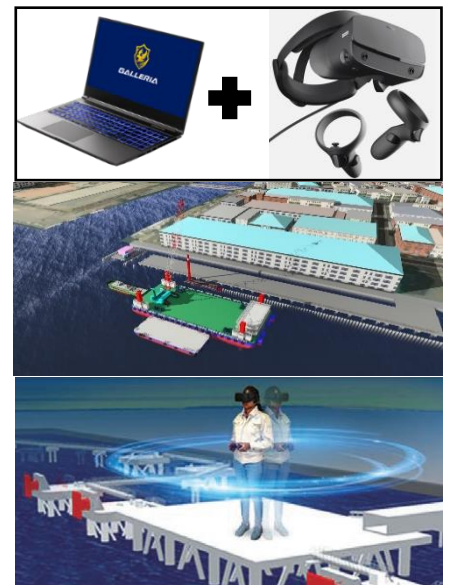


Fig.1 VR Device, 3D Model, Training

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. One of the CIM applications involves the effective utilization of the 3D model in the safety training. Traditional construction safety training provided in a classroom setting with slide presentations and videos is replaced by VR Safety training method using 3D model in Virtual immersive 3D environment, which increases the performance of safety training.

4. ADVANCEMENTS IN VR SAFETY TRAINING

Following are the steps in creating VR safety training contents: (1) Import the 3D model into Virtual environment (2) Add the construction vehicle operation (3) Input the desired work scenario. We have been utilizing VR safety training and is improved periodically with new advancements. Current advancement is conducting training from different viewpoints, such as viewpoint of workers experiencing the danger, viewpoint of construction vehicle operator, viewpoint of the third-person at site. VR safety training are conducted at both land and marine construction sites.

4.1 Case study1: Land Construction sites

In a bridge lower bank construction site, where a backhoe excavator and a rafter crane for digging and lifting the digged soil bags, the VR safety training contents as shown in Fig.2 is created. Fig.2a shows the viewpoint from the worker who unknowingly gets into danger zone, is being hit by the backhoe buckets as highlighted in yellow box. This helps the worker to understand the critical scenario on entering the danger zone. Fig.2b shows the viewpoint of the backhoe operator when the bucket hits the worker as highlighted in yellow box. This helps the backhoe operator understand the visibility difficulties and be cautious

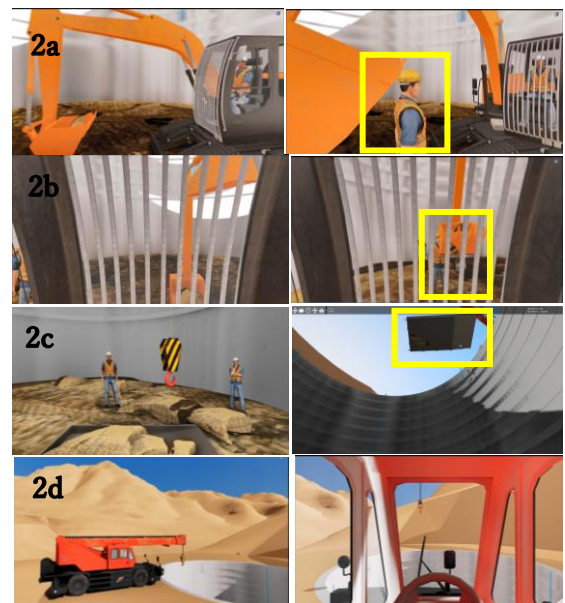


Fig.2 Case study1- Land Construction site

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while operating the backhoe. With this operator viewpoint training, the workers can experience the visibility of the operator, which is not possible normally. Fig2c shows the viewpoint of the workers at the site when the rafter crane is working on lifting the digged soil bags to the ground. This helps the workers to visualise the lifting height as highlighted in yellow box and understand the precautions to be taken. This also helps the operator of rafter crane to visualize the lifting height which normally could not be experienced. Fig2d shows the viewpoint from the rafter crane operator room while lifting the digged sand bags and understand that there is no visibility to the place of lifting from the operator room as heigheted in yellow box. With this operator viewpoint training, the workers can understand the visibility issues faced from the operator room. The entire VR safety training enables the workers and the backhoe & rafter crane operators to experience difficulties in visibility and precarious points from each other's viewpoint, thereby ensuring safety at the site.

4.2 Case Study2: Marine Construction sites

For a quay wall improvement project, where a pile installation barge ship for installing the piles along the existing quay wall is operated, VR safety training contents are as shown in Fig.3 is created. VR safety training content during a pile installing operation includes, a worker standing on the temporary structures unknowingly entering the danger zone is being hit by the pile and fall. Fig.3a shows the viewpoint of the worker from the land, watching the critical scenario of the pile hitting the worker as highlighted in yellow color. This helps the worker to understand the conditions upon which the critical scenario is taken place. Fig.3b shows the viewpoint from the crane operator room while installing the pile. This helps the operator to experience the difficulty in visibility during the installation, if the visibility issues are not understood properly it can lead to the critical scenario of pile hitting the worker as highlighted in yellow box. This viewpoint helps the workers to experience the operator room visibility during the installation process. Fig.3c shows the viewpoint of the worker who is experiencing the hitting of pile during the installation process as highlighted in yellow box. This helps the workers in visualizing the critical scenario that might happen upon entering the danger zone. These different viewpoint experience makes the site workers and operators understand one another's difficulties and precaution points which would increase the awareness in identifying potential harms while working in construction site.

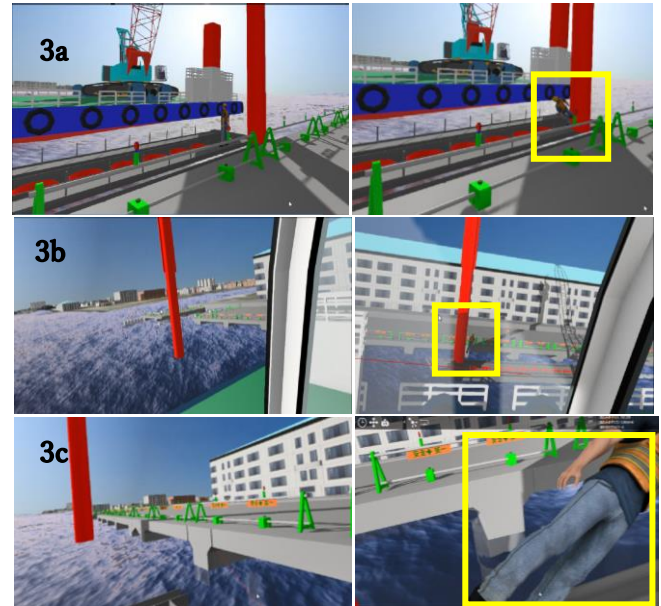


Fig.3 Case Study2 - Marine Construction sites

5. TRAINING AT CONSTRUCTION SITE

In response to the shortcomings of traditional safety training, VR safety training are conducted at many our construction sites as shown in Fig.4. There is an active participation of the site workers that paved way for the interactive discussion on the safety measures to avoid potential harms. We also received feedbacks such as the VR safety training helped to visualize the work site conditions and limitations even before visiting the site. Furthermore, it helps both the workers and operators to get to know each other's work conditions that ensures safety. We also received suggestions for updating the VR contents to make the VR environment closer to realistic construction site.



Fig.4 VR safety training at site

6. FUTURE DEVELOPMENTS AND CONCLUSIONS

VR safety training enabled the workers at site to visualize the critical scenarios from different viewpoints that highlights the safety points from different perspectives in the construction site. VR safety training could be made more realistic by importing SfM data from the drone survey. Other benefits of using Virtual Reality technologies are (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

1. Study Report on the Guidelines for the management of safety for Construction works in Japanese ODA Projects <https://openjicareport.jica.go.jp/pdf/12125084.pdf>
2. Dr.Rita Yi Man Li: An economic analysis on automated construction safety: Internet Of Things, Artificial Intelligence and 3D Printing (Chapter 6- Virtual Reality and Construction safety)
3. Construction Information Modeling / Management <http://cimjapan.com/about/index.html>