



VIRTUAL REALITY TRAINING SOLUTION FOR CRANE OPERATOR

Reference No. : ICT23/80-SI/PTG-0001

Stream: Postgraduate or above

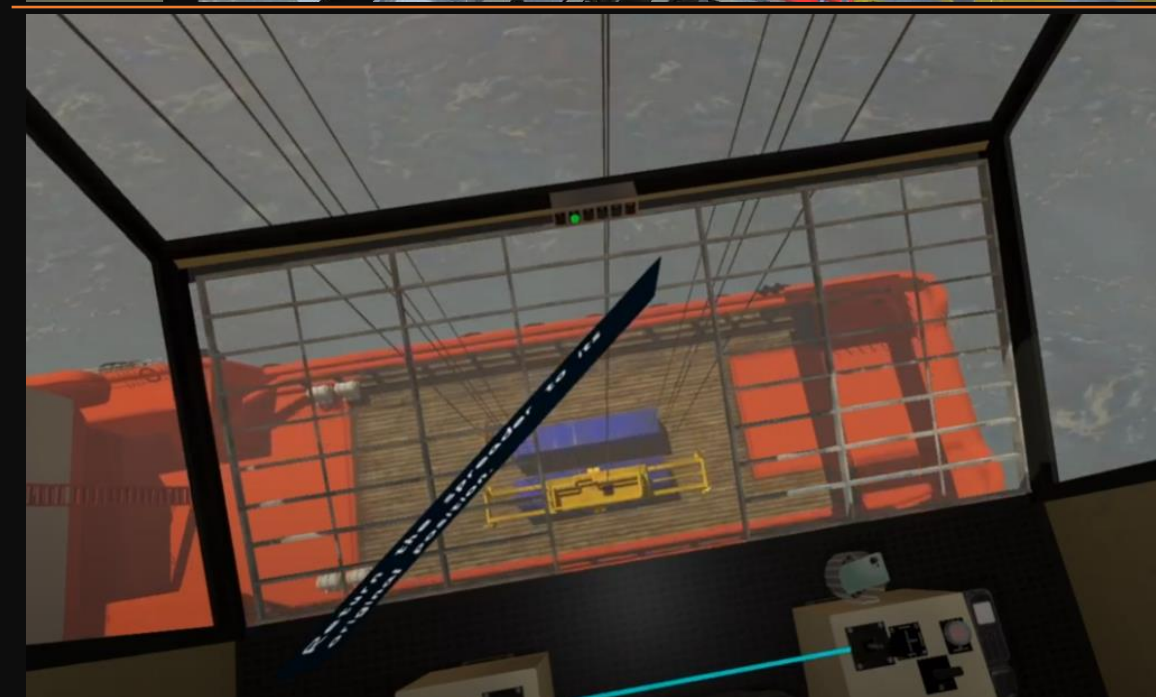
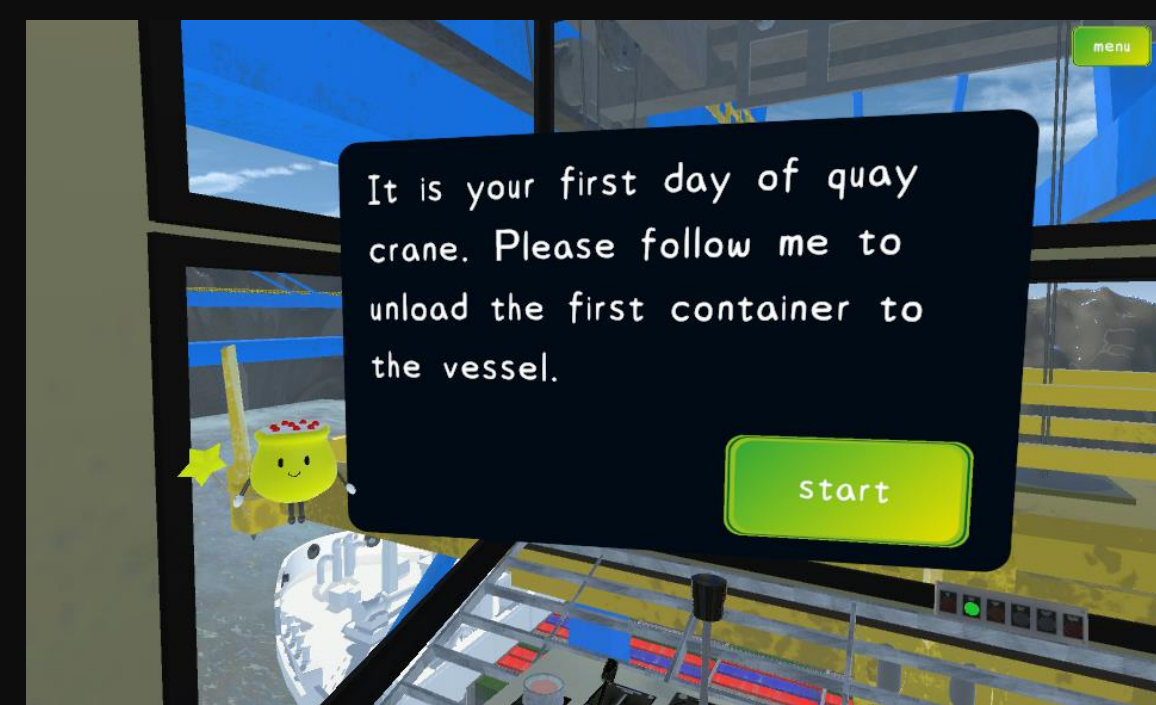
School: City University of Hong Kong

Teacher-in-charge: Zhicong LU

Entry Title: Siu Mai Container Terminal

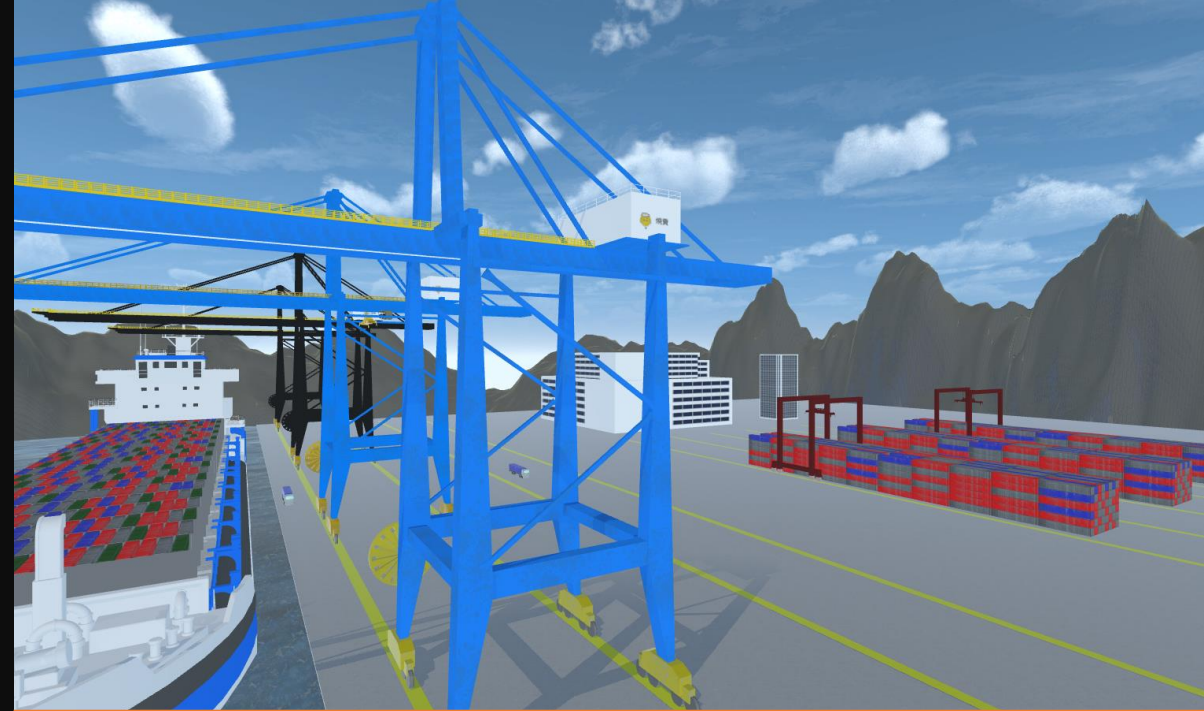
INTRODUCTION

- The training purpose of VRCrane was to enhance crane operating skills. Trainees simulated working in QC cabin to operate the crane in a virtual container terminal with HMD technology.
 - This project report aims to explain the following issue:
 1. What the content design of VRCrane was.
 2. How to implement the VRCrane development.
 3. How the VRCrane can achieve the training propose.
 4. How the interface of VRCrane help the user to complete the VR training.
 5. What the possibilities of VRCrane can apply to other domains and implement other recommendations than training.
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INTRODUCTION (CONT)

- This project specified on HMD technology. It contained one computer, one headset and two controllers. Virtual environment provided a very immersive experience to users.
 - HMD applied in different domains, such as medical and surgical, education, safety and industrial. VR training can enhance user skills.
 - Meta Quest 2 was used. It was affordable and portable. It also contained good resolution with high refresh rate supported
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RELATED WORK

- Training a QC operator is very similar with training a gantry crane (RTGC). A trainee is required to have 24 training days, including 2 days of **theory classes** and 21 days of **practical classes**. On 24th day, he will have a skill test.
- It is just **costly** to spare a quay crane for the training. The company invests human power and battery to train a trainee. Some **trainees leave** the training once they find it difficult to operate the crane. They are afraid to operate the quay crane because the cabin they sit over 40m above the ground.



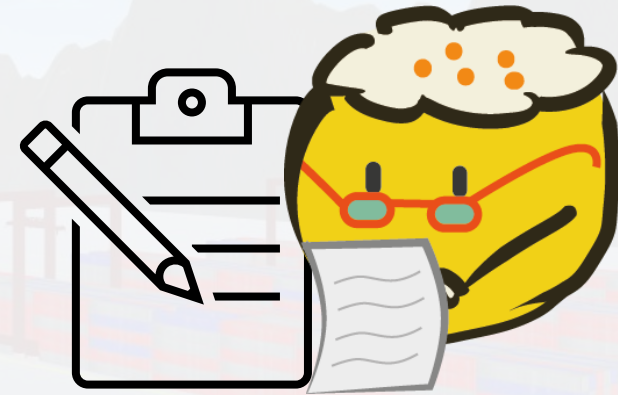
RELATED WORK

- VRCrane benefits both companies and trainees. Trainees try working in virtual environments to practice crane operation. Once they become skillful, they can go onto the real crane. The company can decrease training time in real crane.

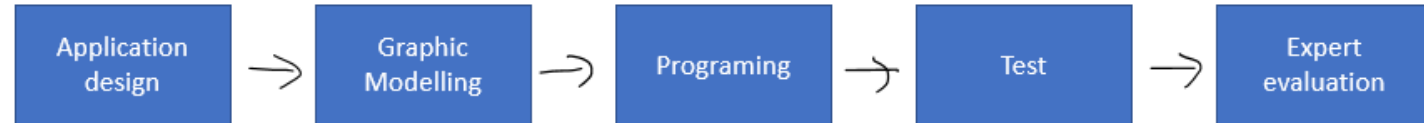


FORMATIVE STUDY

- To design the content of VRCrane, experienced QCO (quay crane operators) and trainers were invited to share how their **training period** was, how they **operate daily tasks** and point out some **potential hazards** of trainee/new QCO. It helped to design the VRCrane content.
- **9 participants**, from Terminal 6,7 & 8
- Interviewed and filled in survey
- Extract several points
 1. Simulate to operate QC.
 2. Simulate to unload the containers from different type of container ships.
 3. Simulate human failure and bad weather conditions.

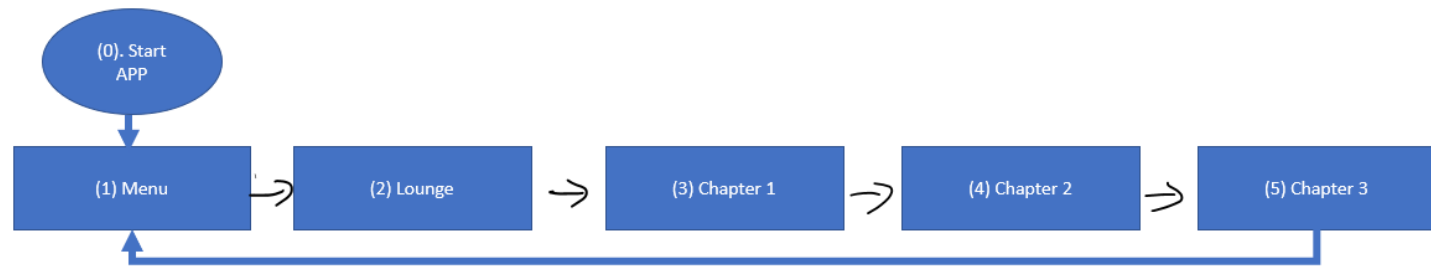


DESIGN AND IMPLEMENTATION



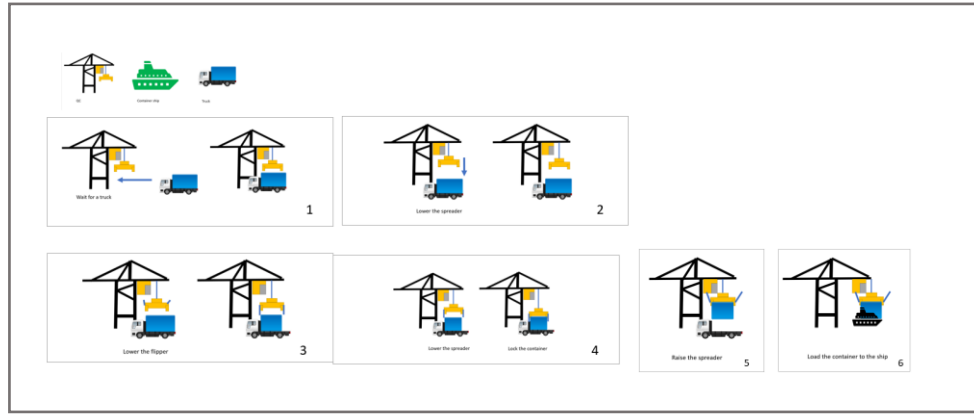
- I used the waterfall process models to develop VRCrane because it was simple to deal with tight project time.

DESIGN AND IMPLEMENTATION



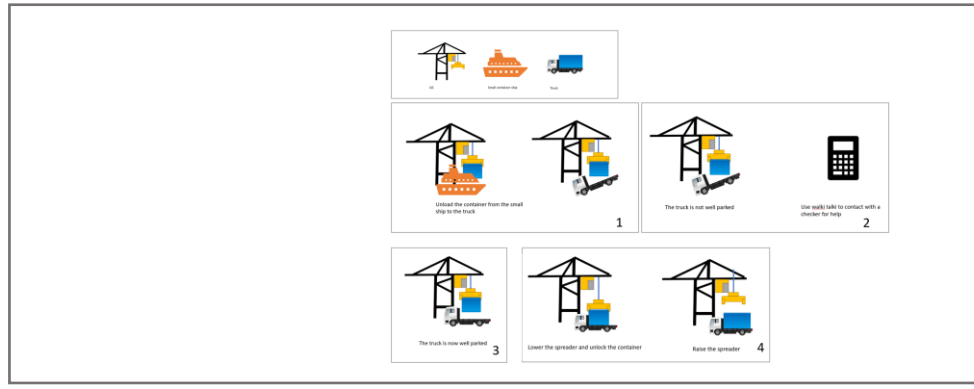
- APPLICATION DESIGN
- Based on the information in “Formative study”, I made a flow chat to describe the flow [fig 5.1.0]. (0) VR trainee starts the application. (1) Trainee goes to the menu scene. He/she can choose to play the game from start or continue playing the last chapter he played. (2) If the trainee chooses to play the game from start, he goes to the lounge to explore the life of the crane operator. (3)–(5) Trainee plays around the chapters for QC operation training. After that, the trainee goes back to the menu scene.

DESIGN AND IMPLEMENTATION



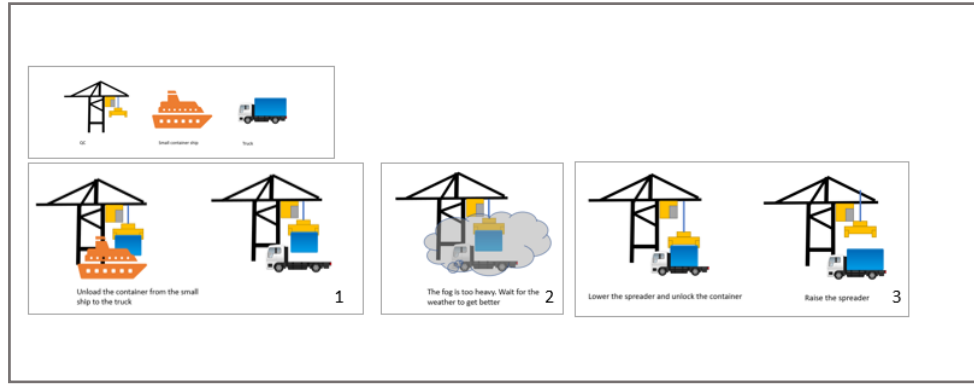
Chapter 1

Trainee gets familiar with the **basic operation of quay crane**. Simply load one container in a mega vessel in the beginning. Here is the demo video.



Chapter 2

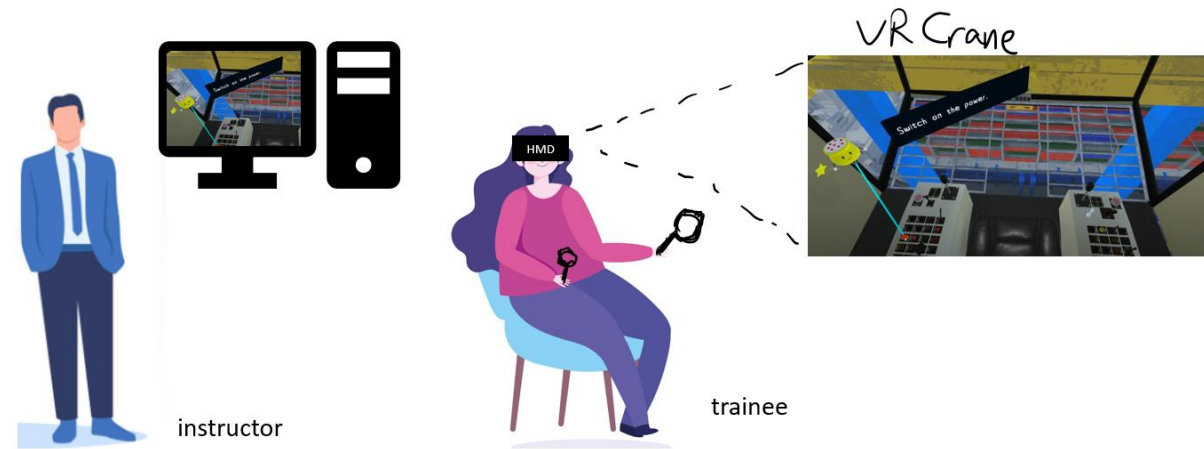
Trainee unloads the container from the small ship. A truck is **not well parked**. He need to communicate with others for help.



Chapter 3

The trainee has to deal with the **bad weather**. It is different to load the container on a fog day. The trainee needs to load the container carefully.

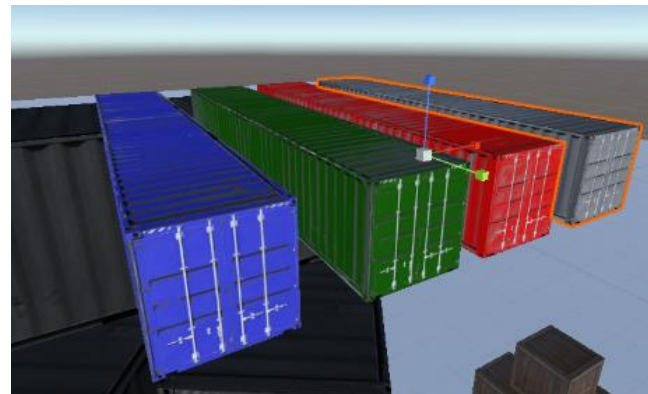
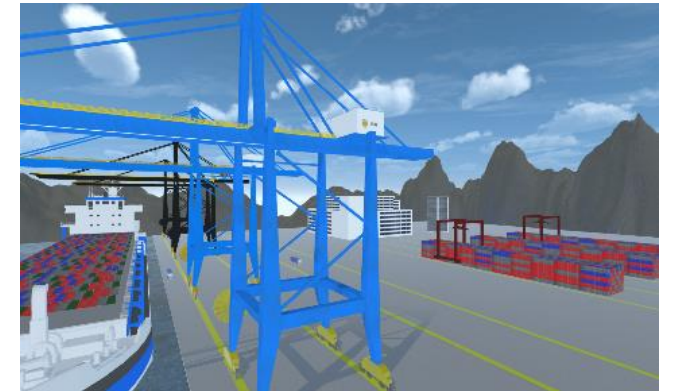
DESIGN AND IMPLEMENTATION



The hardware set up was designed. Trainee used HMD and two controllers. To make the connection stable, the headset is wired connected with the computer. Instructor/trainer can watch computer screen to see what trainee looks at in VR. Trainer and trainee can talk with each other during the VR training.

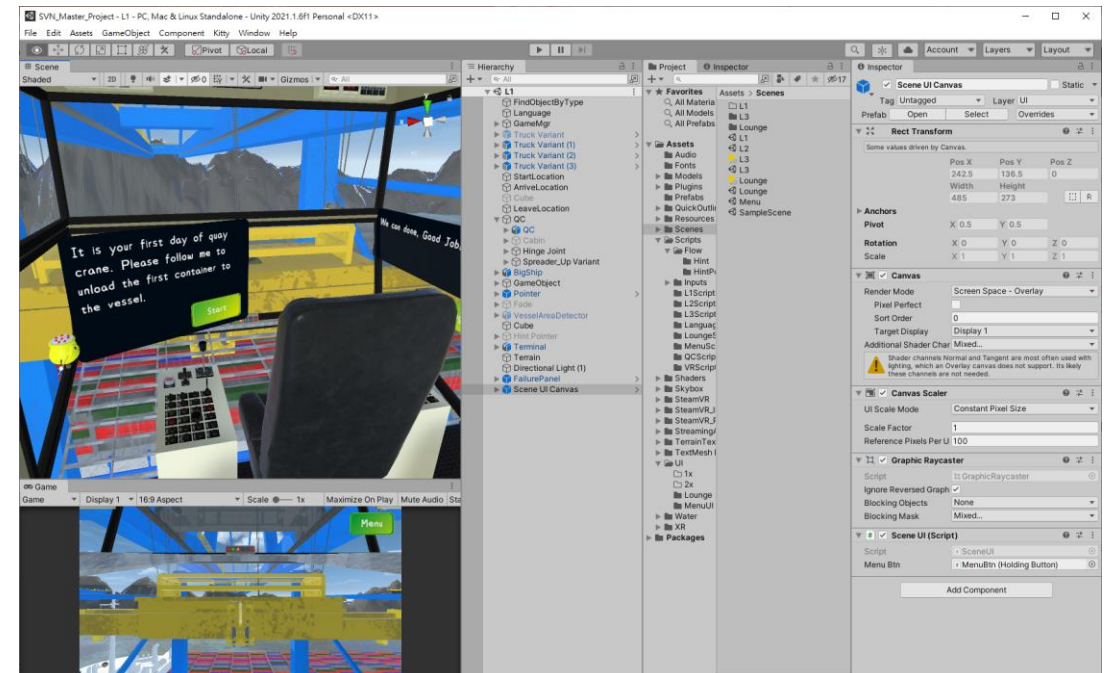
DESIGN AND IMPLEMENTATION

The 3D models made by Autodesk 3ds Max with low-polygons while the textures, normal maps made by Adobe Photoshop.



PROGRAMMING

The user intersection in VR container terminals is coded in C# in Unity. SteamVR, a plug-in of Unity is applied for simulating the virtual environment and connecting VR device inputs to Unity.



DESIGN AND IMPLEMENTATION

- To enhance trainee self-regulated learning, the instructor does not need to contribute to the VR training too much. Trainee can train the process based on his learning time. A virtual instructor, Siu Mai, will guide the trainee step by step. Siu Mai can speak two languages, English and Cantonese. **His AI speech** was generated by Microsoft voice and Speechero. His instruction had also **subtitles**. User knew the training step is changed when Siu Mai speaks. If user did not hear the instruction clearly, he could read the subtitles. It was not nice for user to read a lot of words in VR, therefore, one text line was limited to around 20 words. Even if user did not want to read the text lines, the **blue hint rendering line** guided him to see which button/joystick to be interacted with.



DESIGN AND IMPLEMENTATION



Switch on the power.

- Chapter 0: Lounge
- English version: [https://youtu.be/BHo_VeLV3K0]
- Cantonese version: [<https://youtu.be/RFd4rUaND6M>]
- Chapter 1: load and unload containers in daytime.
- English version: [<https://youtu.be/TmEkzhTNDc>]
- Cantonese version: [<https://youtu.be/8Azaub5IB-s>]
- Chapter 2: load and unload containers on a small ship
- English version:[<https://youtu.be/ZWUapQh8JQA>]
- Cantonese version:[<https://youtu.be/3Qauko3vL2I>]
- Chapter 3: load and unload containers on fog day.
- English version:[https://youtu.be/7_aQwzCcgQA]
- Cantonese version:[<https://youtu.be/g24GkTcOOKQ>]

EXPERT EVALUATION

- The objective of Expert Evaluation is to invite QCO, trainers and trainees to use VRCrane and to check whether VRCrane are addressed the training purpose.
- **13 testers** (9 testers are QCO, 1 is trainer, 3 are non-experienced testers who are trainee and terminal staff)
- My friend, Fanco helped to guide the testers how to use the VR device and fix the computer technical issue.



EXPERT EVALUATION SETUP AND SCHEDULE

- I reserved a room of 6m X 6m. There were two computers, including one computer for back up.
- prepared a **pair of glasses with 300 diopters** and which size fits in the headset.
- All testers were required to **play at least one chapter** in VRCrane, it depended on their willingness and working time schedule. It took 20 minutes per one participant After the test, participants complete the **survey**. The participants also participated in a **10-minute interview** and shared further opinions of VRCrane.



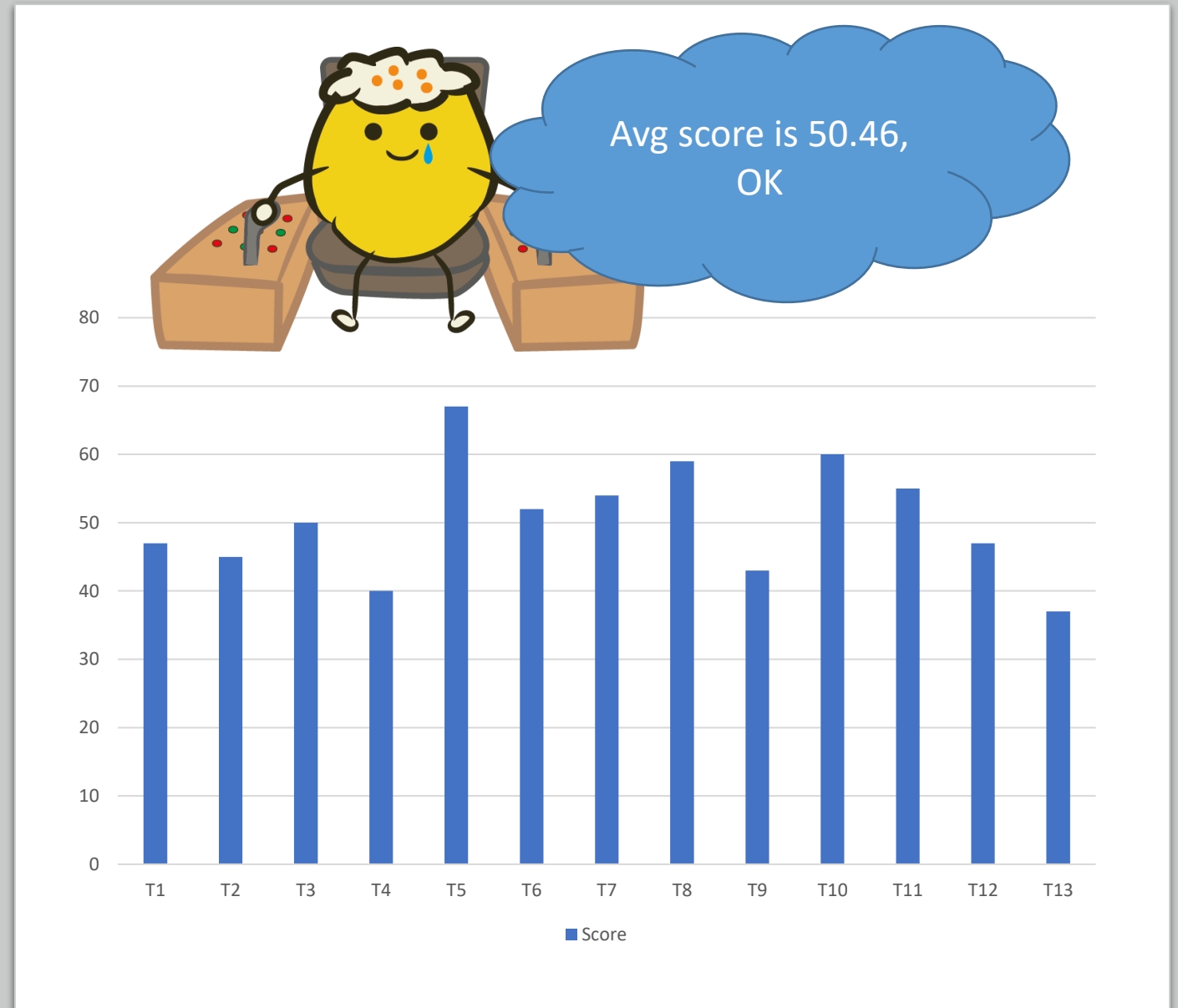
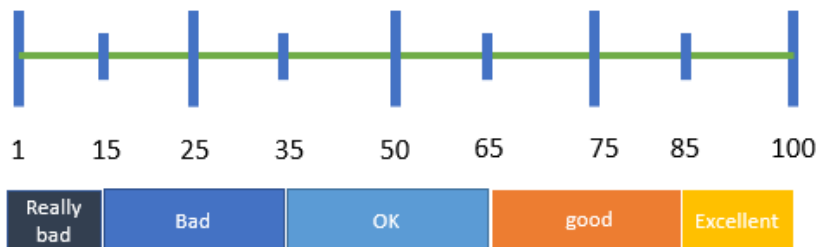
DATA ANALYSIS

- The surveys mainly want to know their satisfaction with the VR training.
- The survey had three parts.
 1. how effective VRCrane is used for training.
 2. how well the VRCrane interface could help trainee to explore in the virtual world.
 3. whether VRCrane could be applied to other crane training or for other purposes.
- I dropped down the participants' comments by pens. The interview would be audio recorded.



EVALUATION RESULTS

- **Part 1:** effectiveness of the VRCrane for training
- Choose “strongly agree”, “agree”, “neutral”, “disagree” and “strongly disagree” to answer the questions.
- The average score of VRCrane is **50.46**, which is “ok”, indicating the effectiveness of VRCrane for training is satisfactory. Fig.7.1.1 shows the result of each tester.



EVALUATION RESULTS: EFFECTIVENESS OF VRCRANE FOR TRAINING

How effective VRCrane is used for training?



VRCrane could only tell **basic operation skills** of QC. It is a nice tool for trainee to try QC for the first time. It relieved a **trainee's nervousness**.

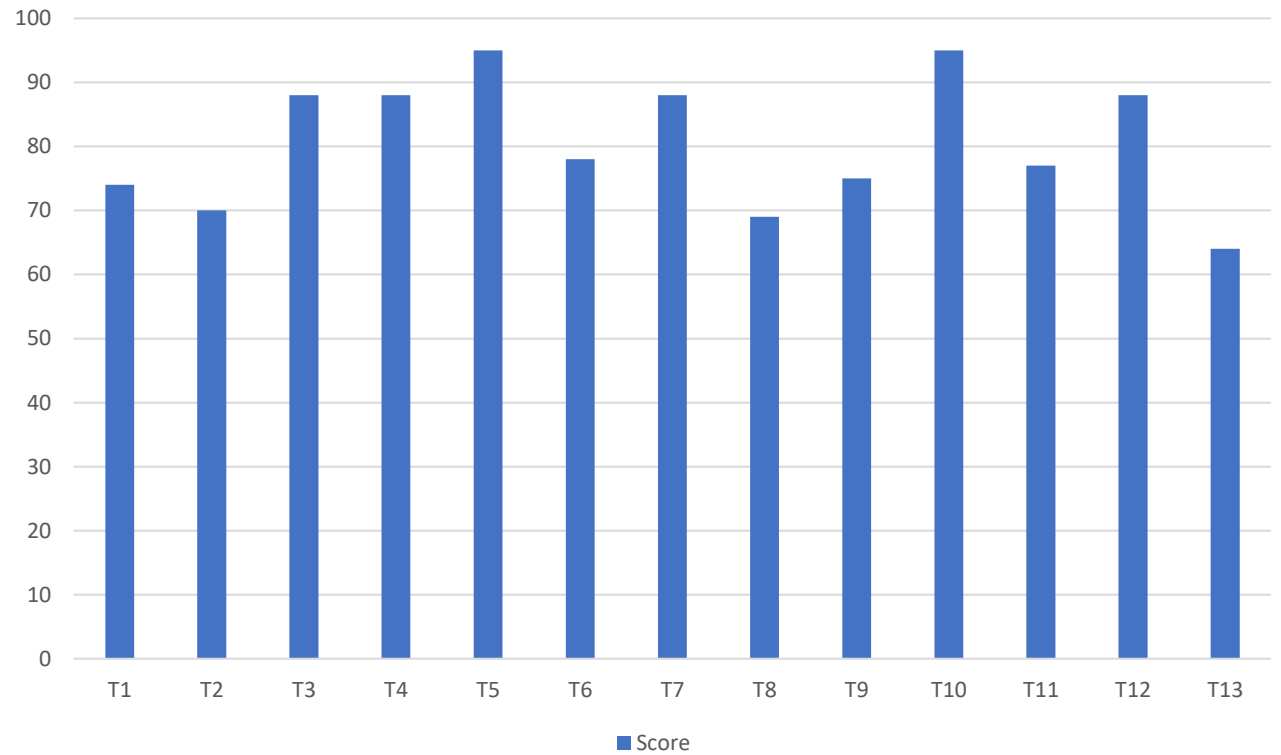
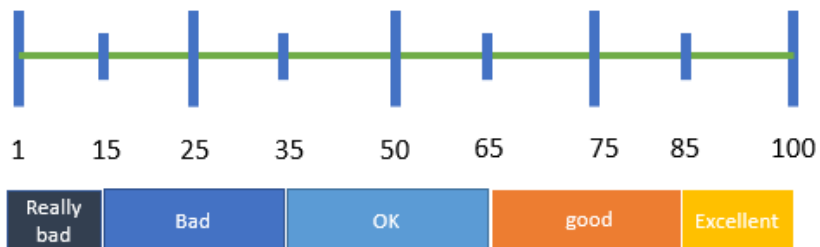
VRCrane could **not simulate everything**, such as the haptics of user touches the joystick and **the physical reaction** when QC moves.



Overall, the testers thought VRCrane is helpful at **the first day of training**

EVALUATION RESULTS

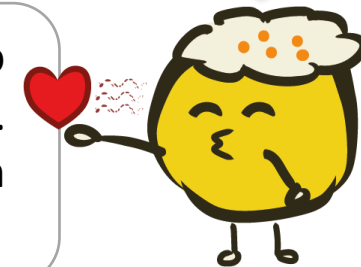
- **Part 2:** Interface of VRCrane
- The average score of VRCrane is **81**, which is **“good”**.



EVALUATION RESULTS: INTERFACE OF VR CRANE



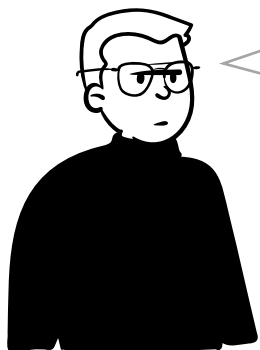
VR Crane is **easy to use**. Siu Mai, non-player instructor, who **speak** and displayed **subtitles**, helps us to know what to do. The 3D graphic is realistic. The first-person view in VR with two hand controllers makes the training immersive.



VR still is **not real world**, the project does not carry any **physical buttons** that I needed turn my head to confirm that I was holding the handles. That makes my neck tired.



I feel dizzy. The symptoms of motion sickness is not caused by using HMD and sensor system latency. I am **nearsighted**. I can't wear my own glasses while wearing the headset. I use the prepared glasses with smaller size, and which might not 100% fit my eyes.



EVALUATION RESULTS: OTHER POSSIBILITIES OF VRCRANE



The VR training is also suitable for RTGC and Kalmar.

It can be used for promotion.



VRCrane is a very good tool before a person joined the crane training course. Some trainees had theoretical trainings in 2 days, **but trainees left in day 3 once they were on the crane.** If the newbies tried VRCrane and knew that they did not want to be a crane operator. Having VRCrane would **save a lot of time and manpower.**



Interesting

CONCLUSION & FUTURE WORK

- The participants thought that VRCrane helped QC trainees some **basic operations** and save company cost. However, **VR cannot cover all the working conditions** without physical control panel. Real practical training is the most important part. Although VRCrane was not perfect, it was suitable to apply into different cranes **for training and for public promotions.**
- VRCrane was capable to conduct different scenarios. I want to add more scenarios, such as loading not only one size of containers, but also different size of containers and special goods, such as aircraft engine and frozen container.

We are done. Game Over!

menu



The End

Q&A



<http://tangwingszekitty.weebly.com/>