2020 - 2021 UROP SUMMER PROJECT

HKUST IN VR

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Abstract

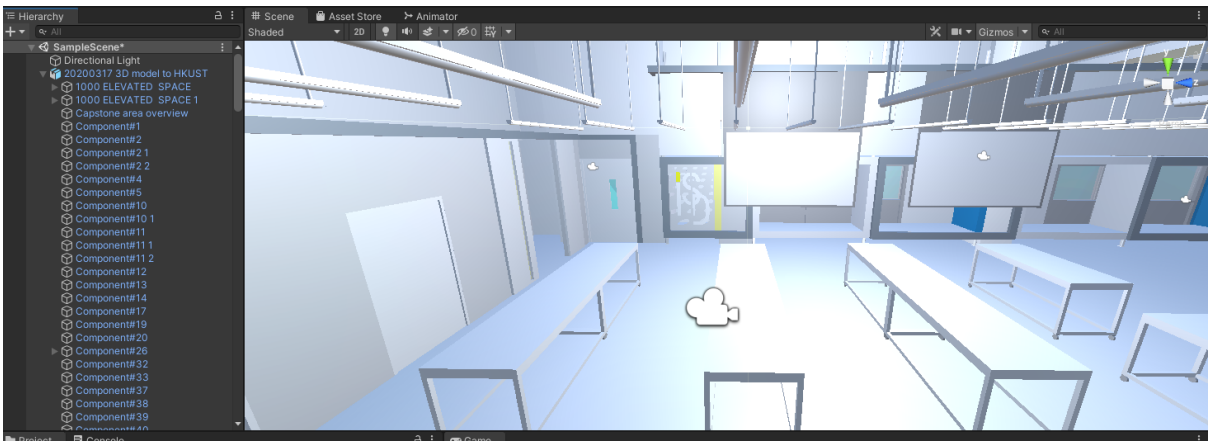
This project requires the use of Unity and VR equipment to create a virtual environment for laser cutter training. Tutorials on Unity VR are taken to familiarize with the application of the software. Training for manufacturing tools used to be tedious and time-consuming, since one-to-one training is usually required for students to be familiar with the operation, which takes technicians so much time and effort to repeatedly teach individual students. Hence, training using virtual reality might be a way to increase the efficiency of training since students can be trained without technicians and it does not require multiple physical devices for training. Currently, laser cutter, water-jet cutter, 3D printer, and welding machine in virtual space are built to make a virtual ISD Works! for students to interact with machine training.

Introduction

Develop a VR application used to train ISD students how to use the laser cutter, and evaluate the students' readiness before operating it. The mistakes made by students during training will be used to improve future training guidelines.

3D Modelling

For model building, Rhino is used for design prototypes and Keyshot applies realistic rendering to the models. As it is aimed to create a virtual environment in ISD Works! , laser cutter, water-jet cutter, welding machine, and 3D printers are built. The floor plan of the Sketchup 4223 space is also given. Therefore, we could put all the objects into the room and create a virtual 4223.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Scene
Asset Store
Animator
Shaded
2D
Gizmos
SampleScene*
Directional Light
20200317 3D model to HKUST
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Capstone area overview
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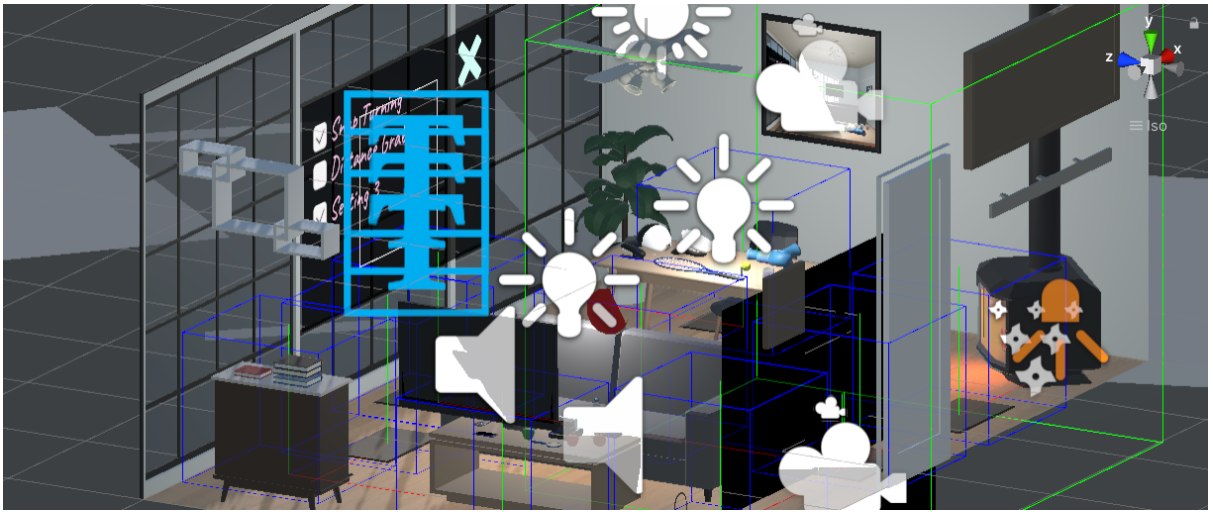


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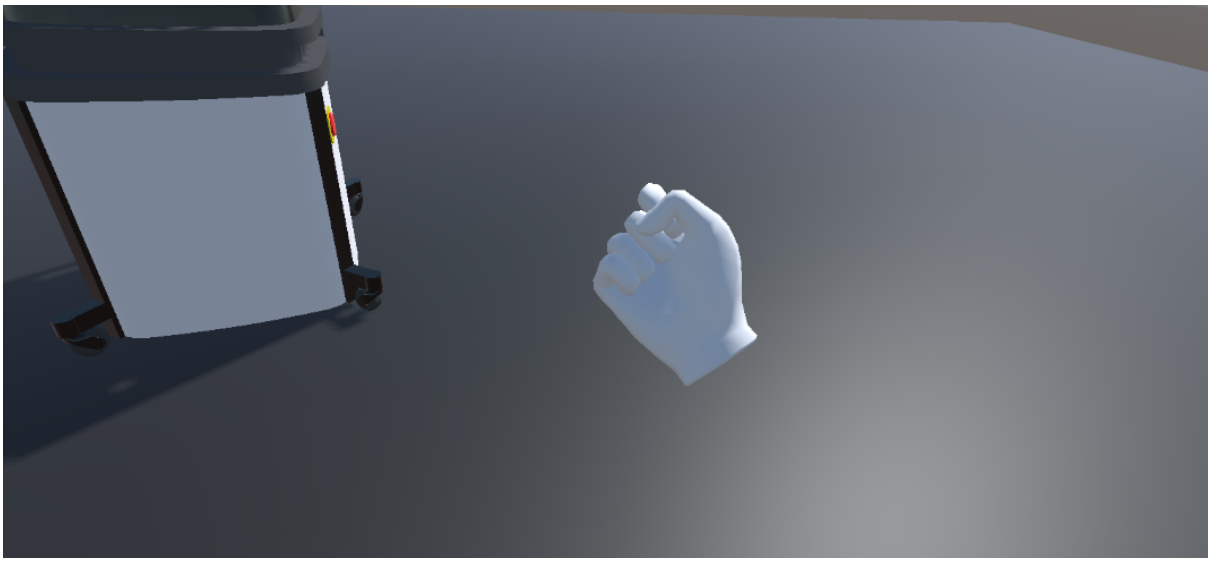
Unity software

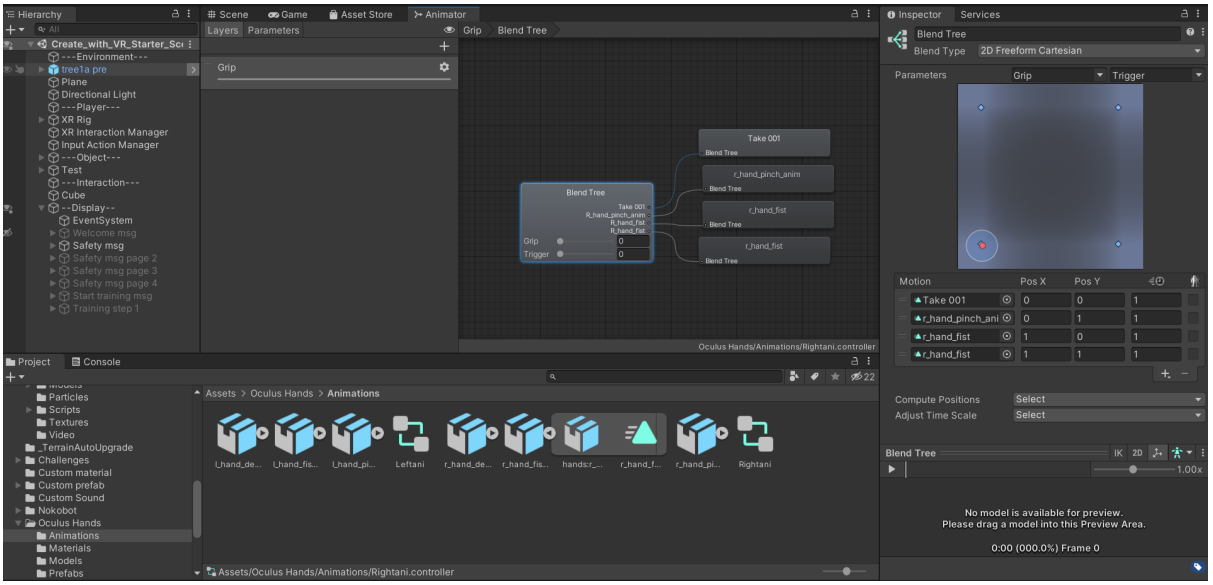
In order to get familiar with the VR software in Unity, tutorials by Unity webpage are necessary for skill-learning. Learners are required to build a virtual room with furniture. Techniques including object transport, interaction, teleportation, sound/ light optimization, animation, video, and canvas building.

Building interface of Unity

Animation

Visuals will be the most important part of this project. With that, hand animations are developed to simulate the real finger movement to give users a realistic experience. Also, the machine we are simulating is highly sophisticated computer-controlled, hence, animations need to be developed further and buttons corresponding to movements need to be built. Take laser cutter as an example. The buttons need to control the movement of the position of the laser emitter to reset the position.





```
using UnityEngine.XR;

public enum HandType
{
    Left,
    Right
}
public class XRhand : MonoBehaviour
{
    public HandType handType;

    private Animator animator;
    private InputDevice inputDevice;

    private float gripValue;
    private float triggerValue;
    // Start is called before the first frame update
    void Start()
    {
        animator = GetComponent<Animator>();
        inputDevice = GetInputDevice();
    }

    // Update is called once per frame
    void Update()
    {
        AnimateHand();
    }

    InputDevice GetInputDevice()
    {
        InputDeviceCharacteristics controllerCharacteristic = InputDeviceCharacteristics.HeldInHand | InputDeviceCharacteristics.Controller;

        if (handType == HandType.Left)
        {
            controllerCharacteristic = controllerCharacteristic | InputDeviceCharacteristics.Left;
        }
        else
        {
```

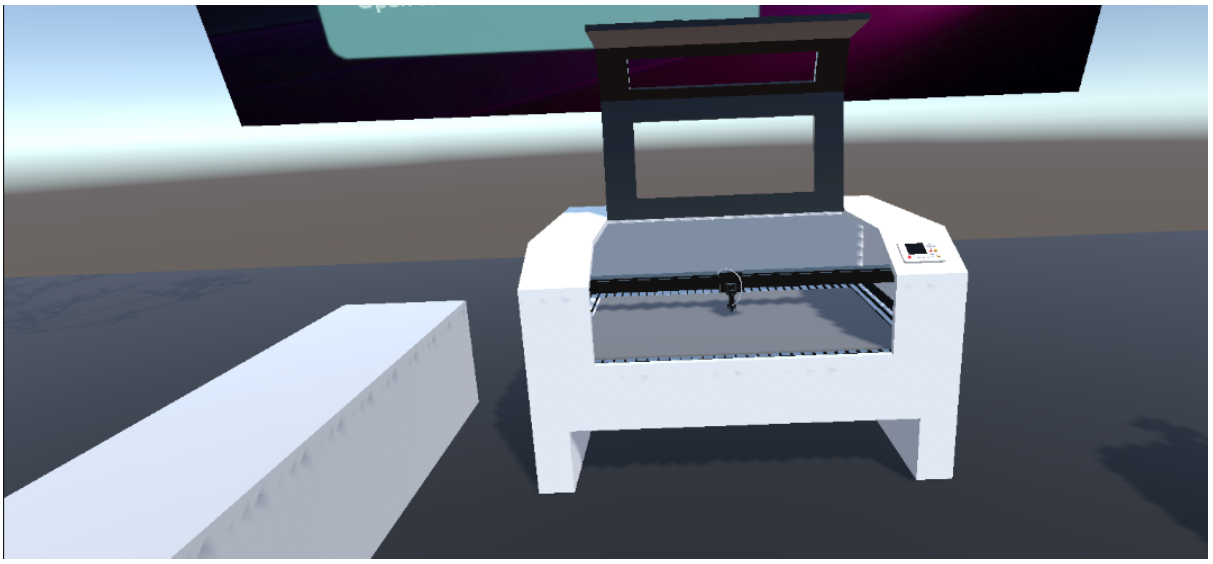
Script for hand animation control

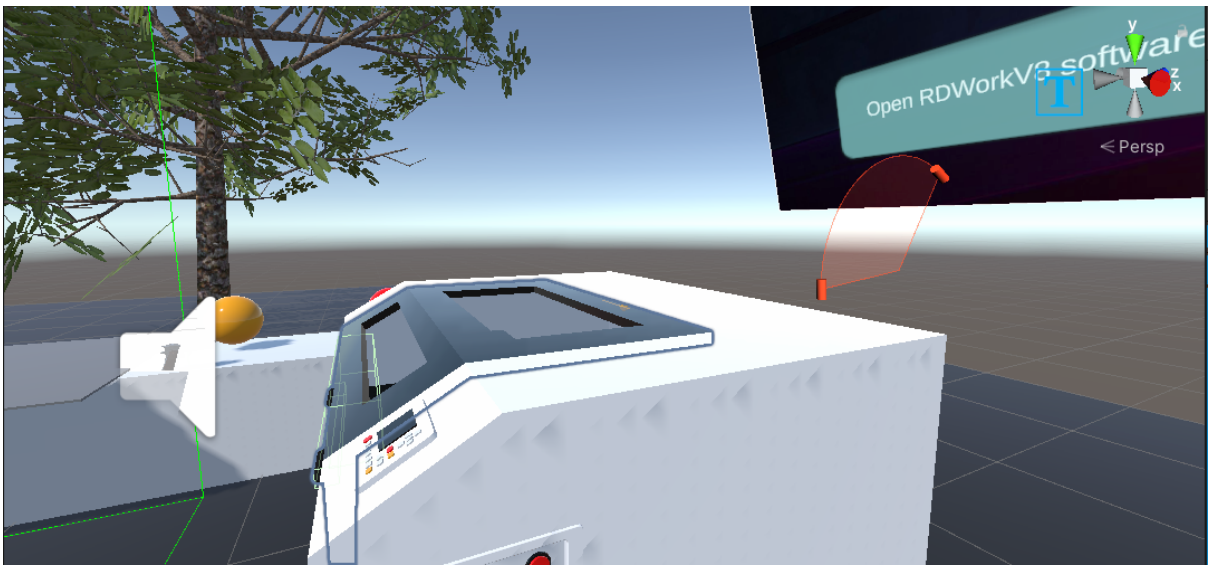
Interaction

Interaction between the users and the machine will be the most critical part of this project. The machines in the virtual world must simulate equipment in the real-world to achieve the training result. Meanwhile, not only visual, both sound cues and touch feedback are critical in the training procedure.

Other than interacting with the machine itself, feeding material for the machine will also be a critical part of the procedure. It is known that feeding the material to the machine is one of

the most critical parts of the whole operation since it is quite often that safety regulations are not be followed, hence damaged the component of the machine. With that, a real machine usually takes weeks to repair, which is also the initiative of the project.

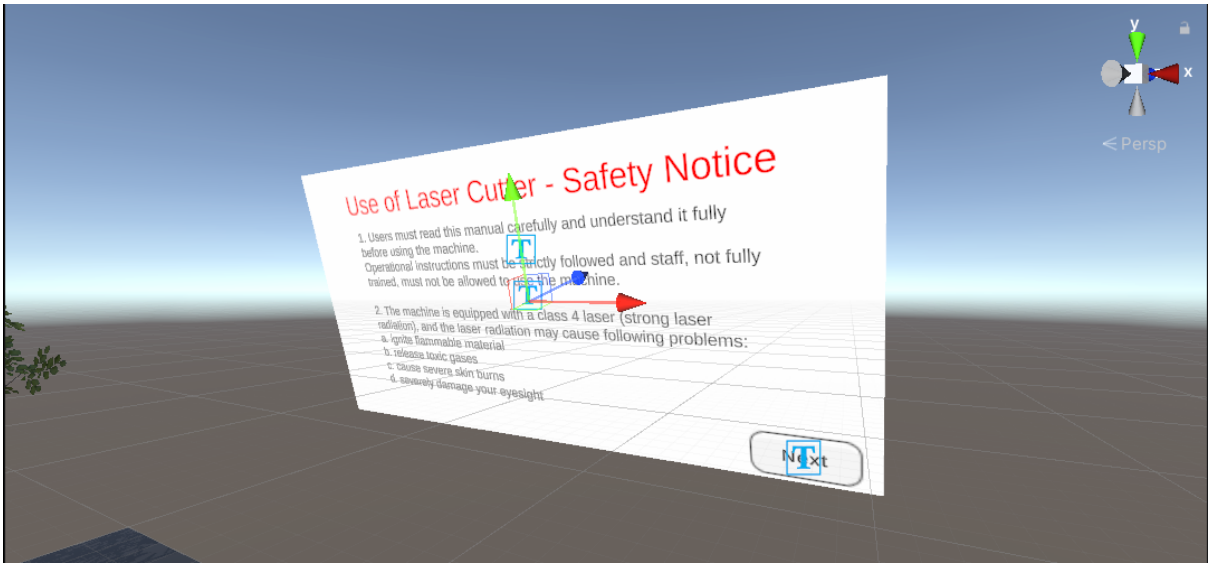


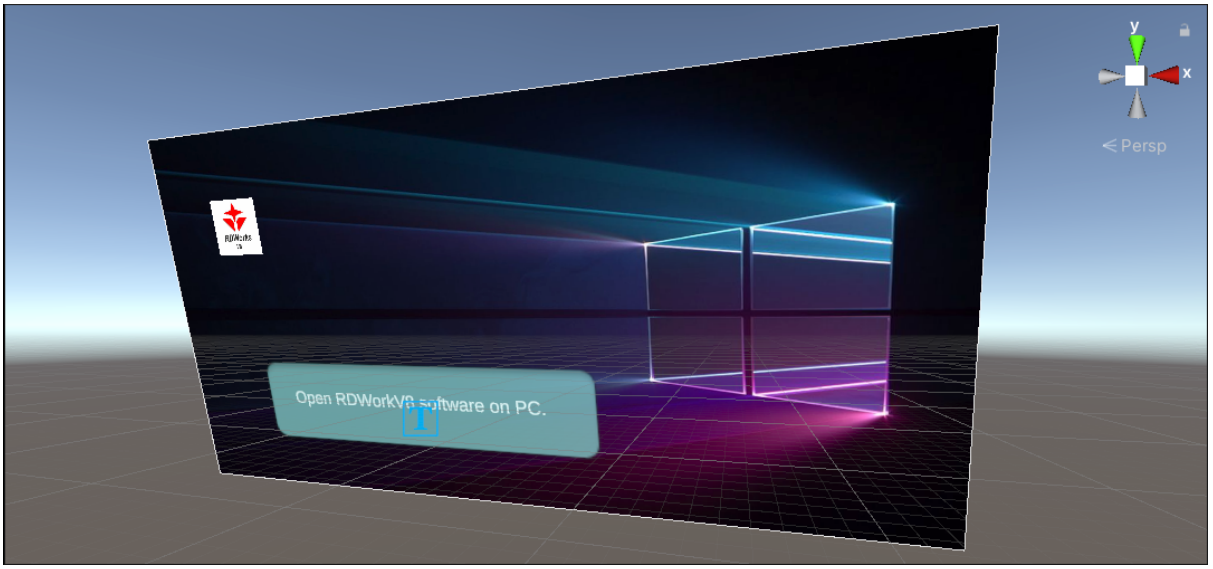


UI

UI is also a critical part of this project, since operating these devices is quite dangerous, even though operating in the virtual world will not really hurt you, essential safety notices and alerts are still needed for the physical operation of the machines in the future. Not only that, a

feedback system is also needed for each step to indicate whether the user's procedure is correct or not.





Guide

For the people who first train or experience VR, necessary guidance is essential for controllers operation. For example, what button stands for certain actions including grabbing, teleportation, transportation, and objects interaction.

Score recording system

It is planned to have two different stages for the laser cutter training. The former stage is a pure training interface with all the guidance and tips teaching users to use the machine. While the latter stage is an assessment platform with a scoring system. Users have to operate the laser cutter without guidance in correct steps and orders to gain marks. This should be the hardest part in writing codes in Unity as the way to detect whether the user is doing the correct step is complicated.

Task record method

Since most of the tasks when using laser cutter cannot be simply measured with a simple variable, the task achievement of the user had to be measured with objects in the game world. Empty objects are placed near the desired states of the cover of the laser cutter. Thus, when the cover reaches said desired state, a collision with the empty object is detected, triggering a increase in the score.

Issues and Optimization

The implementation guidelines/tutorials for different levels of experience on both VR and laser cutter would be considered including beginner, intermediate and advanced users. Students' performance and readiness would be evaluated based on the number of mistakes made during training, time response, and order. Users may face motion sickness after long usage due to static body movement.

The laser cutter simulation is logically and visually realistic but hard to provide a similar haptic effect compared with actual operation. Evaluation from users would be collected for further improvement.

The difference between skillful users and laymen of using laser cutter could be the familiarization on tricky parts of the software (lots of settings, power of nozzles, how strong of cutting power, how accurate want final product should be)

Real training cannot be bypassed completely, but time could be reduced.

Timeline

Prototype Development - September

A completed Unity laser cutter project with suitable guides, actions, and object rendering

Trial Experiment (with a few people) - mid-October

Trial of software with peers and obtain user feedback for improvement

First Key Deadline - 12 November

Test in 4223 with year 1 ISD students during VR experiencing the lesson

Obtains user feedbacks as their coursework

1st Paper Draft - mid-January

Refine the Program

Experiments & Evaluation

ISDN2300 - end November

ISDN2400 - end March

2nd Paper Draft - mid-April

Demo video