Development of Smartphone Application for Versatility of Teaching Materials using Three-dimensional Expression

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ABSTRACT

In recent years, VR (Virtual Reality) technology has been applied in the field of education. In this research, we will develop a system of VR teaching materials that can be operated with a head mounted display using only smartphones so that more people can experience VR teaching materials.

1 INTRODUCTION

Among the various fields in which VR (Virtual Reality) can be used, especially in the field of education, we aspire to enable users who have left classes and experiments to share the same environment or knowledge and perform in groups [1,2]. This time, we will create VR teaching materials to develop interactive online lessons and remote experiments. Commercially available HMDs (Head Mounted Display) such as "HTC VIVE" "Oculus Quest" and "Google-Cardboard" is employed for VR experience, shown in Fig. 1. HMD is a general term for VR display devices that use stereoscopic images using left and right eyes' parallax. A harness is used to wear a goggle-shaped display over both eyes. Our research team has created several VR teaching materials using Unity, an integrated development environment for building 3D projects on variety of platforms. However, these VR teaching materials work only on HTC VIVE [3].

In this research, to make VR teaching materials more accessible, we intend to operate with an HMD that uses only smartphones and does not require additional devices such as controllers. The VR teaching materials' execution platform will be iOS, and it will be possible to operate with the same feel as HTC VIVE as much as possible with only an iPhone and HMD. Furthermore, by utilizing each other's smartphones the chance of infection with diseases like the new coronavirus infection is reduced [4].

Fig. 1 Typical example of HMD.

2 PROPOSED METHOD

This chapter describes the system that was the basis of this research and how to change it.

2.1 Questions to implement

The VR teaching materials used were developed in the laboratory. Unity is used as the integrated development environment, and HTC VIVE is used as the HMD. The completed VR teaching materials will be developed as an iOS compatible application. The contents of the questions implemented in this study are shown in Fig. 2. The pentagon represents the boat, while the green and red dots represent the boat's starting and ending point, respectively. Figure 3 shows the velocity decomposition considered when solving this question.

> There is a boat that travels in still water at 2 m/s. When the river flow is 1 m/s, in what direction should the bow be turned to travel the shortest distance to the opposite shore?

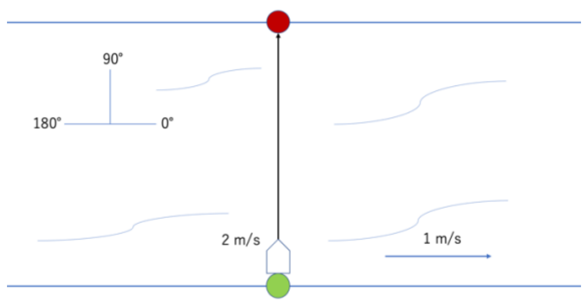

Fig. 2 Questions to implement.

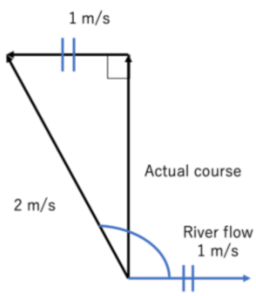

Fig. 3 Velocity decomposition of starting point angle.

According to the trigonometric ratio formula, if the actual velocity component of travel is x, the angle to be tilted the flow of the river can be calculated by the following formula.

$$2^2\ m/s + 1^2\ m/s = x^2,$$
$$x = \sqrt{3}\ m/s\,,$$
$$\frac{\sqrt{3}}{2} = cos30°, \qquad (1)$$
$$90° + 30° = 120°.$$

In addition, there is a challenge of finding the speed when travelling perpendicular to the river flow, and the difference between the opposite shore point and the arrival point when travelling with the bow perpendicular to the river flow. There may be a problem of finding.

2.2 Take advantage of hand tracking

Hand tracking [5] is used in conjunction with a Google Media Pipe [6,7 technology to make VR teaching materials compatible with applications. For example, as shown in Fig. 4, multiple hand movements can be read from an image and displayed on the screen as dots or lines. As a result, as shown in Fig. 5, a virtual hand object can be displayed in the VR space and the object can be manipulated.

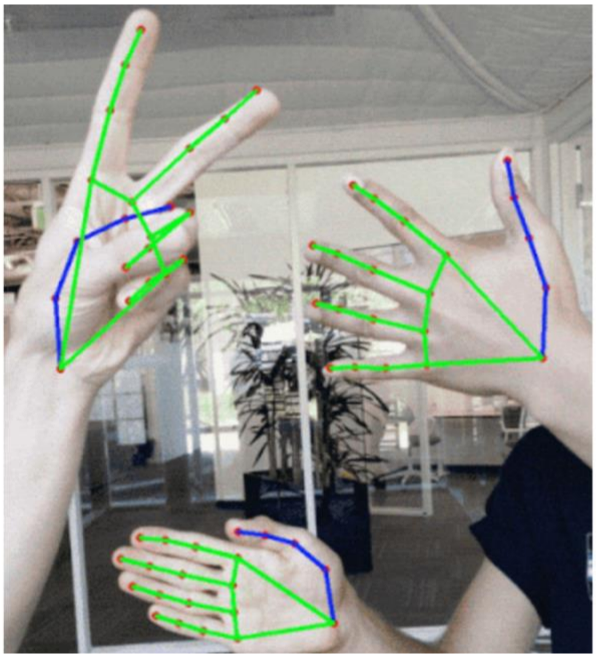

Fig. 4 Multiple hands.

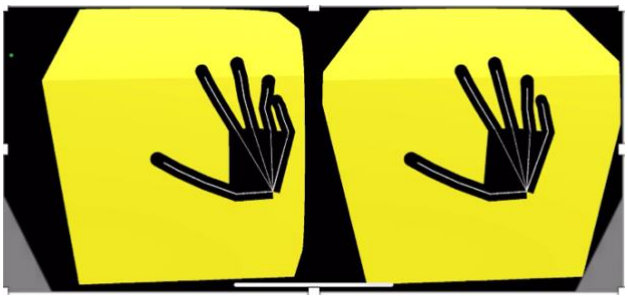

Fig. 5 Hands to implement.

3 RESULTS AND DISCUSSION

3.1 RESULTS

First, as shown in Fig. 6, we developed a UI (User Interface) that can be controlled by touching the hand object created by the previous hand tracking. When the object of the hand touches, the input corresponding to each button is performed. Use the slider in the centre to change the values so that you can select the appropriate value depending on the problem. In addition, depending on the situation, such as before and after starting, only the buttons necessary for the operation at that time are displayed to prevent malfunctions such as pressing an unintended button. Then, as shown in Fig. 7, we developed a UI that allows the user to choose between several problems when the programme is launched. This can also be selected with a hand item, and the back button can be used to return to the previous state after launch. When a hand item contacts it, the developed UI goes yellow and when it is grabbed, it turns gray.

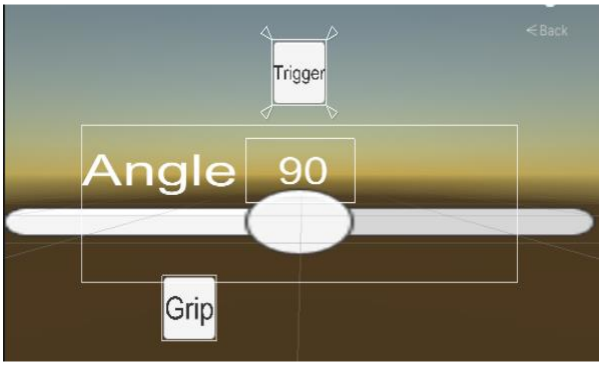

Fig. 6 Operation UI.

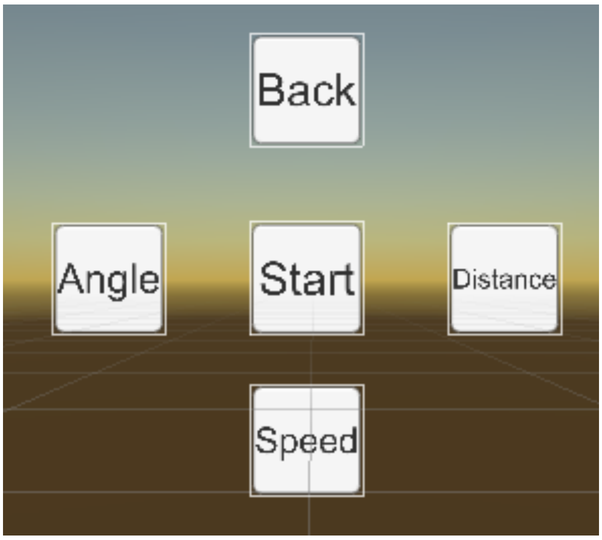

Fig. 7 Problem UI.

We have developed a result screen that solves the newly formed speed and distance issues. To make it simpler to understand visually, change the camera to a bird's-eye view and use a red dotted line to indicate the boat's trajectory when it proceeds according to the correct answer, as well as how much the boat's trajectory shifts when it moves according to your response. It is indicated by a white dotted line. If the correct answer is selected, a right triangle is completed in the problem of velocity as shown in Fig. 8, and in the problem of distance, the two trajectories appear to overlap exactly as shown in Fig. 9.

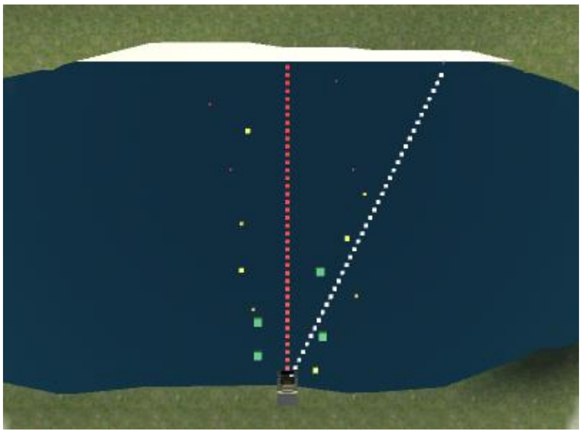

Fig. 8 The result of the speed problem.

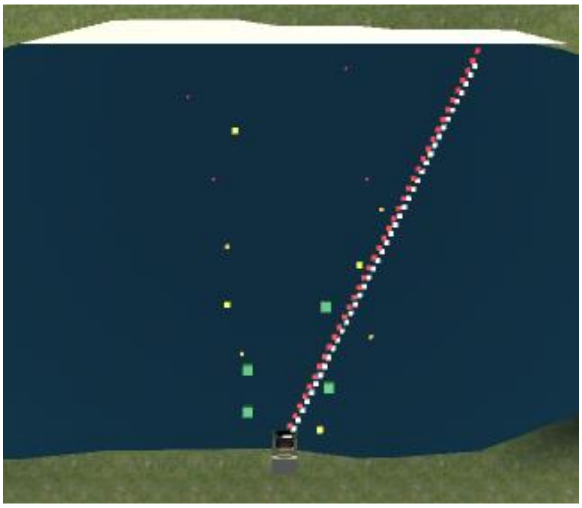

Fig. 9 The result of the distance problem.

The state of the running application is shown in Fig. 10, Fig. 11, and Fig. 12. In Fig. 12, we have implemented a shooting game where you can experience the laws of physics by firing a ball at a target located above the river.

Fig.10 State just before departure.

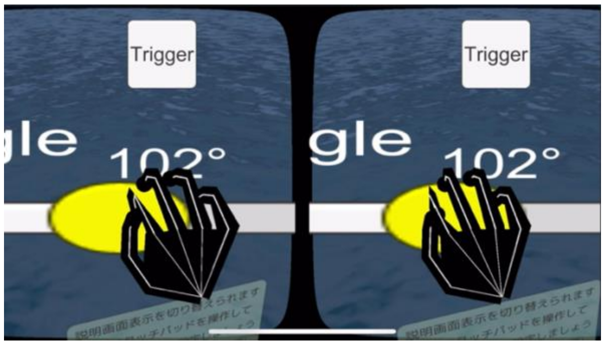

Fig. 11 Numerical adjustment with the slider.

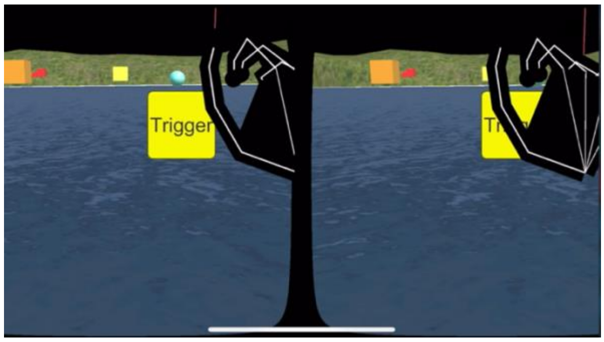

Fig. 12 State of the shooting game.

3.2 DISCUSSION

From the above, we were able to operate the VR teaching materials as a smartphone application. The application implemented this time supports VR experience using HMD such as Google-Cardboard. In addition, because the background of the teaching materials is blackened, you can also experience augmented reality at the same time by using the HMD called Dangra [8]. In addition, since the camera moves according to the position and angle of the smartphone, it is possible to walk around in the virtual space.

In the usual year, we encourage people to use it at the experience meeting, receive feedback from the questionnaire survey, explain the issues that need to be changed, and develop a system that is easier to use. However, due to the influence of the new coronavirus infection, the experience session could not be held this year, therefore we proceeded with the development based on the opinions of the individuals in the laboratory and our subjectivity. One problem I discovered is that while using hand tracking, to control the UI, you must bring the hand object and the UI close to each other, which may be difficult for some individuals to do because arm length varies. There's one point, and there's another that gripping and releasing the UI with a hand object can be a little unresponsive at first.

4 CONCLUSION AND FUTURE WORK

In this research, we have developed a VR teaching material system that can be operated using only smartphones, to make it easier for more individuals to experience VR teaching materials. As a result, we were able to use hand tracking and the newly developed UI to create and execute applications. We intend to solve the identified problems by developing a UI that is independent of physical factors such as arm length, as well as developing teaching materials with minimal flaws. In the future, we aim to make it compatible with smartphones simply by packaging the necessary settings and scripts and introducing them into existing VR teaching materials. We intend to introduce a mechanism that allows other people to see and interfere with the situation in the same virtual space as the person using this application. Finally, we would like to develop more practical teaching materials and continue development to introduce them into school lessons.

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