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Developing Education Support System using Interactive Floor Interface

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Abstract: Recently, ICT equipment has been introduced to classrooms in Japan. Moreover, effectiveness of active learning that engages students as active participants in their learning has been discussed. In order to merge the usefulness of ICT and the effectiveness of active learning, we developed interactive floor interface (IFI) that enables users to see teaching materials displayed on a floor and to control it with their gestures. We also developed an interactive teaching material of wave interference designed for IFI. To confirm the effectiveness of IFI, we gave examinations before and after learning to two groups each of which learns wave interference by using either a usual textbook or IFI. As a result, it was found that average scores of examinations have significantly increased in both groups. Although an average increase of scores for IFI was higher than that of usual textbook, we could not show its significant difference. It is important to improve teaching materials for IFI by giving further interactivity, user-friendliness, and so on.

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1. INTRODUCTION

The rapid spread of information technology is affecting the educational field. In 2017, the government curriculum guideline in Japan was revised for the first time in ten years [1]. In this new guideline, the introduction of ICT equipment to classrooms is considered. Relating to that, it is known that the projectors are introduced to 90% of junior high schools in Japan. Moreover, effectiveness of active learning that engages students as active participants in their learning has been discussed. In order to merge the usefulness of ICT and the effectiveness of active learning, we developed interactive floor interface (IFI) that enables users to see teaching materials displayed on a floor and to control it with their gestures.

2. RELATED STUDIES

Relating to our study, Konishi and Fujita [2] developed an interactive floor where users can see virtual 3D objects in the field that is defined as a superposition of projection areas of two projectors. Users on the interactive floor are recognized by Kinect. By using two projectors, users can see the floor without being disturbed by their shadows. However, the position of the interactive floor was fixed because Kinect and two projectors are settled to ceiling.

As for the teaching material for active learning, Nakano et al. [3] developed a simulator that shows a mirror image and a virtual image of a user on a large display to teach how a mirror works to junior high school students. They found that their system succeeded to make students understand the phenomenon superficially, but essential understanding was not obtained.

Setozaki et al. [4] developed interactive teaching materials for astronomy with which students can learn the principle of moon phases. They compared the active usage of the teaching materials with their passive usage in which teachers use the teaching materials instead of the students. They found that, by the active usage of the teaching materials, the students got higher scores for applied problems.

Based on these previous studies, we develop an interactive floor interface composed of two projectors and Kinect whose relative positions are fixed to make them transportable. This system should display teaching materials with relating equations to realize essential understanding of phenomena. Using this system, we aim to show the effectiveness of active usage of interactive teaching materials.

3. INTERACTIVE FLOOR INTERFACE (IFI)

A schematic diagram of interactive floor interface (IFI) is shown in Fig. 1. IFI is composed of Kinect, two projectors, their bases to keep their relative positions fixed, and PC.

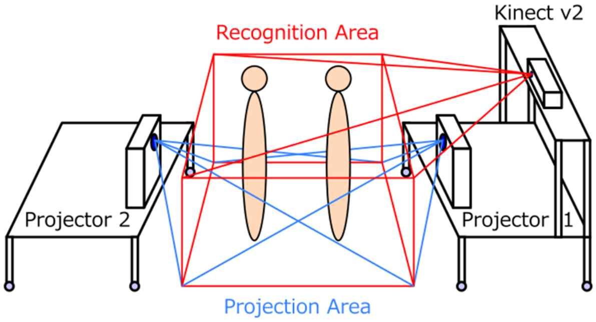

Fig. 1 A schematic diagram of IFI.

In order to make IFI transportable as stated in Sec. 2, casters are settled to the bases for Kinect and projectors.

An information flow in IFI is shown in Fig. 2. The movement and gestures of users are inputs to IFI, and images on a floor are outputs from IFI. When users perform some movement or gestures in the projection area shown in Fig. 1, a program on PC with Kinect recognizes them and images suitable for the situation are shown on the floor.

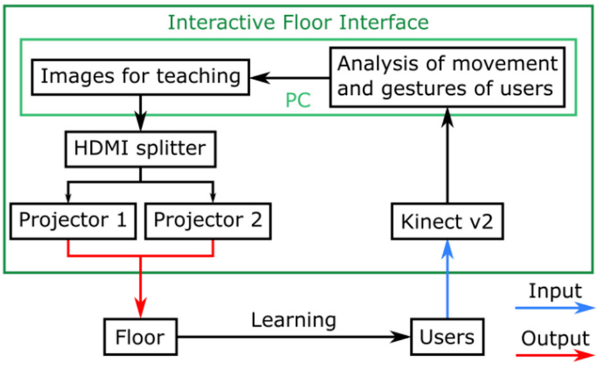

Fig. 2 An information flow of IFI.

In our previous research [5], we developed a workbench system for job training in which a workbench was used as a display instead of floor, and only one projector was used. By using a floor, users can walk around the area freely. Therefore, we assume that IFI is suitable for elementary and secondary education.

Moreover, when the base for the projector 1 and Kinect in Fig. 1 is settled on a mobile robot, IFI can be a mobile information giving system.

4. TEACHING MATERIAL: WAVE INTERFERENCE

As a teaching material for IFI, we focused on wave interference treated in high school because it is hard to experience wave interference in our daily life and many students are not good at it. It is expected that the learning of wave interference with IFI is effective because students can see the multiple waves in IFI and control them interactively. As stated in Sec. 2, a logical understanding of phenomena based on mathematics is also emphasized in this study.

Let L_A and L_B as distances of wave origins from a point P and λ as a wave length. Then a condition for constructive interference is:

$$|L_A - L_B| = n\lambda$$

where n is an integer. And a condition for destructive interference is:

$$|L_A - L_B| = \left(n + \frac{1}{2}\right)\lambda.$$

Understanding of these equations is also a purpose of our teaching material for IFI.

We created three modes of the teaching material for wave interference, i.e., distance mode, real mode, and moiré mode as shown in Fig. 3. They are explained in the following.

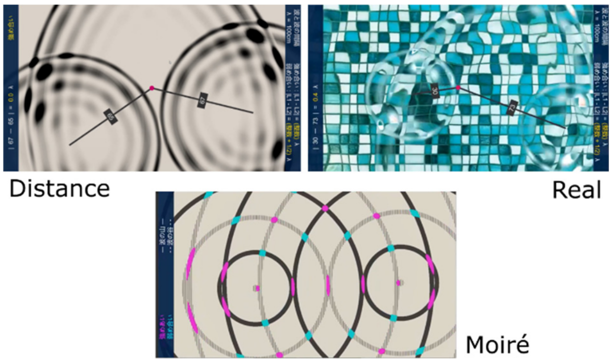

Fig. 3 Three modes of the teaching material for wave interference.

The distance mode is a default mode of this teaching material. Its purpose is to understand the conditions of constructive interference and destructive interference. This mode is used by two users, and wave sources are set at the positions where users stand in the projection area. The users can observe the patterns of wave interference on the floor generated by two waves. In this mode, the conditions of constructive/destructive interference at the center point of projection area are checked based on the equations, and the results and the equations are shown on the left edge of the area. Using this mode, users can move the wave sources by walking around in the projection area, and they can observe the change of the interference pattern. As a result, they can understand the wave interference both intuitively and logically.

In the real mode, the background of the wave was changed to a tile pattern similar to a floor of pools. The functions of real mode are identical with those of distance mode. By changing the background, users can feel that the wave interference is a familiar phenomenon. Switching between the distance mode and the real mode is realized by a gesture of raising left hand. In order to implement these two modes, we referred to the programs for Unity with C# in [6].

In the moiré mode, waves are represented as geometric patterns. Peaks and troughs of waves are shown in black and gray lines, respectively. Intersections of peaks of two waves are shown in pink, and intersections of troughs of two waves are shown in light blue. The appearance of waves in this mode is close to that used in examinations in physics. Therefore, this mode is suitable for exam preparations. Because positions of wave sources are fixed in this moiré mode, users can observe the interference patterns and their time variations in detail by walking around in the projection area. Switching between the real mode and the moiré mode is realized by a gesture of raising both hands.

Besides the above three modes, we implemented two functions for changing the frequency of waves and for pausing waves, which are used in the distance mode and the real mode. By changing the frequency of waves, users can observe the change of interference patterns. The frequency of waves can be changed by a gesture of raising a right hand. By pausing waves, users can observe the interference patterns in detail. Waves pause by a gesture of raising both hands horizontally.

5. GESTURE RECOGNITION OF USERS

As shown in Fig. 2, movement and gestures of users are given to IFI. By assigning appropriate functions to them, we can introduce interactivity to IFI. In this study, we implemented the following three functions in IFI.

1. Wave sources are placed at the positions of users in the projection area.
2. The frequency of wave changes according to gestures of users.
3. The mode of IFI changes according to gestures of users.

The first and second functions changes properties of a wave, and the third function changes the mode of IFI that was explained in the previous section.

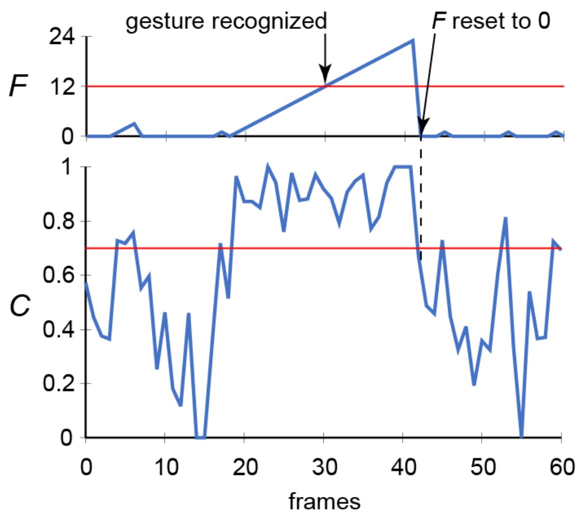

Fig. 4 A schematic diagram of gesture recognition.

In order to realize the second and third functions, gesture recognition of users is required.

To realize gesture recognition from skeleton data of Kinect, we constructed a classifier of gestures using Kinect Studio and Visual Gesture Builder in Kinect for Windows SDK. This classifier returns a boolean value for gesture recognition, and, when it takes true, a value of confidence C in the range [0, 1] is also returned. To exclude gestures with small C, we defined a successive frame F in which C take large values. When $C \geq 0.7$, F is incremented, and, otherwise, F is reset to 0. When $F \geq 12$, a gesture is recognized as shown in Fig. 4. With preliminary experiments, we found that two conditions $C \geq 0.7$ and $F \geq 12$ gave a best recognition rate.

6. EVALUATION OF IFI

To confirm the effectiveness of the teaching materials for IFI to learn wave interference, we gave examinations before and after learning to two groups each of which learns wave interference by using either a usual textbook or IFI. Each group includes ten students, and the identical examinations were used before and after learning. As a result, it was found that average scores of examinations have significantly increased in both groups as shown in Fig. 5.

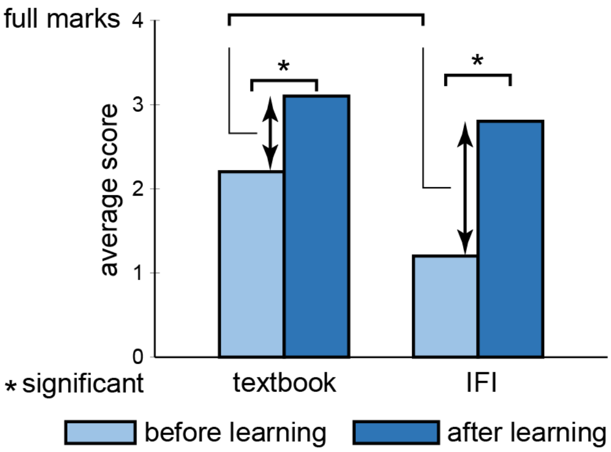

Fig. 5 Improvement of scores after learning.

Although an average increase of scores for IFI was higher than that of usual textbook, we could not show its significant difference. It is important to improve teaching materials for IFI by giving further interactivity, user-friendliness, and so on.

7. CONCLUSION

In this study, we developed an interactive floor interface (IFI) for education that have both the usefulness of ICT and the effectiveness of active learning. The relative positions of Kinect and two projectors were fixed, and we successfully made IFI transportable.

Besides an intuitive understanding of wave interference, its logical and mathematical understanding was emphasized. Although an average increase of scores for IFI was higher than that of usual textbook, we could not show significant differences. It is important to improve teaching materials for IFI by giving further interactivity, user-friendliness, and so on.

REFERENCES

[1] Ministry of education, culture, sports, science, and technology in Japan, The new government curriculum guidelines (2017).

[2] Y. Konishi and S. Fujita, “Developing an interactive floor using two projectors (in Japanese),” The 77th annual conference of information processing society of Japan, pp.247-248, 2015.

[3] H. Nakano, Y. Kubota, Y. Komatsu, and M. Osaki, “Developing and trial of a teaching material that simulates mirror images based on AR using Kinect (in Japanese),” Japan Journal of Educational Technology, vol.39, Suppl., pp.105-108, 2015.

[4] N. Setozaki, T. Iwasaki, and Y. Morita, “Effec ts of active manipulation in teaching practice with multi-view astronomical teaching equipme nt (in Japanese),” Japan Journal of Educational Technology, vol.36, no.2, pp.81-90, 2012.

[5] U. Suda and T. Kanamaru, “Development of a workbench system for job training based on behaviors of worker,” The 16th International Symposium on Advanced Technology, p.210, 2017.

[6] keijiro/RippleEffect, https://github.com/keijiro/RippleEffect