BELONG: Body Experienced Learning Support System based on Gesture Recognition

Enhancing the Sense of Immersion in a Dinosaurian Environment

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Abstract: As the first step toward realizing an immersive learning support system for museums, Yoshida et al. developed and evaluated a prototype system. However, this system was problematic in that it could only be operated by using simple body movements. Moreover, the other problem was that learning about paleontology itself cannot be performed only by learning about a paleontological environment. Therefore, we developed an immersive learning support system "BELONG" as an upgraded version of the above-mentioned system. Using a recognizer capable of gesture recognition, the system can be operated using complicated body movements. The improved system enables learners to enhance their sense of immersion in a paleontological environment and learn about the fossil itself and its paleontology. This paper summarizes the prototype of "BELONG" and describes the experiments that were performed to evaluate its ability to achieve learning support and immersion.

SCIENCE AND TECHNOLOGY PUBLICATIONS

1 INTRODUCTION

Museums are important places for children to learn about science (Falk, J. H., 2012). They also operate as centers for informal education in connection with schools, and they enhance the effectiveness of scientific education (Stocklmayer, S. M., 2010). However, because the main learning method within museums is the study of the specimens on display and their explanations, there are few opportunities for learners to observe or experience the environment about which they are learning. In particular, it is impossible to experience a paleontological environment, which includes extinct animals and plants, and their ecological environment (Adachi, T., 2013). It is difficult for children to learn about such environments merely by looking at fossils and listening to commentary. Overcoming this problem would qualitatively improve scientific learning within museums. As for these problems, a system that simulates a paleontological environment and transitions that would be impossible to experience in reality would solve the problem. The system would also need to enhance learners' sense of immersion. Therefore, such a system is needed.

In order to enhance the sense of immersion, a full body interaction interface in which the movement of the whole body is linked to the operation of the system was previously shown to be effective (Klemmer S., 2006). Yoshida et al. also developed a system targeting a full body interaction interface; however, the system could only be operated using simple body movements and this was problematic (Yoshida, R., 2015). Moreover, learning about paleontology itself cannot be performed only by learning of a paleontological environment.

Therefore, we developed an immersive learning support system "BELONG" as an upgraded version of the original system by Yoshida et al. The upgraded system solves the above problems. Compared with the conventional learning support system, using a recognizer capable of gesture recognition, the system is operated using complicated body movements.

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Moreover, body movements are incorporated as part of the observation behavior of a fossil exhibition, which previously consisted of a conventional written explanation. The system enables learners to enhance their sense of immersion in a paleontological environment and learn about the fossil itself and its paleontology.

In this paper, we summarize the prototype of "BELONG" as the first step toward developing the immersive learning support system for the fossil exhibition at the museum. In addition, we describe the results of our experimental evaluation of the learning support and immersion abilities of the system with the aim of clarifying whether it can provide learners with a realistic paleontological observation experience.

2 LEARNING SUPPORT SYSTEM

2.1 Belong

We aim to realize the immersive learning support system "BELONG" that simulates a paleontological environment and transitions that are impossible to experience in reality for efficient learning at the museum. Figure 1 illustrates the concept of "BELONG." This system accepts body movements as input for observational behavior. The movements of the whole body and the system operation are linked; therefore, it is possible to enhance the sense of immersion in the paleontological environment. The sense of immersion improves if the system can be operated in conjunction with complicated body movements as compared with a case in which the system is operated with simple body movements. The recognition of complicated body movements should not involve attaching expensive sensors or devices to learners when implementing it in a museum. In this system, we utilize Microsoft's Kinect v2 sensor, a range-image sensor originally developed as a home videogame device. Because BELONG comprises only a Kinect v2 sensor, projector, and control PC, it allows us to provide a low-cost immersive learning experience within a small space. The advantage of this arrangement is that it is possible to easily change the learning contents. Moreover, we recognize the body movements of learners by gesture recognition using the Kinect v2 sensor. The gesture recognition system, which can also interpret complicated body movements, registers the body movement the creator wishes to recognize and judges whether it is recognized by verifying the similarity with the body movement.

Figure 1: Concept of BELONG.

2.2 Configuration of the System

We developed an immersive learning support system "BELONG" that simulates a paleontological environment and transitions that are impossible to experience in reality. As a first step towards the realization of this system, we are developing a system to simulate paleoecology, especially learning about dinosaurs, based on experiences that simulate a paleontological excavation. Our assumption was that learners' interest would increase by virtually excavating fossils included in the current exhibition. However, because excavation motions are complex body movements, gesture recognition was used. (Tokuoka, M., 2017) When the excavation proceeds successfully, videos showing the characteristics of the dinosaur are displayed. Linking the body and the video in this way increases the sense of immersion. These body movements are recognized by a Kinect v2 sensor, the properties of which are described below.

Microsoft's Kinect v2 sensor is a range-image sensor originally developed as a home videogame device. Although it is inexpensive, the sensor can record sophisticated measurements regarding the user's location. Additionally, this sensor can recognize humans and the human skeleton using the library in Kinect's software development kit for Windows. Kinect can measure the location of human body parts such as hands and legs, and it can identify the user's pose or status with this function and the location information. Moreover, Kinect Studio and Visual Gesture Builder are used to recognize complicated body movements captured by the Kinect sensor. These enable complicated body movements to be recognized using the discriminator (Tokuoka, M., 2017). By using these, it is possible to create a discriminator that registers the body movements we want to recognize and can accurately recognize body movements using machine learning. As a complicated body movement, this time we adopted the movements associated with performing an excavation.

Figure 2 shows that this system consists of the above Kinect V2 sensor, a control PC, and a projector.

As shown in Figure 3, the current system enables children to learn about five dinosaurs, namely Tyrannosaurs, Tambaryu, Archeoptery, Pteranodon, and Ichthiosaurus. This system starts operation when learners stand in front of the screen. First they select the dinosaur fossil of which they want to learn by using a pushing motion of the palm toward the screen. After selection, learners excavate the corresponding dinosaur fossil. We recognize the excavation movement in this step using the Kinect v2 sensor. When the excavation succeeds with the excavation movement at full power, the video showing the characteristics of dinosaurs is shown. This video shows the habitat of the dinosaur in the Paleozoic era and the size of the animal. Our evaluation aimed to recognize whether complicated body movements such as excavation are recognized by the discriminator of the subsystem. (Tokuoka, M., 2017) We determined that movements associated with excavation are recognized when extensive and accurate movements are made at full power. If learners are shy and make a small movement, it is not recognized as an excavation movement and fails. Learners concentrate further by moving their bodies towards the screen with enthusiasm, increasing the sense of immersion in the paleontological environment. In the museum, fossils are mere sightings; however, they felt that the virtual excavation enhanced their participation by visualizing the virtual world.

After the excavation movement succeeds, you can conduct separate learning for the five dinosaurs. This is followed by an explanation of five contents. Figure 4 (a), (b), (c), (d), and (e) show the operation for each of the contents.

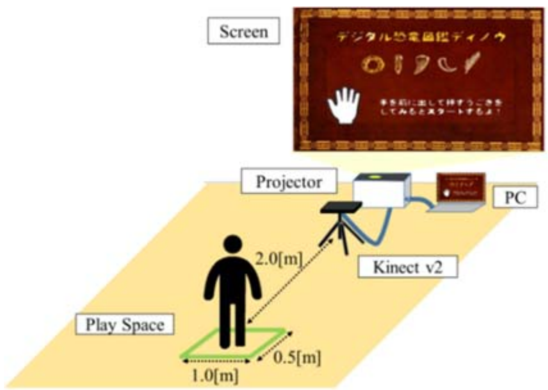


Figure 2: Setup of the system.

Figure 3: Details of dinosaurs.

(a)Tyrannosaurs

Learners can answer quizzes about the tyrannosaurs in this content by using a pushing motion of the palm toward the screen. There are three quizzes. A commentary video follows when learners answer correctly. An incorrect answer allows learners to make another selection. By learning about dinosaurs in the form of quizzes, they can learn while having fun.

(b)Tambaryu

Tambaryu moves sideways following learners' movement to either the right or the left. Thus, Tambaryu moves in response to their movement, thereby increasing their sense of immersion in the paleontological environment.

(c)Archeoptery

Learners can feed an Archeoptery by using the hand action of gripping and opening. First, they can select the bait of the Archeoptery displayed on the screen by using a hand gripping action. They then move this bait toward the mouth of the Archeoptery and open their hands. Then, the Archeoptery eats the bait. Therefore, they virtually experience feeding and they know what the Archeoptery ate.

(d)Pteranodon

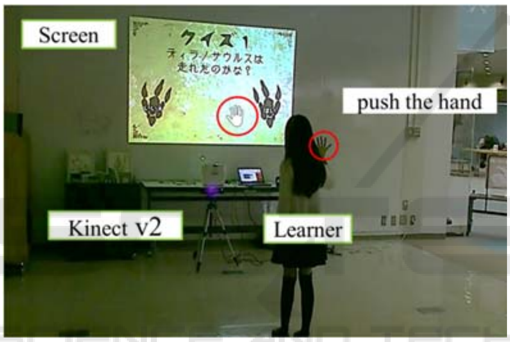
When learners wave their hands in a greatly animated way a Pteranodon approaches. A video of the Pteranodon approaching is shown, and they seem to be attacked by it. However, in the video the Pteranodon does not have muscular strength as it takes learners away. This enables them to learn about the physical features of dinosaurs.

(e)Ichthiosaurus

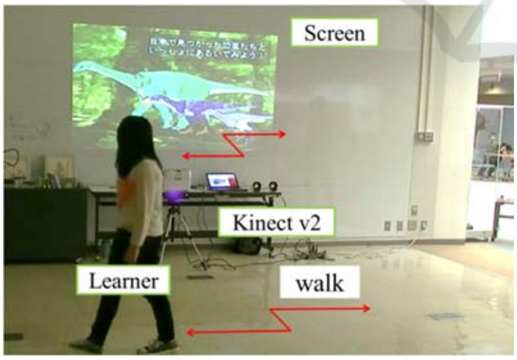
When learners move forward and backward, they can learn about the physical features of the Ichthiosaurus. When they approach the screen, a video showing the state of the stomach is shown. When they retreat from the screen, the video shows the full appearance of the body. Thus, their sense of distance changes in conjunction with moving forward and backwards. This enables them to learn about the size and shape of the Ichthiosaurus.

As an observation behavior of paleontology, this system can learn while experiencing contents accompanying five kinds of different physical behaviors using the above-mentioned technique of gesture recognition.

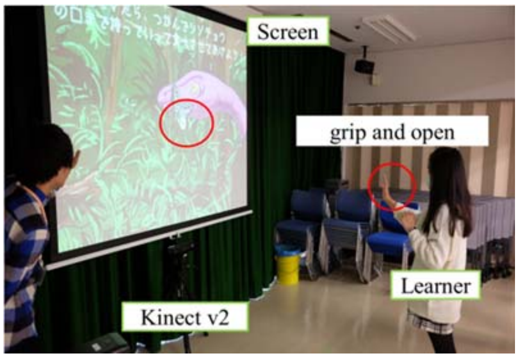
By performing more complicated body movements than would be possible with conventional systems, we were able to develop a full-body interactive interface that is more immersive. The use of different actions for each dinosaur enables learners to learn while having fun. Moreover, learners can learn about five dinosaurs themselves and clearly understand the difference between these dinosaurs.



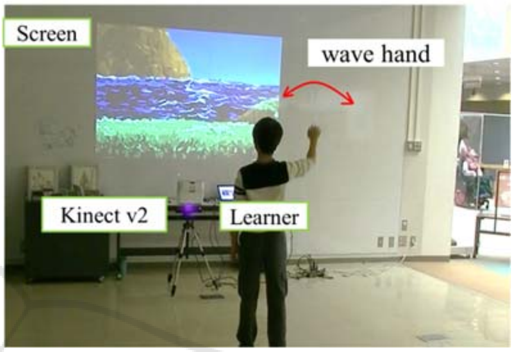
(a)



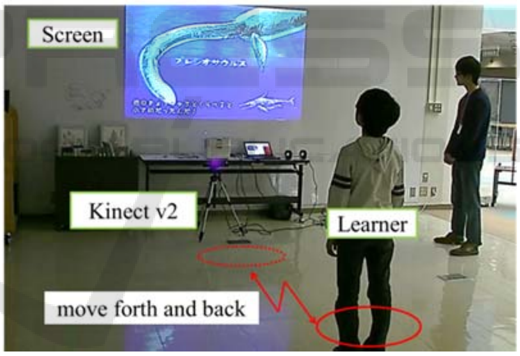
(b)



(c)



(d)



(e)

Figure 4: Five contents.

3 EVALUATION

3.1 Methodology

Participants: Twenty-two fifth grade students (9 boys and 13 girls) from elementary schools attached to the national university corporation.

Location: H Prefectural Museum of Natural History

Topic: The participants each experienced the system individually, after which they evaluated the system. The evaluation method was used to obtain their feedback using a seven-point Likert scale questionnaire on paper; the values on the Likert scale correspond to “strongly agree,” “agree,” “somewhat agree,” “neither agree nor disagree,” “somewhat disagree,” “disagree,” and “strongly disagree,” from seven to one, respectively. The questionnaire structure was based on the physical/emotional/narrative presence scale (PENS). The questionnaire consisted of eight statements in response to which the participants rated their agreement: “When I was moving my body and playing the game to learn about dinosaurs, I felt like I was in a time or place different from my usual environment,” “The details of the ancient time made me feel like I was actually having an adventure in that time,” “What happened within the system (creatures and their movements) did not inspire me (reverse score question),” “The system experience was fascinating,” “I was able to experience the ancient time just as deeply as the real world,” “During my system experience, I felt as though I became part of the time when dinosaurs lived,” “I felt very satisfied with the system experience,” and “I felt that the ancient scenery, creatures, and the way they lived on the screen were very real.”

Test Date: 11/26/2016

3.2 Results

Responses for “strongly agree,” “agree,” and “somewhat agree” were grouped as positive responses; those for “neither agree nor disagree,” “somewhat disagree,” “disagree,” and “strongly disagree” were grouped as neutral/negative responses. The number of positive and neutral/negative responses was analyzed using Fisher’s exact test with a 1 × 2 contingency table. The responses for the reverse score question were reversed.
Table 1 summarizes the system evaluations. The positive responses exceeded neutral/negative responses for all eight questions. Additionally, there were significant differences at the 1% level between the number of positive and neutral/negative responses for seven of the statements: “When I was moving my body and playing the game to learn about dinosaurs, I felt like I was in a time or place different from my usual environment,” “The details of the ancient time made me feel like I was actually having an adventure in that time,” “What happened within the system (creatures and their movements) did not inspire me (reverse score question),” “The system experience was fascinating,” “I was able to experience the ancient time just as deeply as the real world,” “I felt very satisfied with the system experience,” and “I felt that the ancient scenery, creatures, and the way they lived on the screen were very real.”

Furthermore, there was a significant difference at the 5% level between the number of positive and

Table 1: Subjective evaluation of the DINOU experience: physical/emotional/narrative presence.

		7	6	5	4	3	2	1
1.	When I was moving my body and playing the game to learn about dinosaurs, I felt like I was in a time or place different from my usual environment**	4	10	4	1	2	0	1
2.	The details of the ancient time made me feel like I was actually having an adventure in that time**	2	8	7	3	0	1	1
3.	What happened within the system (creatures and their movements) did not inspire me (-)**	1	1	1	5	2	7	5
4.	The system experience was fascinating**	11	4	5	1	0	0	1
5.	I was able to experience the ancient time just as deeply as the real world**	1	6	9	3	2	0	1
6.	During my system experience, I felt as though I became a part of the time when dinosaurs lived**	2	5	8	2	3	0	2
7.	I felt very satisfied with the system experience**	7	9	3	2	0	0	1
8.	I felt that the ancient scenery, creatures, and the way they lived on the screen were very real**	4	6	6	3	2	0	1

N = 22 $^{**}p$ <.01, $^{*}p$ <.05 (-): Reverse score question
7 = Strongly agree; 6 = Agree; 5 = Somewhat agree; 4 = Neither agree nor disagree; 3 = Somewhat disagree; 2 = Disagree; 1 = Strongly disagree

neutral/negative responses for the statement: “During my system experience, I felt as though I became a part of the time when dinosaurs lived.”

4 CONCLUSIONS

In this paper, we proposed a prototype of "BELONG" as the first step of the immersive learning support system at the fossil exhibition at the museum. This system comprises a full body interaction interface using a Kinect v2 sensor as a gesture discriminator. We used an experimental evaluation to assess the extent to which the system supported learning and immersion.

The results of the evaluation experiments revealed that learners experienced reality, presence, and appeal for paleoecology through experiencing this system using complicated body movements. The results showed that virtual observation behavior of paleontology using the gesture recognition ability of "BELONG" enabled learners to experience reality. This indicates that "BELONG" is effective as a method capable of providing a place of observation to learn about aspects of paleontology such as dinosaurs where a direct observational experience would be impossible.

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