Augmentation of Museum Science Education Using Human-Interaction Technology

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Abstract

Museums are often important institutions of scientific learning for children. The main teaching method in museums is the display of specimens for study and their explanations. Therefore, few chances exist for learners to independently observe or experience the environment about which they are learning. Moreover, it is difficult for visitors to learn using only displays and their commentaries. Overcoming this problem would qualitatively improve the learning of science in museums. We therefore developed an immersive learning support system that enables learners to explore a virtual paleontological environment in a museum. This system is intended to provide a sense of immersion in the paleontological environment by employing multiple screens showing paleontological environments. In an initial step toward realizing an immersive learning support system for museums, Yoshida et al. developed and evaluated a prototype system. However, their system is limited because it does not enable learning about paleontological environments. Our proposed immersive learning support system, on the other hand, enables learning about paleontological environments, including extinct animals and plants, as well as ecological environments. We evaluated the operability of this system, degree of learning support that it provides, and the sense of immersion that it enables for primary school children. Through evaluation interviews, we obtained various participant positive responses. In this paper, we present the proposed immersive learning support system. We describe the contents of the current system and the results of our evaluation.

Keywords: Kinect Sensor, Museum, Immersive Learning Support System, BESIDE, Palentological Environments ;

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Introduction

Museums are often important places of scientific learning for children [Falk & Dierking, 2012]. They can enhance the effectiveness of scientific education. Accordingly, they can operate as centers of informal education in connection with schools [Stocklmayer, Rennie, & Gilbert, 2010]. However, the main teaching method in museums is the display of specimens and their explanations. Therefore, few opportunities exist for visitors to independently observe and experience the environment about which they are learning. For example, it is impossible for visitors to experience in the real world paleontological environments, including extinct animals and plants, as well as ecological environments [Adachi et. al., 2013]. Furthermore, it can be difficult for children to learn using only fossil displays and their commentaries. Overcoming this problem would qualitatively improve scientific learning within museums. One solution to this problem would be some sort of booth and video content that reproduced the paleontological environment artificially. However, issues pertaining to space and cost mean that most museums cannot accommodate such an exhibit.

We therefore developed an immersive learning support system that enables learners to explore virtual paleontological environments in a museum. This “Body Experience and Sense of Immersion in a Digital paleontological Environment” (or BESIDE) system acquires information regarding the learner’s movement using a Kinect sensor, and operates according to this information. The system uses multiple screens spread across the learner’s entire field of vision. By being projected into this virtual space, the learner can adopt physical movements as observational actions. We expect that this will engender a sense of immersion in the virtual space. Because BESIDE comprises only a commercial image sensor, projector, and control PC, we can provide a low-cost immersive learning experience within a small space. Figure 1 illustrates the concept of BESIDE.

In an initial step toward realizing an immersive learning support system for museums, Yoshida et al. developed and evaluated a prototype system [Yoshida et. al., 2015]. This system fosters the visitor experience of paleontological environments, and the visitor can adopt their own physical movements as observation actions. This can engender a sense of immersion in the paleontological environment. However, this system does not enable learning about specific aspects of paleontological environments, such as extinct animal names and characteristics.

In this paper, we propose an immersive learning support system that enables learning about paleontological environments, including extinct animals and plants, and ecological environments, such as extinct animal names and characteristics.

Fig.1 Concept of BESIDE.

Body

Immersive learning support system “BESIDE”

We are developing a system that includes a figure of the learner in a virtual environment displayed on the screen, allowing the learner to experience the paleontological environment and learn about extinct animals and plants and the ecological environment. Figure 2 shows the setup of the current system.

In the system, the learner first stands in front of the screen, and a camera image of the learner is displayed with the background removed. Learners can change the background by moving their hands and interacting with the content. The system then allows learners to select animals appropriate for different geologic eras, and these are then displayed on the screen. Furthermore, the animal’s characteristics are displayed in the screen. Learners use their hands to select the animal’s name and then interact with the content.

The system must be able to acquire real-time data regarding the learner’s location and movements. Thus, we utilize Microsoft’s Kinect sensor, 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 (Shotton, 2011). 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. We use these functions to recognize humans and detect the human skeleton.

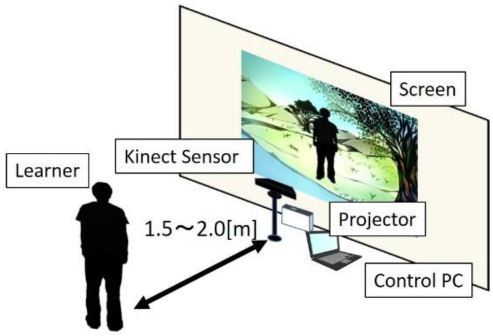


Fig.2 Setup of the Current System.

The system reproduces a paleontological environment by placing a suitable animal from one of three geologic eras (viz., Paleozoic, Mesozoic, and Cenozoic) into the display. The animals appropriate to each era are listed in Table 1. We also prepared three kinds of fossils that are typical of these animals—i.e., fossils that can be found at the museum. Furthermore, we prepared animals' names and characteristics. With this system, information regarding the frames and depth are measured with the Kinect sensor. The measurements are sent to the PC, and various images are displayed on the screen. The system has the following functions:

(a) Displays images based on sensor information;

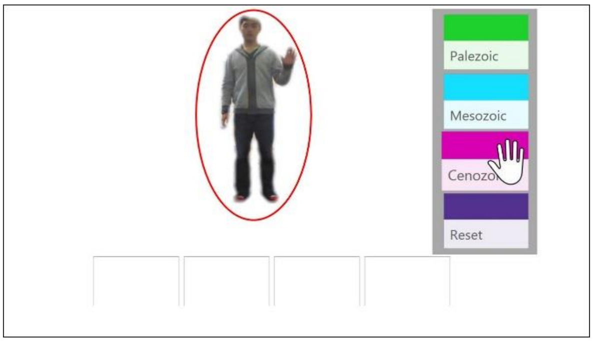
(b) Operates using the learner's body motion;

(c) Enables observations of animals as GIF animations.

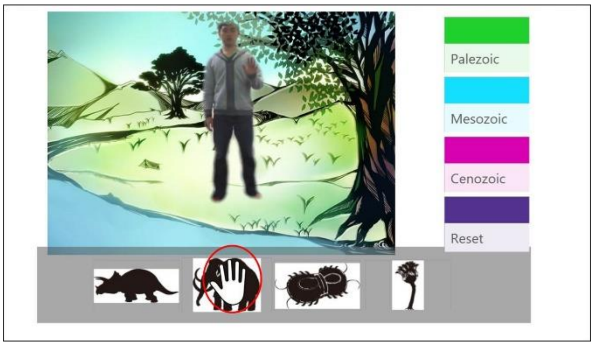
(d) Teaches animal names and characteristics

Table.1 Details of Animals.

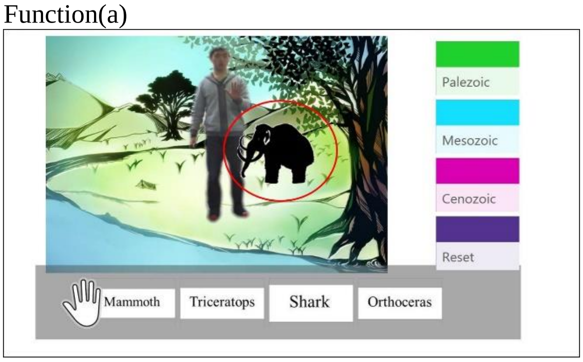
Palezoic	Mesozoic	Cenozoic
Elrathiakingi (Trilobite)	Perisphinctina (Ammonoidea)	Mammoth
Orthoceras	Triceratops	Merycoidodon
Crinoidea	Mosasaurus	Shark



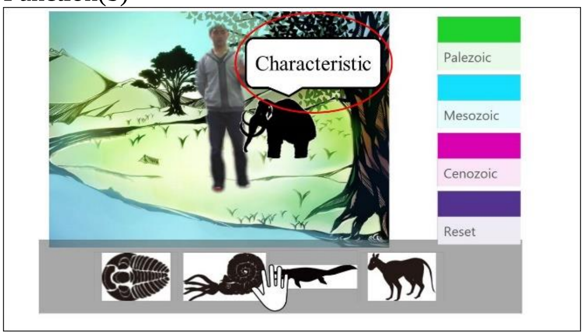
Function(a)



Function(b)



Function(c)



Function(d)

Fig.3 Function of the Current System.

Experimental evaluation method

Participants: The participants included 27 students (10 and 11 years old; 12 boys and 15 girls) from an elementary school in Kobe, Japan.

Experiment Date: July 25, 2015.

Process: We interviewed each participant for ten minutes. We evaluated their described sense of immersion, degree of learning support, and operability of the system. In terms of immersion sense, we asked the participant about perception of their figure in the virtual environment displayed on the screen, and about the system adoption of physical movement as an observation action. In terms of learning support extent, we asked participants about the experience of learning to name extinct animals and their characteristics using full body interaction. For system operability, we asked participants if they could effectively operate the system based on their hand movements. Figure 4 shows children using the current system.

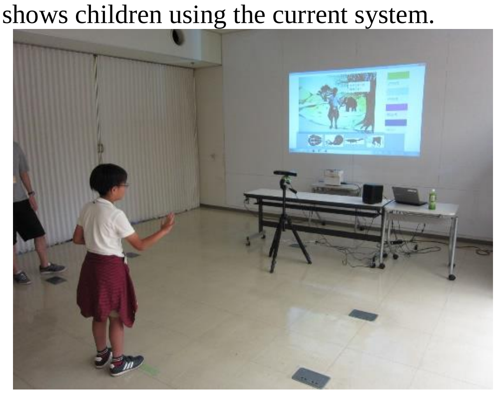


Fig.4 Using the Current System.

Evaluation Results

We aggregated the results from the interviews described above. Eighteen subjects had a positive opinion about the sense of immersion, while eight had a negative opinion. The remaining subject was undecided. Some of the responses in this regard were that “the system is very good because I can feel as if I am in a paleontological environment” and “It is very interesting that we can experience a paleontological environment.”

In terms of learning support, 24 subjects had a positive opinion, no subjects had a negative opinion, and the remaining three subjects were undecided. Some responses included: “The system is very nice because we can review the information as though it were a game” and “It is easy to remember the learned information using the quiz.

Regarding system operability, four subjects expressed a positive opinion, 22 subjects had negative opinions, and the remaining subject was undecided. Some of the responses included: “I cannot click a button well by pushing my hand toward the Kinect sensor” and “It is somewhat difficult to operate the system according to hand movements.”

Based on the above results, we confirm that the proposed system is effective at displaying the learner’s figure in a virtual environment displayed on the screen and in adopting physical movement as observation actions. We additionally confirm that the system is effective at teaching the names and characteristics of extinct animals using full body interactions. In terms of its present limitations, we confirm that it is difficult for users to operate the system with hand movements.

Conclusion

In this paper, we presented an immersive learning support system for museums that can teach visitors about paleontological environments, including extinct animals and plants, as well as ecological environments, such as extinct animal names and characteristics. Although the evaluation results suggest that the system is limited in terms of its ease of operation—which will be addressed in future work—the results confirm the effectiveness of the system in enhancing the immersive learning experience of paleontological environments.

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