Learning Support System for Paleontological Environment Based on Body Experience and Sense of Immersion
Extinct Animals Move in Synchronization with Human Actions

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Abstract: This paper proposes a simulation-based learning support system that animates extinct animals in synchronization with a human's location and actions. The system provides learners with a near-real body experience, and the sense that they have entered the paleontological environment. The aim of the proposed system is for this experience to improve the learning effect. Obviously, it is impossible for learners to experience the actual paleontological environment, and it is therefore difficult for them to understand the link between this environment and its actuality. This difficulty can be decreased by the proposed system, which provides learners with a real body experience and sense of immersion. At this point in time, the authors are implementing a system based on the proposed concept. As a preliminary evaluation, we conduct an experiment using the system, and interview the participants about the improvement in the learning effect. The experimental results confirm that most learners feel a tangible improvement in the learning effect due to the enjoyment of moving their body during the learning process.

1 INTRODUCTION

In recent years, environmental problems involving the destruction of nature have worsened. To improve our understanding of these problems, we must understand life in past geological periods and the biological environment of former generations. However, learners cannot watch or experience extinct animals and their environment. Thus, it is difficult to consider the learning target in relation to real things, which presents a difficulty in improving the learning effect.

Thus, to overcome this issue, we focus on the body experience and sense of immersion in learning. We are developing a more experiential simulation-based learning support system, in which the learner can enter the virtual environment of extinct animals. The system measures specific information, such as the human's location or actions. This allows the virtual environment and extinct animals to move across a large-scale screen. In this way, the system can compensate for near-real body experiences and immerse users in the environment. This experience and immersion lead to an improvement in the learning effect.

In this paper, as the first step toward realizing the above system, we describe a learning support system that moves in synchronization with the learner. After the learners have used the system, we interview them about the effectiveness of the proposed approach.

2 LEARNING THROUGH BODY EXPERIENCE

2.1 Introduction of Body Experience into Learning

Worsening environmental problems mean that education is becoming increasingly treasured as a way of relating the linkage between man and the environment. To develop an understanding of these problems, we must understand the wider transition of the biological environment from ancient to

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modern times. However, although extinct animals and their environment actually existed, it is impossible for learners to watch and experience them. Additionally, it is impossible for learners to experience the wide-scale transition of the biological environment from such periods. There is a difficulty in learning about what one cannot actually experience, and so learners struggle to link their understanding of the animals and their environment to reality. Thus, learners may not realize that what they are being taught substantively existed, which prevents an improvement in the learning effect.

In this regard, we consider that the difficulty in immersing the user into the virtual environment is caused by a lack of body experience in the learning. The body experience of the learner is limited to watching or hearing the virtual environment from the outside, and so learners are not immersed in the environment(Akiko Deguchi, 2010; Takayuki Adachi 2012).

In recent years, it has become possible to replicate various environments with increasing degrees of reality using technologies such as computer graphics. Hence, the number of learning support systems that use these technologies in the form of an animation or game is increasing (El Rhalibi, 2011; Wernhuar Tarng, 2007; Michael Tscholl, 2013). These systems improve learners' motivation and the learning effect in a recognizable manner. However, learners can still only watch or learn from outside the virtual environment. Thus, they cannot obtain a satisfactory body experience and level of immersion, and it is difficult for them to consider what they learn from the virtual environment in relation to its substantive existence.

With the aim of improving the learning effect, we are developing an effective learning support system that permits a body experience (Figure 1). In this system, extinct animals and their environment are projected onto a large-scale display. Learners move the animals or environment, and obtain knowledge by moving their own body. To realize this, we use various sensors, and measure the learners' location, pose, and actions. Based on these measurements, the system can be controlled in a realistic manner. In this way, by changing the virtual environment according to body actions, learners feel more of a body experience and sense that they have entered into the environment. From this body experience, the system provides deeper immersion than watching illustrations or videos. This immersion can help to improve the learning effect.

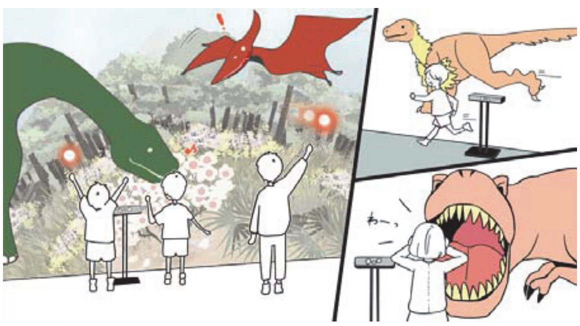

Figure 1: Proposed experiential learning support system.

Furthermore, moving the extinct animals in synchronization with the learner makes it possible to consider the extinct animal as being, in some sense, real, rather than imaginary. Thus, the learner can understand extinct animals more completely.

2.2 Current Implemented System

2.2.1 Overview

To implement the above learning support system, we are developing an animation system incorporating extinct animals. Figure 2 shows an overview of the system. This animation moves in synchronization with a human's location and movement. By playing with the content of this animation, the learner listens to information about the animal and their environment.

In this system, the extinct animal begins to walk when the human walks, and stops when the human stops. The background image scrolls according to the human's location. The learner sees the extinct animal following the pace of his/her walking. In this way, learners feel an affinity with the extinct animal, and obtain the sense that they are walking in the environment with the animal.

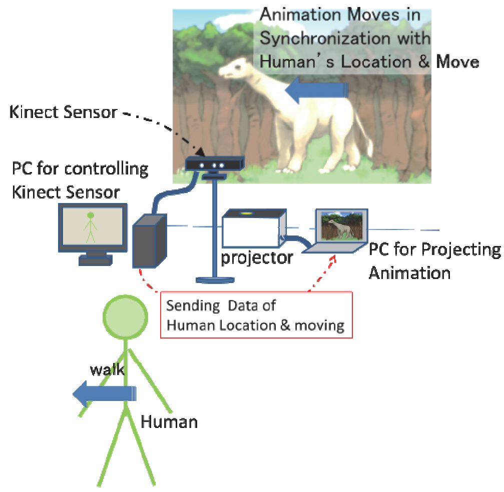

Figure 2: Overview of the -implemented system.

We expect that this experience and sense will lead to improvements in the learning effect.

2.2.2 Configuration of the System

The system must be able to control the animation in synchronization with the human's movement, which requires real-time knowledge of the human's location and movement status (walking or stopped). We utilize Microsoft's Kinect sensor for this purpose. Figure 3 shows the configuration of the system.

The Kinect sensor is a range image sensor, originally developed as a home video game device. Although cheap, the sensor can record advanced measurements of a user's location. Additionally, this sensor can recognize humans and the human skeleton using a library such as OpenNI. It can measure the location of human body parts, such as hands and legs, and we can detect the human's pose or status (e.g., walking, standing, sitting) from this function and location information(Jamie Shotton, 2011).

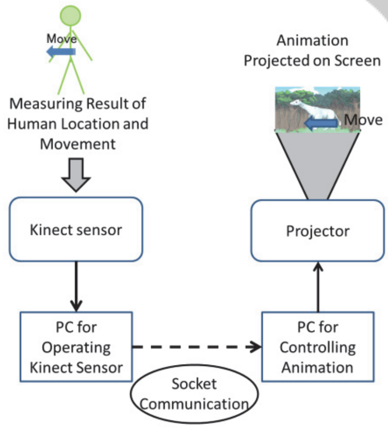

Figure 3: System configuration.

Figure 4: Measuring of human torso location.

We use these functions of the Kinect sensor and OpenNI library to recognize humans and detect the human skeleton. Then, we measure the location of the human torso (Figure 4). From the transition of pixel coordinates in the camera image of the human torso location, we can estimate the velocity and direction in which the human is walking.

The animation of extinct animals is created with ActionScript, and moves according to input numeric values. Information about the human's location, walking speed, or direction is sent to the PC that controls the animation. At this point, socket communication is used for the exchange of information. The PC controls the FLASH animation according to the information received, and the animation is projected onto the screen.

3 EXPERIMENT

3.1 Motion Experiment

First, we conducted a motion experiment to confirm that the animation system moves in synchronization with human walking.

As shown in Figure 5, we installed a Kinect sensor and a projector, and then asked a human to move across the front of the Kinect sensor once or twice, as shown in Figure 6. Thus, we can confirm that the following functions have been realized.

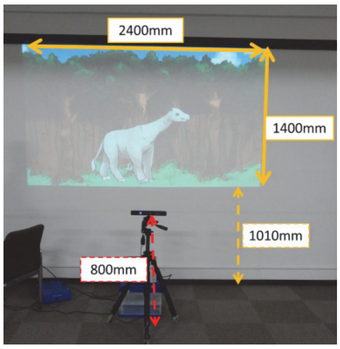

Figure 5: Installation status of sensor and projector.

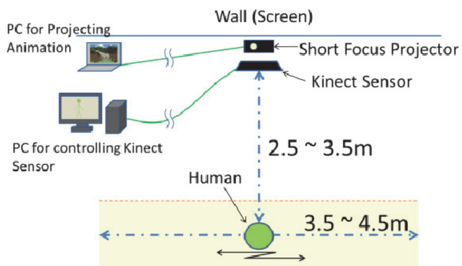

Figure 6: Movement of human in the experiment.

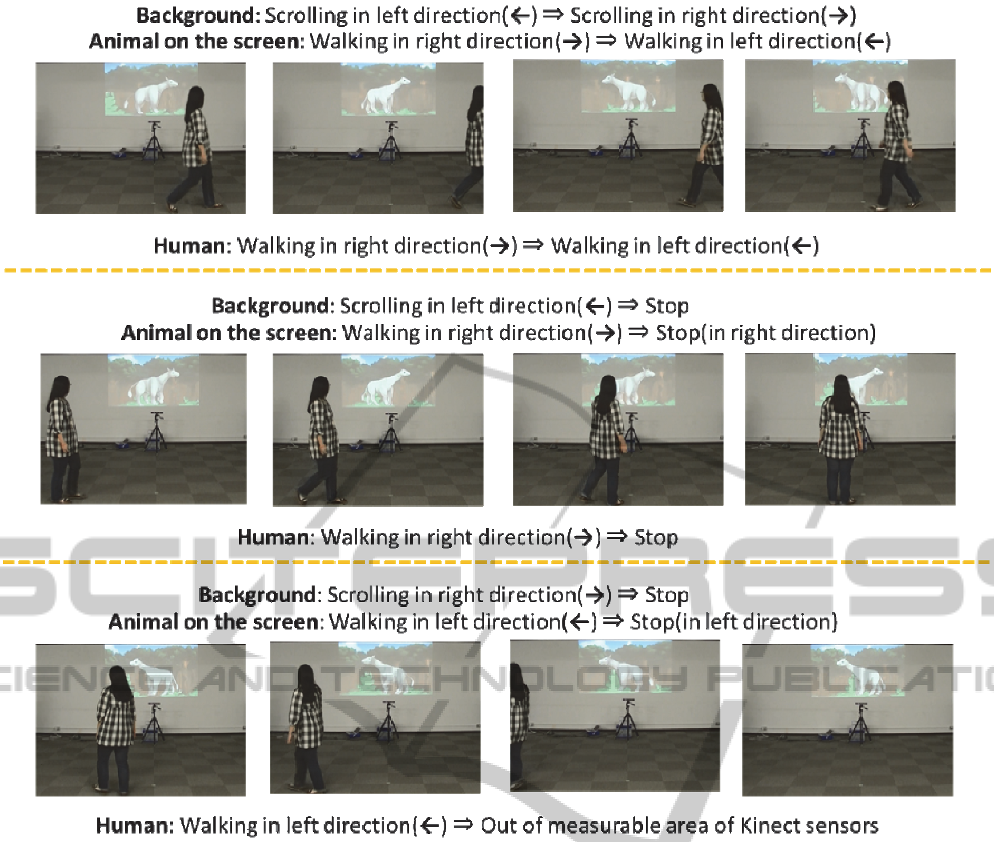

Figure 7: Experimental conditions.

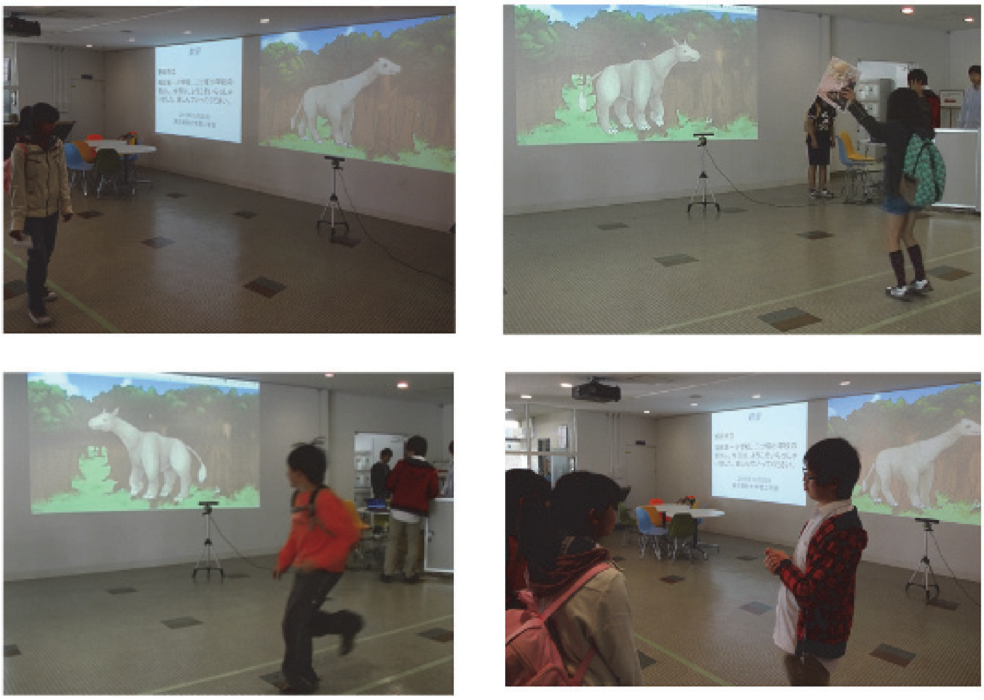

Figure 8: Evaluation experiment.

- Scrolling of background image linked with human location.
- Change in behavior of extinct animal on the screen according to human actions and direction of movement.
- Animation stops when the human moves beyond the measurable area of the Kinect sensor.

Figure 7 shows the experimental conditions. The animal on the screen moves in same direction as the human is walking, and stops when the human stops. When the human changes direction, the animal changes direction in synchronization with the human. Additionally, when the human moves out of the range of the Kinect sensor, the animal looks in the direction that the human walked away, as if watching after the human.

The background image scrolls in the opposite direction to that in which the human is walking, as if the human is moving forward in the environment. The background image scrolls according to the human's location, moving faster when the human walks faster.

From the above, we can confirm that we succeeded in realizing the proposed system in which animation contents move in accordance with a walking human.

3.2 Questionnaire Survey

Second, we conducted an interview to assess the improvement in the learning effect produced by the proposed system. We allowed children to play and learn with the system, and then conducted interviews with them.

The experiment employed 29 6th-grade children. As the children played with the proposed system, we explained about the extinct animal and environment on the screen (Figure 8). We then interviewed the children using the following questionnaire.

< Questionnaire>

Which learning contents help to progress your learning?

1. *This learning support system (proposed system)*
2. *Conventional learning method (e.g., textbook, classroom learning, model, movie, etc.)*
3. *Neither of the above*

Figure 9 shows the results of this questionnaire.

We then asked the children who chose "*1. Proposed system*" why they thought this was the case. Some of the responses are given below.

- "It is effective for enjoying learning to move my own body."
- "It is interesting that the extinct animal moves according to my actions."
- "We can remember the learning content, because it is fun."
- "It is very interesting that the animal follows that the animal follows my movements"

From these answers, we can confirm that the participants enjoyed learning by moving their bodies. By moving the animal and background according to their body actions, they felt a degree of enjoyment, and sensed that they were closer to the animal and its environment. In this way, most of the learners felt an improvement in the learning effect due to this sense of immersion.

Additionally, the following opinions were voiced:

- "It is interesting to learn the role and mechanism of the sensors."
- "I wonder how this system measures the human torso location."

Thus, the children took an interest in both the learning content and the system and sensors. From this, we believe the system led to an increased interest in intelligent machines.

One of the children who chose "*2. Conventional learning method*" stated, "In a museum, I feel the learning targets ancient things more deeply. So, in the case of studying old things such as extinct animals, I think it is better to study in a museum than with the proposed system." In a museum, many things are displayed that provide a sense of the ancient. In contrast, our system uses various modern devices, such as a PC and Kinect sensor. We think that seeing these devices may prevent users from 'feeling' the ancient period. Thus, seeing the system and its sensors may lead to an interest in intelligent machines, but these devices should be hidden so that learners cannot see them. Another opinion stated, "I have watched more large-scale exhibits. They are more dynamic and attractive than this system."

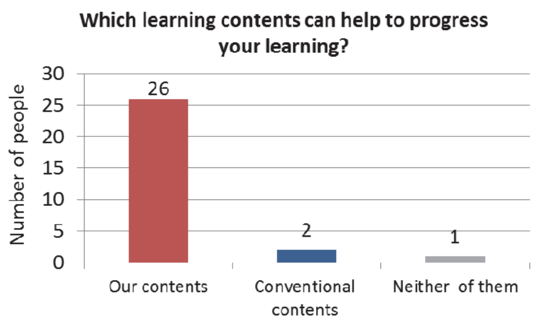

Figure 9: Questionnaire results.

At this point, we are using only one Kinect sensor and one projector. In future, we intend to increase the number of sensors and projectors, and expand the scale of the system. Thus, we will make the proposed system more experiential than conventional learning methods or contents.

4 CONCLUSIONS

While learning about extinct animals and the environment in which they lived, learners cannot actually watch or experience the environment.

Hence, it is difficult for learners to understand the linkages between real things and attain a greater degree of learning. Thus, to compensate for this, we have focused on the body experience component of learning, and have proposed a learning support system in which users learn by moving their body.

In this system, the learning content is controlled according to the location, status, and actions of thelearner. By moving their own bodies, learners can obtain a near-real experience, as if they have entered the environment, and this improves their understanding of the learning target. In this paper, towards the realization of such a system, we developed a learning support system that moves in synchronization with the learner's location and actions (walking or stopping). After confirming that the system operated as intended, we conducted a questionnaire survey. From the results of the experiment, we have confirmed the potential for improvement in the learning effect due to the enjoyment of moving their bodies while learning. In the future, we intend to develop the system so that one can synchronize with not only walking also the other action. And then we intend to conduct evaluation test for more subjects.

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