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Full-body Interaction Digital Game of Vegetation Succession for Children

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Abstract: We developed a full-body interaction digital game "Human SUGOROKU". This game enables elementary school students to enjoy and learn vegetation succession by playing simulation game with their body movement. We conducted this game to elementary school students and effects of the system were investigated with questionnaires. The result showed that the full-body interaction promotes a sense of immersion in the game. This paper describes the structure of this game and the questionnaire results.

Keywords: Interactive Content, Ultrasonic Sensor, Embodiment, Learning Support System

1. Introduction

Elementary school students often find it difficult to understand environmental problems because they cannot easily experience the knowledge they gain at school. In this light, we are aiming to collaborate with schools to teach elementary school students about environmental problems.

Toward this end, we have developed a simulation tablet game based on the digital SUGOROKU board game for vegetation succession (Matsumura and Takeda, 2010), (Deguchi, Inagaki, Kusunoki, Yamaguchi, Takeda and Sugimoto, 2010). This game simulates the real forest area of Mt. Rokko in Japan. Figure 1 shows students are playing the tablet game. Multiple players can participate in a SUGOROKU game. Figure 2 shows a screenshot of the digital game. There are grids around the board and each player handles a piece. Players move their own pieces on the grids according to event cards, with their aim being to have the most advanced piece. In our game, a piece corresponds to a plant and grids correspond to the succession phase of the plant. Event cards disturb or promote plant growth. The window visualizes vegetation succession according to the progress in the game. In other words, the children play the role of plants in the simulation. We conducted an experimental evaluation that revealed that our game effectively stimulated the interest of students and supported their learning.

However, one drawback of our game is that it is digital and is therefore played on a computer screen; we found that the virtual world did not well approximate the real world. The experimental evaluation suggested that making the virtual world more immersive would not only further motivate the students but also enhance their further understanding. To immerse students in the digital game, we focused on realizing operations via body movements.

Accordingly, we are developing a new learning support system called "Human SUGOROKU.". In tablet game, we use a touch panel interface. Students move pieces by using a mouse or a touch pen. To make this game more immersive, we replaced the touch panel interface with a full-body interaction interface that was developed by combining a human detector interface to measure a person's movement and the digital game core to run the digital SUGOROKU game. In Human SUGOROKU, the students themselves move on the board as pieces and play the digital game.

We conducted an experiment for the elementary school students to verify the affect of full-body interaction. We took questionnaires to the students after they played both the tablet game and Human SUGOROKU. Based on these results, we examined the affects of Human SUGOROKU. In this paper, we describe the structure of Human SUGOROKU and the evaluation experiment.

Figure 1. Tablet Game

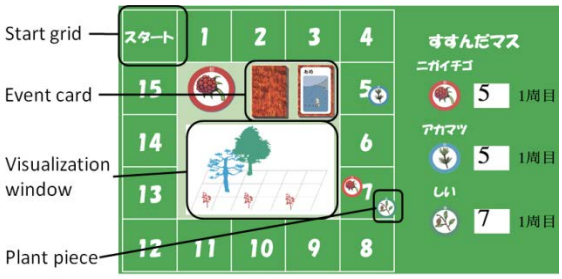

Figure 2. Screenshot of Digital Game

2. Human SUGOROKU

Figure 3 shows Human SUGOROKU. In Human SUGOROKU, people operate the pieces of the digital SUGOROKU game by moving on the board drawn on the floor. To realize this operation, technologies to measure a person's position and to identify people in the room are necessary. A technology to measure a person's 3D position through attached ultrasonic sensors has already been proposed (Nishida, Aizawa, Hori et al. 2003). Because the transmitters have unique identifiers, the ultrasonic sensors can measure the positions of people using the transmitters and identify them. Accordingly, we used ultrasonic sensors as the human detector interface. Receivers are placed on the ceiling and transmitters are attached to people moving on the grids drawn on the floor.

Figure 4 shows the structure of Human SUGOROKU. This system is composed of ultrasonic sensors, two computers, and a projector. The digital game core runs on the computer and is projected by the projector. Therefore, learners can visually understand the state of the game. A server computer is connected to the ultrasonic sensor. Another client computer runs the digital game. By setting transmitters that correspond to a type of plant piece in advance, we can understand the type of plant and the position of a learner. This information measured by the ultrasonic sensors is sent over the network. Therefore students can play the digital game by their body movement.

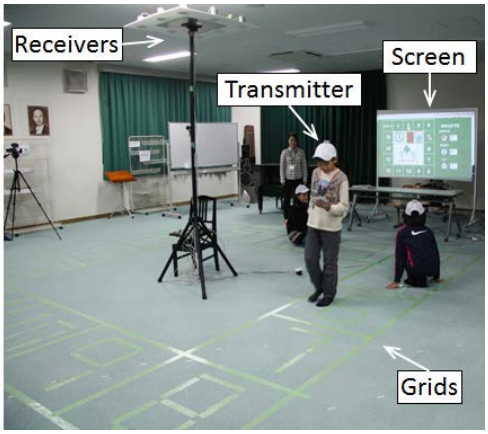

Figure 3. Human SUGOROKU

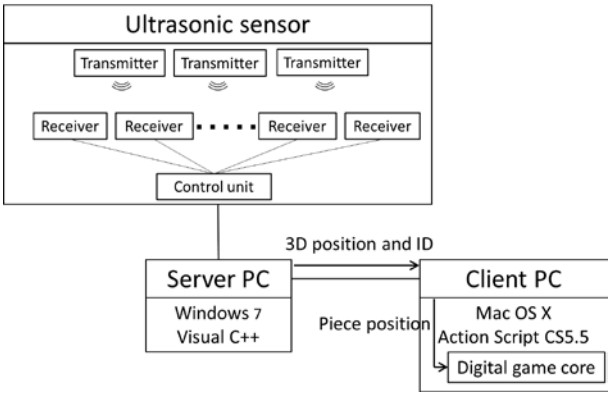

Figure 4. System Configuration

3. Evaluation

We conducted an evaluation experiment to clarify whether it is easier for elementary school students to immerse themselves in the virtual world of vegetation succession through "Human SUGOROKU" compared to a "Tablet Game". The subjects were 35 students (ages 11–12 years) at an elementary school Kobe, Japan. Elementary school students played both games. A questionnaire survey was conducted after students played both games.

The research task involved of four statements. We asked elementary school students to rate statements about the "Human SUGOROKU" game and "Tablet Game" separately using a 5-point scale: 'Strongly agree', 'Somewhat agree', 'Neither agree nor disagree', 'Somewhat disagree', and 'Strongly disagree'.

Table 1 shows the statements and responses of the elementary school students.

First, we mention the results of the individual evaluation on the “Human SUGOROKU” and “Tablet Game”. Of all the responses from the elementary school students, we categorized ‘Strongly agree’ and ‘Somewhat agree’ as positive responses and ‘Neither agree nor disagree’, ‘Somewhat disagree’, and ‘Strongly disagree’ as neutral or negative responses. Skegness in the number of responses was then examined using Fisher’s exact test. We found that the number of students who gave a positive response was significantly higher than the number of students who gave a negative response on all statements on the “Human SUGOROKU” and “Tablet Game” ($p < .01$).
Based on this result, it can be said that elementary school students was able to immerse themselves in the virtual world of vegetation succession in both the “Human SUGOROKU” and “Tablet Game”.
Next, we describe the results of comparing the tendencies in responses on the “Human SUGOROKU” and “Tablet Game”. To determine whether there is a difference in the tendency of responses to the two games, a Wilcoxon signed-rank test was conducted. We found that the number of elementary school students who gave a positive response on Statement ‘I was able to get a real sense of being a plant’ was significantly higher for the “Human SUGOROKU” than with the “Tablet Game” ($z = -2.132$, $p < .05$).
We can confirm that the characteristics of the “Human SUGOROKU” in which the players can use their entire body to act as a plant contributed to this result. Based on this, we can conclude that the “Human SUGOROKU” had a certain advantage over the “Tablet Game” in terms of being able to easily immerse oneself in the virtual world of vegetation succession.

Table 1:Results of questionnaires.

	SA	A	N	D	SD
I was able to get a real sense of being a plant					
Human SUGOROKU*	20	10	3	1	1
Tablet Game*	11	17	6	0	1
I felt happy when I moved forward					
Human SUGOROKU*	22	11	1	1	0
Tablet Game*	23	8	3	1	0
I hoped the number of my plants would increase					
Human SUGOROKU*	22	6	6	0	1
Tablet Game*	24	6	4	1	0
I had fun					
Human SUGOROKU*	28	6	1	0	0
Tablet Game*	29	4	1	1	0

$N = 35$; $p < .01$ SA:Strongly Agree A:Agree N:Neither agree nor disagree D:Disagree SD: Strongly Disagree

4. Conclusion

In this paper, we described the full-body interaction digital game “Human SUGOROKU”. In this game, elementary school students can learn vegetation succession by their body movement. We conducted experiment to elementary school students and investigated effects of this system by questionnaires. The results of questionnaires showed that this system enabled students to be more immersive than “Tablet Game”. Thus Full-body interaction was effective to promote students’ sense of immersion in simulation game.

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