World Academy of Science, Engineering and Technology
International Journal of Sport and Health Sciences
Vol:10, No:8, 2016

BECOME: Body Experience-Based Co-Operation between Juveniles through Mutually Excited Team Gameplay

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***Abstract*—**We aim to develop a full-body interaction game that could let children cooperate and interact with other children in small groups. As the first step for our aim, the objective of the full-body interaction game developed in this study is to make interaction between children. The game requires two children to jump together with the same timing. We let children experience the game and answer the questionnaires. The children using several strategies to coordinate the timing of their jumps were observed. These included shouting time, watching each other, and jumping in a constant rhythm as if they were skipping rope. In this manner, we observed the children playing the game while cooperating with each other. The results of a questionnaire to evaluate the proposed interactive game indicate that the jumping game was a very enjoyable experience in which the participants could immerse themselves. Therefore, the game enabled children to experience cooperation with others by using body movements.

***Keywords*—**Children, cooperation, full-body interaction game, kinect sensor.

I. Introduction

THE importance of play in early education is recognized by education systems around the world [1]. Studies show that children create knowledge when they play [2], [3]. Children learn well by being active [1]. Kinesthetic learning facilitates cognitive development [4], particularly for younger children [5], [6]. The learning environment becomes more natural when children use gestures and movements [7]-[9], and children can retain more of the knowledge being taught [10], [11]. Based on these research efforts, many full-body interaction games have been developed as learning support systems for children. These full-body interaction games allow children to acquire knowledge by interacting with the system though body movements.

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In addition to knowledge, sociality and cooperation are important for children's growth. It is indisputable that sociality and cooperation cannot be acquired without actual experiences gained from interacting with others to achieve some goal. Play is a good opportunity for children to gain such experience. The only factor to significantly affect cooperation is the group size, with children in small groups cooperating significantly more than children in larger groups [12]. Gender and subject matter had no effect on cooperation [12]. However, although many full-body interaction games have been developed as learning support systems for children, very few of them allow children to cooperate with others in small groups to enhance cooperation skills. Previous learning support systems for children that used full-body interaction games tended to emphasize interaction between the children and the system. There was almost no emphasis on interaction between the children. Therefore, we focus on the interaction between children playing full-body interaction games. Based on findings in previous studies, the game is designed to enhance cooperation between children by allowing them to cooperate with others in small groups by using body movements. As the first step in our study, we developed a full-body interaction game that allows two children to cooperate with each other. This paper provides an overview of the current implemented game, and describes an experiment in which children were observed played the game.

II. Current Implemented Game

A. Concept

The game developed in this study enables children to interact with each other. Figs. 1-3 show an overview of the game. A certain device, a meter, and lamps expressing the "electricity" of the device are projected onto the screen. In this game, two players are asked to cooperate to "make electricity." The device's electricity is generated through the cooperation of two players, who must jump together with the same timing. Two players cannot make electricity without adjusting their reciprocal timing. If two players jump together with the same timing, the red meter on the left side of the screen increases. When all lights on the red meter are lit, the lamp on the top of the screen is also lit. When all lamps are lit, electricity has been generated for the device and the game finishes. To achieve this, two players must jump together with the same timing; thus, it is likely that the two players will communicate with each other. For this reason, the game developed in this study produces interaction between children.

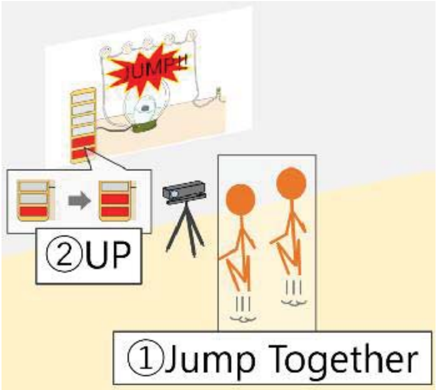

Fig. 1 Overview of the game #1

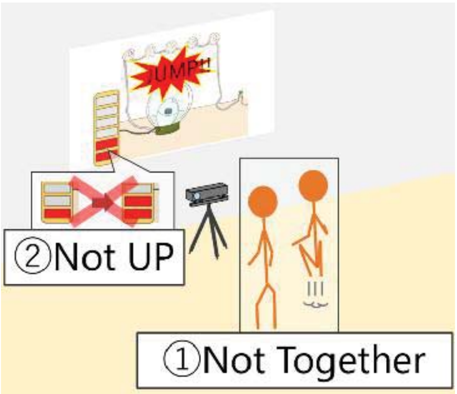

Fig. 2 Overview of the game #2

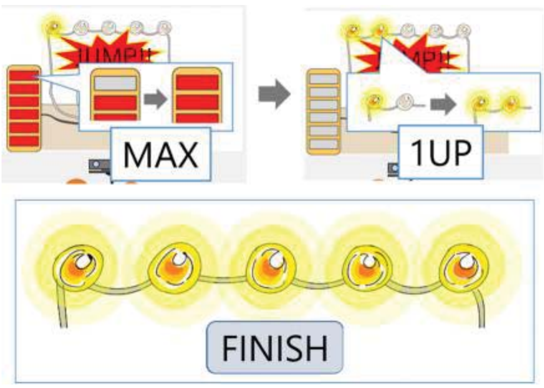

Fig. 3 Overview of the game #3

B. Overview and Configuration of System

Fig. 4 shows an overview of the system. The system consists of a screen, a short focus projector, a notebook computer, and a Kinect sensor. The notebook computer operates the Kinect sensor and controls the game screen. These operations and controls were implemented using a C# program that we developed in Visual Studio 2013. The playing area recognized by the sensor is set freely by the program. The Kinect sensor is a range image sensor, originally developed as a home video game device. Although inexpensive, the sensor can capture complex measurements that accurately represent the user's location. In addition, by using a library such as KINECT for Windows SDK., this sensor can recognize humans and the human skeleton. It can measure the locations of human body parts such as hands and legs. By using these functions, the Kinect sensor can recognize the gestures of a person. Jump gestures are used to progress the game developed in this study. Fig. 5 shows the configuration of the system. The notebook computer processes jump information recognized by the Kinect sensor. The game screen, which is projected by a short focus projector, changes according to the processing results. Jump recognition achieved with the Kinect sensor is discussed in the following section.

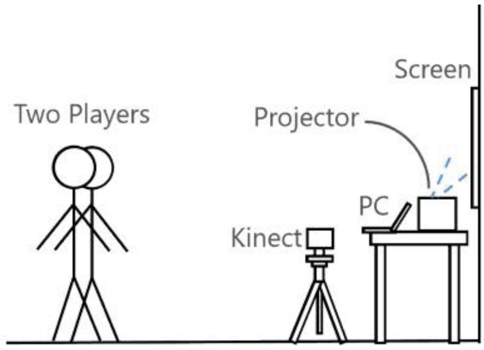

Fig. 4 Overview of the system

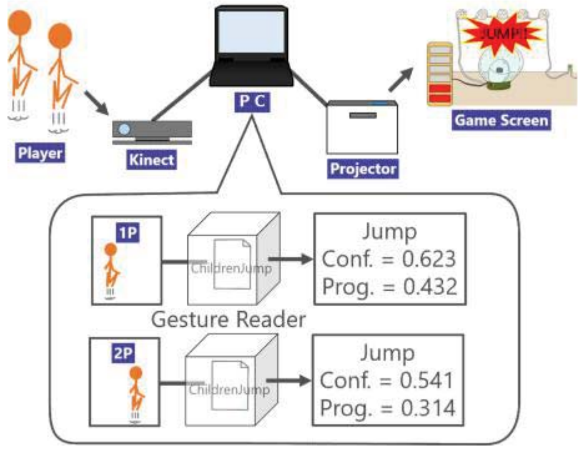

Fig. 5 System configuration

C. Jump Recognition by Kinect Sensor

1. Tools

Kinect Studio and Visual Gesture Builder are used to recognize and process jumps captured by the Kinect sensor.

Kinect Studio can record the 3D position information of a human body captured with a Kinect sensor. By using this tool, a player's 3D position information can be recorded when they make a gesture that must be recognized by the system. This data can be used to train the gesture reader in Visual Gesture Builder, by means of a machine learning process. The gestures the system needs to recognize are recorded by Kinect Studio in a clip file, which is used by Visual Gesture Builder as training data. In this file, frames that contain gestures that must be recognized by the system are marked. The gesture reader learns the 3D position information of players while building its gesture database after the frames are marked. In this manner, the gesture reader can learn the gestures that must be recognized in Visual Gesture Builder. A program that recognizes gestures captured by the Kinect sensor can be created by accessing the gesture reader that was trained by Visual Gesture Builder.

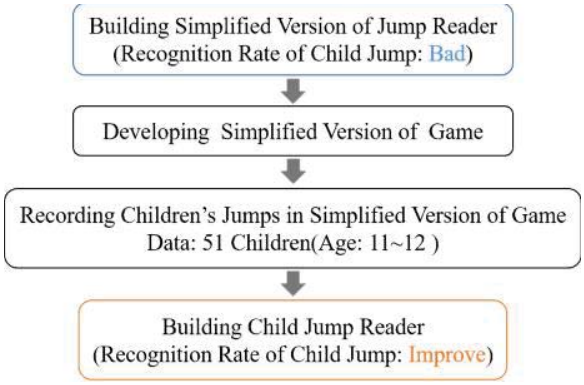

Fig. 6 Flowchart for building jump reader that can recognize jumps of children

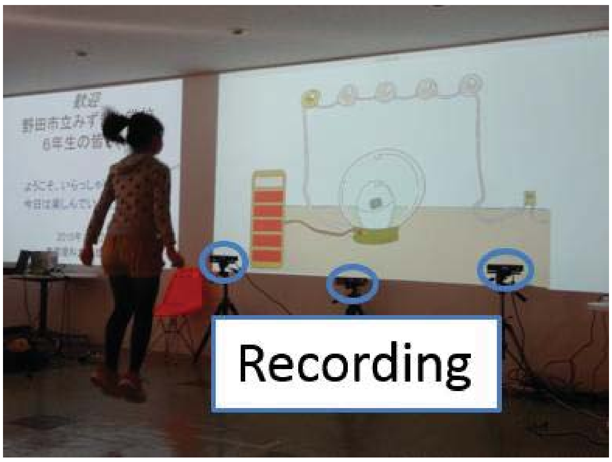

Fig. 7 Children's manners of jumping is recorded

2. Recording Jumps of Children

The full-body interaction game developed in this study is for children. Because of this, the training data used for learning in Visual Gesture Builder should be collected from children, not adults. The Kinect sensor recognizes the jumps of children in the game developed in this study. Therefore, manners of jumping specific to children must be recorded by Kinect Studio. A jump reader that can recognize the jumps of children must then be built. Fig. 6 shows the flowchart for building a jump reader that can recognize children's jumps. First, we recorded our own jumps in Kinect Studio and built a simplified version of a jump reader in Visual Gesture Builder. This reader cannot effectively recognize the jumps of children. Second, a simplified version of the game that can be played by one player was developed. Third, we let children play the simplified version of the game. On that occasion, the children's manners of jumping were recorded in Kinect Studio. Thus, the training data used for learning in Visual Gesture Builder were collected from children. Finally, the jump reader was rebuilt using the training data collected from children. As a result, the jump reader was improved to recognize the jumps of children. Fig. 7 shows the children's manners of jumping being recorded. During this process, we recorded the jumping manners of 51 11- and 12-year-old children.

III. Evaluation Experiment

A. Method

Participants: The participants were 18 fifth-grade students (aged 10–11) at an elementary school connected to a national university. Figs. 8 and 9 show the experimental environment.

Process: The participants were split into pairs. Each pair participated in the jumping game. The game proceeded as follows. First, the groups spent two minutes discussing how to synchronize their jumps. Next, the participants played the game. The duration of the game was approximately five minutes. Finally, they evaluated the game.

Evaluation Assignment: Evaluations were conducted using the questionnaire method. The questions pertained to the enjoyableness of the jumping game. The questionnaire consisted of three statements; the participants were asked to assess the statements using a seven-point Likert scale with the choices "strongly agree," "agree," "slightly agree," "neither agree nor disagree," "slightly disagree," "disagree," and "strongly disagree." The statements were: "I enjoyed the jumping game," "I was focused on finishing the game," and "I put a lot of thought into finishing the game."

Dates of the Experiment: December 15 and 16, 2015.

B. Results

Figs. 10-12 show the children playing the game.

Fig. 10 shows the children who were told how to play the game telling their partners how to play the game. The following explains were voiced:

- "We must jump with the same timing."
- "If two players jump together, the meter increase."
- "Let's jump after saying "One, Two, Three.""

In eight out of the 9 groups, the children who were told how to play the game by their partner asked their partner to confirm the rules of the game. In these cases, we observed children assuring one another about uncertain matters.

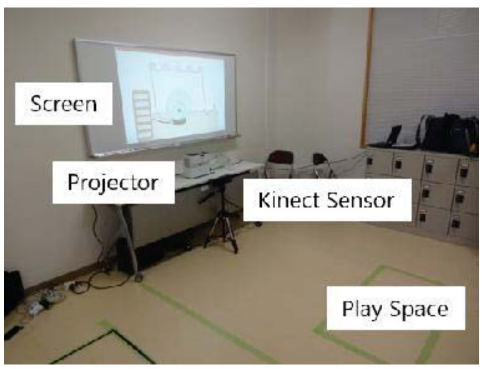

Fig. 8 Experimental environmental #1

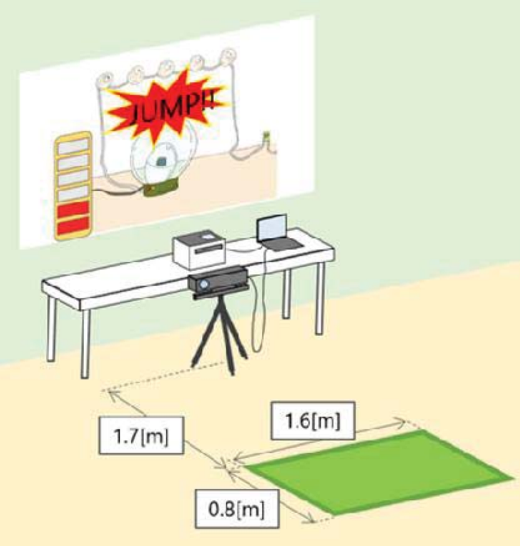

Fig. 9 Experimental environmental #2

Fig. 10 Children who were told how to play the game first needed to tell their partners how to play the game

Fig. 11 shows instances in which two children were able to coordinate the timing of their jumps. Instances in which two children coordinated their jumping by watching each other were observed in all groups. Further, we observed instances in which children shouted cues to coordinate their timing. These states were often observed in groups that were previously unable to coordinate their jumps. In these cases, we observed children trying to cooperate with each other to coordinate their jumps. Further, one group jumped in a constant rhythm, as if skipping rope. This group could play the game more efficiently.

Fig. 12 shows instances in which two children jumped together with the same timing. In this experiment, children thought out ways to play the game more efficiently.

We divided the results into two groups: positive responses (comprising “strongly agree,” “agree,” and “slightly agree”) and neutral/negative responses (comprising “neither agree nor disagree,” “slightly disagree,” “disagree,” and “strongly disagree”). Subsequently, deviations in the number of responses in both groups were analyzed using Fisher’s exact test for a 1 x 2 contingency table.

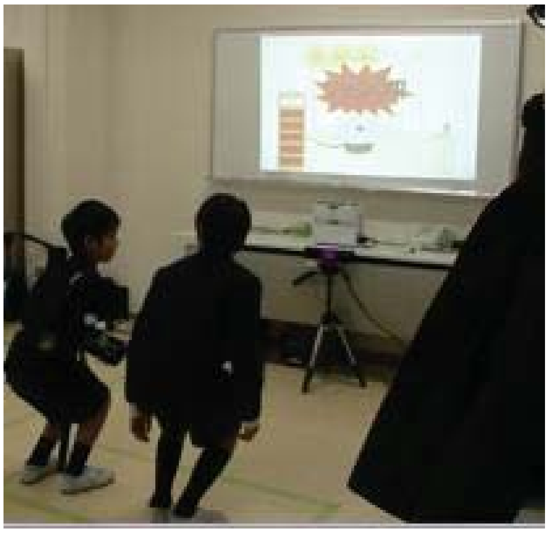

Fig. 11 Children strategizing to coordinate their jump timing

Fig. 12 Two children jumping together with the same timing

TABLE I
QUESTIONNAIRE RESULTS OF THE JUMPING GAME'S ENJOYABLENESS

Items	7	6	5	4	3	2	1
1. I enjoyed the jumping game**.	14	4	0	0	0	0	0
2. I was focused on finishing the game**.	12	4	2	1	3	1	2
3. I put in a lot of thought into finishing the game**.	4	9	3	1	0	0	1

N = 18, **: $P < 0.01$, 7: Strongly agree, 6: Agree, 5: Slightly agree, 4: Neither agree nor disagree, 3: Slightly disagree, 2: Disagree, 1: Strongly disagree.

Table I shows the results of the questions pertaining to the enjoyableness of the game. For all three questions in the questionnaire, there were significant differences in the number of positive and neutral/negative responses. Furthermore, there were more positive responses than neutral/negative responses for all questions. The results indicated that the jumping game was a very enjoyable experience in which the participants could immerse themselves.

IV. CONCLUSIONS

This paper has given an overview of the current version of our game, and has described an experiment in which children played and evaluated the game. The game requires two children to jump together with the same timing to achieve a goal. A number of children played the game and answered a questionnaire. The results suggest that the children enjoyed playing the game with their friends, and used several strategies to coordinate the timing of their jumps. Strategies included shouting and watching each other. Thus, we observed children cooperating with each other while playing the game developed in this study. The game clearly allowed children to cooperate with each other through bodily movements.

In future work, we intend to increase the number of players in order to analyze how players might cooperate with each other in small groups.

ACKNOWLEDGMENT

This work was supported by JSPS KAKENHI numbers 15H02936 and 26560129. The demonstration experiment was supported by Kobe University Elementary School.

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