Remote Kenken: A Networked Real Hopping Game Based on Hopscotch

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***Abstract*— An exertainment support system called Remote Kenken is proposed in this paper. The game resembles hopscotch. Pressure sensors are used to determine the position of the feet of a player and judge the accuracy of the steps during jumping. Victory or defeat is decided by the accuracy of the step and time required. The support system is networked to a server to allow the game to be played remotely by more than one player. Experiments were performed with players located in different rooms playing the game simultaneously. The test results suggest that the subjects could enjoy the game as an exercise and entertainment. The system also includes video and audio equipment for communication and awareness of the steps.**

I. Introduction

Games that use one's own body as input through a sensor have become widespread and, accordingly, the number of exercise games has also been increasing [1]. These games are popular among families because they can provide pleasure and exercise within their home. Such games, which have elements of exercise and entertainment, are called exertainment [2]. These games are developed for playing indoors to simulate the effects of exercises. Remote Kenken resembles hopscotch and can be played by two or more remote players who are connected by a network. Each player has a web camera and a microphone that allow audio and video communications among the players. Hence the exercise can become a competition. Kenken (hopping) is a game that is common throughout the world [4], the goal of this study is to make Remote Kenken a popular exercise game worldwide for all ages.

II. Existing Systems vs Remote Kenken

The Wii balance board and Wiifit game software [5] were developed for the Wii game console to encourage family members to exercise together. A balance Wii board is attached as a peripheral device. Multiple strain gauges are installed on the board to sense minute movement of the player, such as weight shifting.

Another widely used exercise system is the family trainer called Power Pad [6]. The system includes a mat controller attached to a Wii console. It does not use any special sensor like the Wii balance board. "Kenken step" is included to perform hopping on the spot. Like Wiifit, Family trainer is limited to exercise on the mat controller. The lack of lateral and forward movement in these games put the players in motions that are not as natural as during outdoor exercises.

Remote Kenken, like hopscotch, requires the players to perform forward and lateral movements. The differences between Remote Kenken in this study and Kenken Step [3] are shown in Table 1. The display of score and requirement in the precision of the steps are two major distinctions between the two systems.

A survey was performed to collect the responses of players who exercise on "Remote Kenken" and "Kenken Step" [3]. In the sense of reality, Remote Kenken is rated 4.5 / 5.0 compared to 2.1 / 5.0 for Kenken step. The respective interest factor ratings were 4.6 / 5.0 and 3.9 / 5.0.

TABLE 1

DIFFERENCES BETWEEN REMOTE KENKEN AND KENKEN STEP

	Remote Kenken	Kenken step
Moves	Jumps in the same way as in reality.	Jumps only on the spot.
Score	Score based on precision of step (sensors) + Playing time	There is no indication of the score. Pace of jumping is fast not requiring precision. The player must jump as displayed on a screen.

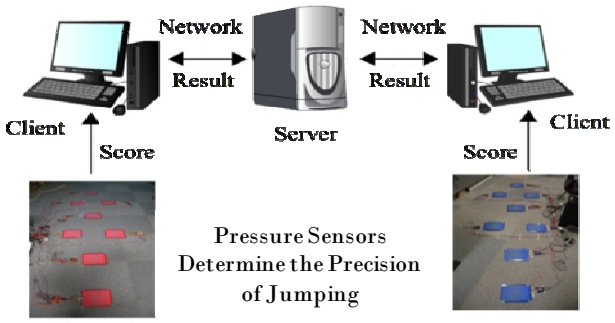

Fig. 1. A networked exercise system for two players.

III. Remote Kenken

A. System

The complete system for Remote Kenken is shown in Fig.1. The software is written in Visual C# and consisting of about 2,100 lines in the client application and about 600 lines in a server application. The hardware of the system shown in Fig. 1 includes a server, two clients and up to eight pressure sensors per player. The sensors provide the analog value of the position of the foot for judging the accuracy of the step. The pressure sensors in a board are shown in Fig. 2.

Communication and awareness for each player are supported by a web camera, a microphone, and a projector (see Fig. 3). The client application manages the score by its player, while the server application handles the interactions between two players.

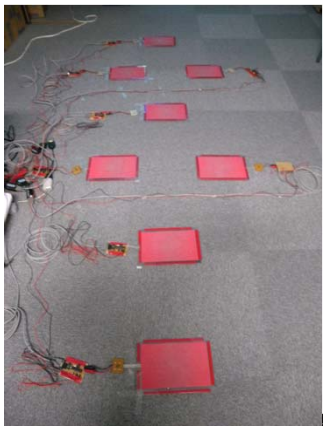

Fig. 2 Pressure sensors in Remote Kenken.

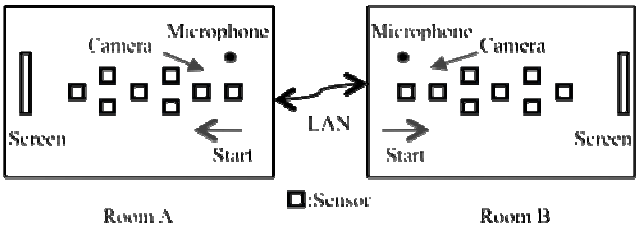

Fig. 3. Placement of the devices. The Web camera shoots a player at the starting point. The microphone is placed near the starting point. The image of the projector is projected on screen.

B. Score

Scoring is based on the accuracy of the steps, which is calculated from the data collected from the pressure sensors. When a player steps on the center of the pressure sensor, two points are awarded. A step not landed at the center of the pressure sensor is awarded one point.

The normal mode is 32 points by stepping forward on the sensors. The score for playing time is up to 8 points. The maximum total score is 40 points (8 points + 32 points). The perfect score for five round-trips of most accurate stepping forward at the best playing time is 200 point. The ratio of the score for stepping to playing time is 4:1. Hence, weight for scoring is put on the accuracy of steps.

The score is zero when the player didn't step on any pressure sensors. It is imperative that the player step on the first and the last sensor, otherwise the game cannot proceed or finish, respectively.

As an example of the normal mode, a player got 20 points based on the degree of accuracy of their steps on the pressure sensor. When the playing time was 10 seconds, 2 points were added. The total score then became 22 points.

C. Ranking function

The software provides ranking to allow viewing of past records. The display order can be in descending or ascending order by score, name, or play time. When a player first appears on the ranking, it is displayed with yellow and makes it possible to easily grasp one's position. A player is not ranked unless he gets 100 points or more.

D. Sound effects

Ten kinds of sound effects are used in the system. Thus a player can grasp his/her status even without watching the screen. Two kinds of sound effects are used to differentiate points scored by steps placed at the center and by steps that are not.

There is a sound effect used to tell the player the number of round trip laps he or she is playing and another sound effect to identify the step number within a lap. We come to understand the number of the laps and the step of the current lap by a sound as well. The three remaining sound effects are for countdown, start and goal time.

E. Network play functions

The system has three functions for the game to be played by more than one player remotely.

First of all, this system has a countdown and start function. Countdown begins, and then the sound of the gun comes out at the time of start. Two remote players start simultaneously.

The system has a web camera and a microphone to provide a sense of reality through life video and conversation. A player can see on his/her screen a projected life-sized picture of the other player.

Figure 4 is a window displaying results of the play (score and victory or defeat) at the end of play. The window is on the screen as shown in Figure 5. The player scoring the most points is the winner.

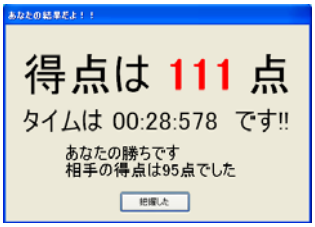

Fig. 4. The results of the play. "111" is score of a player. "00:28:578" is his/her playing time. "95" is score of a partner. So, a partner lost.

Fig. 5. The appeal of the winner. "The results of play" in Fig 4 is shown on the left of the screen.

IV. Experiments And Results

Experiments were conducted to determine the effectiveness of the system for exercise and entertainment. Subjects were students of Wakayama University. They measured their own pulse before and after playing the game. In each experiment, two subjects play in the game simultaneously and their score were compared. The experiments were conducted for 5 times involving ten persons. The player and his/her partner were in separate rooms. At the start signal, each player began to make 5 round trips.

Subjects completed a questionnaire as shown in Table 2. Their rating can be 1 for very poor, 3 for neither good nor poor and 5 for very good. The averaged rating by all the subjects for each question is on the right column in Table 2.

TABLE 2

QUESTIONNAIRE AND AVERAGED RATINGS

Questions	Averaged Rating
Did you feel that you faced it?	4.2
Was there the effect of the video image?	3.8
Was there the effect of the sound (a microphone)?	4.1
Were you able to be conscious of a partner?	4.2
Do you think that there is a merit by facing it?	4.6
Do you think that pleasure increases by facing it?	4.7
Was the indication of the result easy to look?	4.6
Do you think that a motivation is given by victory or defeat indication after the play?	4.6
Was a motivation possible by ranking?	4.4
Do you think that the play leads to maintenance of the motivation?	4.3
By sound effects did you understand the number of the surroundings or you were able to step?	4.0
Do you want to do it again?	4.7
Do you feel it was "exercise"?	4.5
During a play, do you want the information of the partner more?	4.0
Were you interested?	4.6

A. Concerning the Hopping Game

The averaged rating for the question "Were you interested in the game?" was 4.6 and "Do you want to do it again?" 4.7. The high ratings suggest that the subjects could enjoy the game as entertainment.

B. Use of Web Camera & Microphone during Competition

The rating for "Did you feel that you faced competition?" was high (4.2/5.0). This indicates a strong sense of rivalry. The "effect of sounds (microphone)" was rated high (4.1/5.0). Figure 5 shows a winner celebrating by pumping his fist. He could able to see the live video of his partner during the competition. His awareness of the competition was from the sounds and images.

The rating of "Were you able to pay attention to your partner?" was also high (4.2/5.0). The questions of "Do you think that there is merit in facing competition?" and "Do you think that pleasure increases by facing competition?" were given high ratings as well (4.6/5.0 and 4.7/5.0). One player claimed to be able to know status of the game from the sound of the other player. Therefore, we believe players can feel competitive through the video images captured by the web camera and the sounds by the microphone.

C. Display of Player's Score and Ranking

The rating of "Was the indication of the results easy to see?" was 4.6/5.0. The score and ranking of the players are readily available and easy to understand. The rating of "Do you think that a motivation is given by victory or defeat indication after the play?" was also high (4.6/5.0). With the ranking function, players are aware of the scores of other players; this motivates players to improve their ranking (4.4/5.0). We believe that displaying the results and ranking are effective in motivating the player.

TABLE 3

PULSE RATE OF THE SUBJECT

Subjects	Pulse rate (before)	Pulse rate (after)	Difference
1	80	112	32
2	85	119	34
3	80	74	-6
4	72	99	27
5	76	113	37
6	80	101	21
7	74	92	18
8	87	94	7
9	84	120	36
10	82	108	26

D. Sound effects and Information of Playing Partner

The rating for sound effects was 4.0. A sound was used to indicate the second lap, while a human voice is used for the third lap. This makes the status of the player easy to understand.

The averaged evaluation concerning the information of the partner was 4.0. Most players wanted information about their partner during the game.

E. Concerning Exercise

The average score of "Do you feel it was an exercise?" was 4.5. Many subjects felt that they were exercising. According

to the rating of perceived exertion (Borg scale) [7], approximately half of the subjects felt that the experiments made up for their lack of exercise. The pulse rates of most players after playing increased by around 20 (Table 3).

V. CONCLUSION

In this paper, we reported an exertainment system named "Remote Kenken," and performed experiments with participants playing the game in different remote locations. The results show that the subjects regarded it effective for exercise and entertainment. The use of video and sound were successful in providing communication and awareness during the game. The display of scores and the ranking motivated the players to compete for high scores.

In the next step in the development of Remote Kenken, some functions will be added to the support system to improve the game. We plan to add guiding lights on the floor and new sound effects to enhance the player's awareness of the status of the games and position of their steps. Both features will give a sense of support to the players and motivate them to intensify their exercise to get better scores.

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