Remote Kenken: An Exertainment Support System using Hopping

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Abstract **-** Games that use sensors and the physical body have become widespread. However, existing games have a problem that the playing position is fixed. In this study, we propose a system, "remote kenken," by which one can really move their body, and can exercise. We have overcome the limitation on body movement by arranging sensors in the same way as "kenken". In addition, a moderate exercise load was realized by repeating the game five times. We performed a comparison between the proposed system and a kenken game, in which a subject jumped over the same place. The proposed system was evaluated highly in the sense of reality.

Keywords: pressure sensor, exercise, game, entertainment, kenken

1 INTRODUCTION

TV games are one of the forms of entertainments that can easily be enjoyed within the family. Most of them mainly use a controller, but there are few sensor operating systems. There are some games for exercise and entertainment, which we call "exertainment". Physical exercise is recommended for senior citizens [1]. It is expected to become one of the future exercise methods. However, one's position is fixed in these games, and there is the problem that movement is limited. In other words, it is only a simulation of exercise.

We have proposed an exertainment support system, "remote kenken," which overcomes this limitation on movement. We simulate kenken by the proposed system using pressure sensors.

2 EXISTING SYSTEMS

Wiifit [2] is a popular software developed for the game console "Wii," released by Nintendo. Wiifit is a game aimed at doing exercise within the family. It is attached to a balance Wii board as a peripheral device. A balance Wii board is shown in Figure 1. Plural sensors are put on this balance Wii board and can sense careful movement such as weight movement.

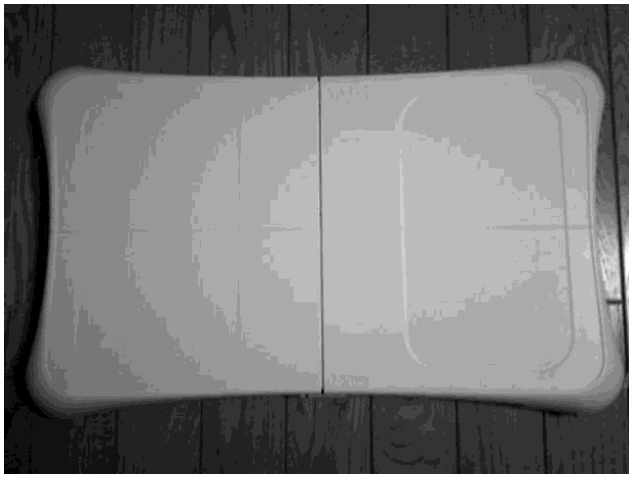

Figure 1: Balance Wii board.

Family trainer [3] is software developed for "Wii," and is designed for exercise. A mat controller (shown in Figure 2) is attached as a peripheral device. It is simple structure. This system does not use a special sensor like a balance Wii board. "Kenken step" is included to perform hopping on the spot. Like Wiifit, Family trainer is limited to exercise on the mat controller.

The differences between remote kenken and kenken step are shown in Table 1.

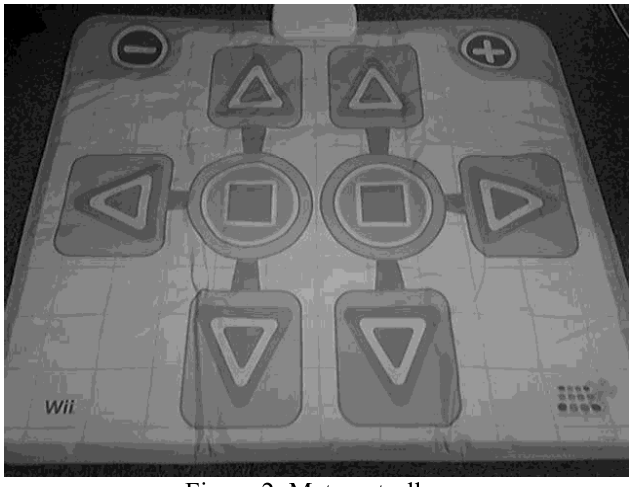

Figure 2: Mat controller.

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	Step precisely on pressure sensors. + Playing time.	There is no indication of the score. Time should be fast. The player must jump as displayed on a screen.

3 REMOTE KENKEN

3.1 Design policy

This system is performed in the same way as conventional kenken. We raise the sense of reality and aim at exercise. Therefore we use pressure sensors. We get the analog value of the position of a foot by pressure sensors. The system aims at exercise and entertainment.

3.2 Development environment

The system was developed by Visual C#. The program is about 1,800 lines of a client application, and about 600 lines in a server application. The circuit of the pressure sensor uses a PIC. 16F873-20/SP was used for processing data from a pressure sensor. The program is about 60 lines. The pressure sensor uses FlexiForce [4].

3.3 System constitution

This system consists of a PC (server and client) and pressure sensors (max 8). The circuit of the pressure sensor is shown in Figure 3, and a pressure sensor with acrylic board in Figure 4. Eight pressure sensors in a board are shown in Figure 5. The client manages the score. Two players are enabled by using a server application. The total constitution of this system is shown in Figure 6.

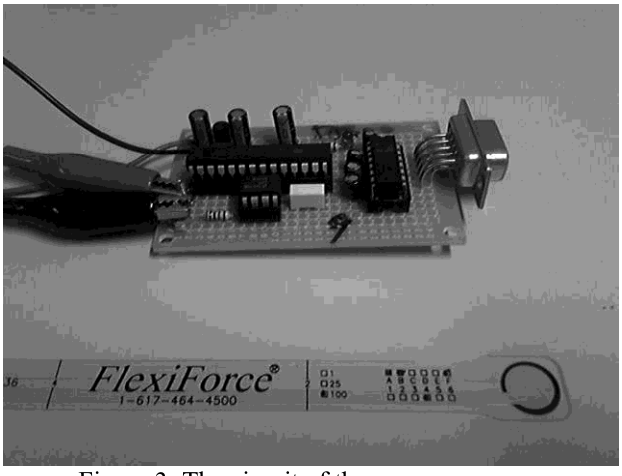

Figure 3: The circuit of the pressure sensor.

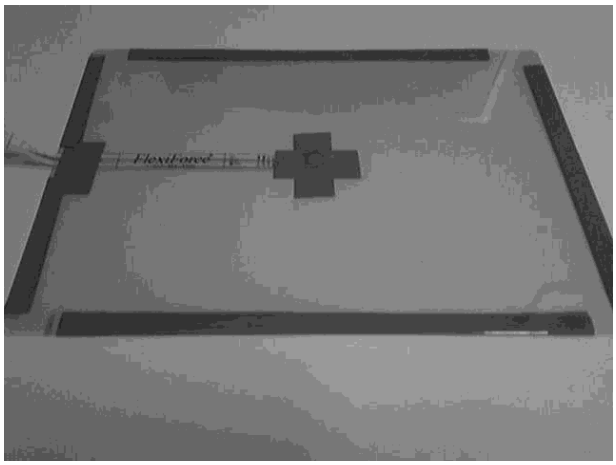

Figure 4: A sensor with acrylic board.

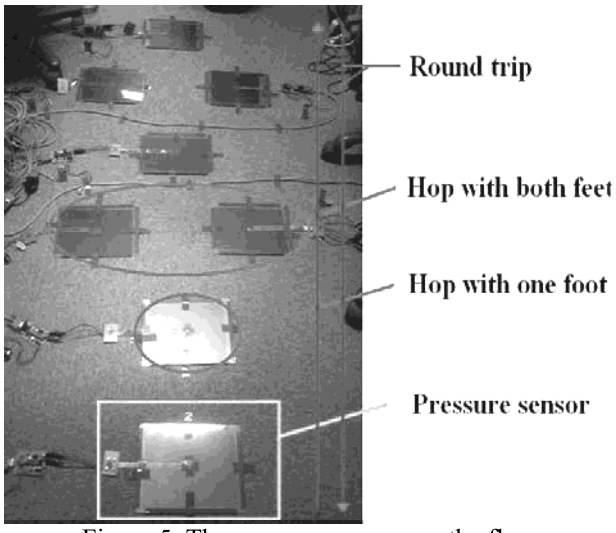

Figure 5: The pressure sensors on the floor.

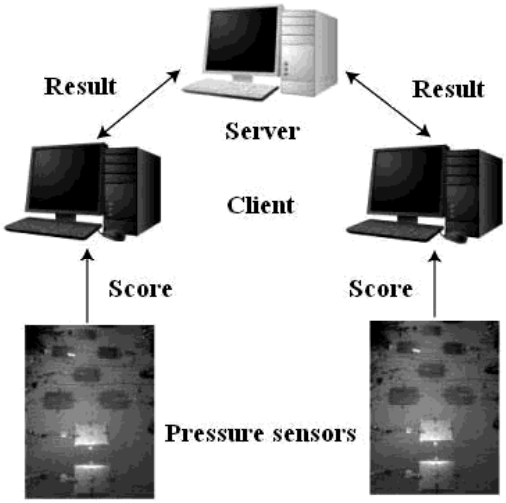

Figure 6: Total constitution of the system.

3.4 Calculation method of the score

As for the score, it is calculated by data from sensors. When a player steps on the center of the pressure sensor, two points are awarded. When a player steps any place other than the center of the pressure sensor, one point is awarded.

The normal mode is 32 points by stepping forward on the sensors. Furthermore, the score by playing time is expressed at 8 points. Total score is 40 points in maximum (8 points + 32 points). The five round trips mode is 160 points by stepping forward on the sensors. A score by playing time is expressed at 40 points out of a total of 200 points, which is a perfect score. The ratio of the score is 4:1. We put weight on the accuracy of steps.

Remote kenken usually performs this with eight pressure sensors connected.

The score of the player becomes 0 when a 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.

As an example of the normal mode, a player got 20 points with the pressure sensor. When the playing time was 10 seconds, 2 points were added. The total score becomes 22 points in this.

3.5 Sound effects at the time of the play

Seven kinds of sound effects are used in the system. This is because a player can grasp present status even without watching the screen. When a player gets a point, we use two kinds of sound effects, so the player comes to understand whether he placed his foot on the center or not.

4 EXPERIMENTS AND RESULTS

4.1 Experiment summary

We carried out the experiment into whether it was useful as exercise. Subjects measured their pulse before and after playing the game. We assumed two players in the game simultaneously and compared the score of the game with partner.

4.2 Experiment environment

Subjects were eight persons at Wakayama University. A scene of the experiment is shown in Figure 7.

A subject pushes the standby button after having been connected to the server. The game starts. Subjects performed five round trips. Subjects step on the pressure sensor. Subjects repeated "kenken" five times from the starting point.

Figure 7: A scene of the experiment.

4.3 Results of application experiment

The results of the experiment are shown below.

The scores and pulse rates of the subjects are shown in Table 2. The average time of playing is 42.5 seconds. (Reference: The average of "kenken step" was 33.9 seconds). The average score was 129.6 / 200. The pulse rate rose 20.6 per one minute after the game. The average of "exercise strength" became 17.6%. "Exercise strength" is shown below.

Exercise strength (%) = (The pulse rate while exercising - The pulse rate at the time of rest) / (The best pulse rate - The pulse rate at the time of rest) × 100

Table 2: The score and pulse rates of the subjects

Playing time (seconds)	Score	Pulse rate per minute	
		before	after
33.2	128	99	115
38.1	131	82	108
60.7	134	65	82
42.4	112	86	108
44.5	122	80	95
37.8	127	87	116
38.4	127	87	112
44.9	156	77	92

The results of the questionnaire are shown in Table 3 (1: very poor, 3: neither good nor poor 5: very good).

The description part of the questionnaire is as follows.

(1) Is the score reasonable?

・The ratio of weight for playing time and score from sensor is reasonable.

・If I can't step on the sensor, I think zero score is reasonable.
・The parameters of playing time are reasonable.

(2) Concerning others opinion and impression.
・I enjoyed it. There should be several variations about the kenken.
・I was worried about the delay of the sound.
・It is hard to understand the lap now.
・There should be comments from the system depending on your score. By getting a point, it should say "do your best!"

Table 3: Questionnaire results of experiments

Questions	Evaluation average
As for playing time, was it reasonable?	4.5
Were you able to understand the rules?	4.9
Were you able to step well?	3.4
Did you understand whether you were able to place your foot by sound?	4.4
Was it like real hopping (kenken)?	4.5
Do you feel it was "exercise"?	4.4
Were you motivated more by a result of victory or defeat?	4.5
Do you think the setting of the score is reasonable?	4.1
Were you interested	4.6

4.4 Consideration of the experiment

The results of the questionnaire on "remote kenken" and "kenken step" shown in Table 4. We shall next discuss the results of experiments based on Tables 3 and 4.

Table 4: Comparison with kenken step

Questions	Remote kenken	Kenken step
As for playing time, was it reasonable?	4.5	3.9
Were you able to understand the rules?	4.9	3.7
Were you able to step well?	3.4	2
Was it like real hopping (kenken)?	4.5	2.1
Do you feel it was "exercise"?	4.4	3.6
Were you interested?	4.6	3.9

(1) Concerning playing time and the understanding of the rules.

Average playing time for remote kenken took 42.5 seconds. The evaluation was 4.5. The length of playing time can be said to be reasonable. It took 33.9 seconds in average playing time for kenken step. Because the average of evaluation was 3.9, we thought that playing time of around 40 seconds is reasonable.

The average evaluation was 4.9 for understanding of the rules. That evaluation is higher than kenken step. Five round trips was easy to understand.

(2) Concerning sensors and sound effects.

The evaluation of "Did you understand whether you were able to place your foot by sound?" was high (4.4 / 5.0). But, pressure sensor sometimes sent incorrect data, and the players misunderstood their situation. A variety of sounds related to the lap is needed.

(3) On hopping sense and exercise.

The evaluation of the sense of reality was high (4.5 / 5.0).The evaluation of sense of reality was higher than kenken step (2.1 / 5.0).

The evaluation of "exercise" became 4.4. There were many people who felt it was "exercise". As for the pulse rate, an average of 20.6 per one minute increased. Remote kenken seems to be exercise.

(4) The score and victory or defeat indication.

Victory or defeat indication added motivation to the game. It was highly evaluated (4.5 / 5.0).

There were answers such as "the parameters of playing time were reasonable" for a description questionnaire. It was popular to get numerous points from pressure sensors.

(5) Concerning fun.

Evaluation of whether it was "interesting" was 4.6 which was higher than that of kenken step. There were opinions of "I enjoyed it. There should be several variations of kenken". By this experiment, we fixed the position of the pressure sensor. The sense of reality was kept in the system. If sound effects are added, the evaluation might go up.

5 CONCLUSION

In this paper, we proposed an exertainment support system named "remote kenken".

Remote kenken is a system in which players can jump around in the same way as real hopping by stepping on pressure sensors on the floor. We experimented 8 times (8 people) using the system.

The results of the application experiment are as follows.

(1) The sense of hopping seems to be highly evaluated in comparison with "kenken step," which simulates hopping.
(2) Around 40 seconds were judged to be reasonable in playing time. Because "kenken step" is thought to be reasonable at around 40 seconds, we thought such a small amount of time was reasonable for "kenken".
(3) After each experiment, pulse rates rose, so its value as exercise was accepted.
(4) Displaying victory or defeat by the score was evaluated as fun.

Sense of reality was high in this system. In the future, we will improve the system for exertainment and perform experiments between remote players.

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