Proceedings of the International MultiConference of Engineers and Computer Scientists 2014 Vol I,
IMECS 2014, March 12 - 14, 2014, Hong Kong

Rope Skipping Motion Recognition System Using Kinect

Youji OCHI

Abstract—**Rope skipping is an effective way of training. In this study, we concentrated on the rope skipping exercise of using the equipment without a rope which is called "air jump rope". We have developed a system for recognizing the rotational motion of the rope skipping exercise. The system analyses a motion of jumping rope using the moving image processing using the IR camera of Microsoft Kinect. By attaching a polystyrene sphere to air jump rope, the system recognizes the motion of a jump rope exercise the Kinect sensor. In this paper, we describe the outline of our approach and the performance evaluation.**

***Index Terms*—Motion Recognition, Kinect, e-Learning, Rope-skipping**

I. Introduction

Training or exercise promotes a healthy and improves the skills of the sport. There are many researches of a training support system. In their researches, many different hardware and software are used in order to facilitate sports-related skills [1]. It is often called "Skill learning". A gesture-based technology is very important to implement a skill learning environment. Generally, it is based on image-processing technologies [2] [3]. However, recently, Microsoft Kinect (hereafter, Kinect) is a low-cost motion sensing input device. It has some potential as a tool for teaching or learning [4]. Some researchers in an educational technology are trying to adopt several educational environments [5] [6] [7]. We have been developing an air-squat training support system and Human Motion Mining Supporting System using the Kinect [8] [9].

In this research, we have focused on the rope-skipping exercise as a training system using Kinect. Rope-skipping is a famous play and training with children and many young adults. The aim of our research is basic jump. The user holds both feet slightly apart and jumps at the same time over the rope. Still, it makes the user alone. Consequently, it is often difficult for her/him to keep her/his motivation of the training. Moreover the rope-jumping requires the place constraints. For instance, it is difficult to exercise the rope-skipping indoors. Because the rope hits the floor, and scratches it. In this study, we focus on the equipment called "air jump rope". It is a toy and sales at some market. It does not have a rope so that it makes easy to exercise the rope-skipping in doors. We have developed a module for recognizing the rotational motion of the rope-skipping. In this paper, we describe the schema of our approach and the performance evaluation.

Manuscript received Jan 8, 2014; revised Jan 30, 2014. This work was supported by Grant-in-Aid for Scientific Research(C) 23501122 from the Ministry of Education, Culture, Sports, Science & Technology in Japan.

Youji Ochi is with Faculty of Science and Engineering, Kinki University, Higashi-Osaka, 5778502 Japan (e-mail: ochi@ ele.kindai.ac.jp).

II. Procedure for Paper Submission

A. Problem of Rope-skipping Training

Rope-skipping is an easy sport. However, there are the following problems in order to practice rope-skipping indoor.

(1) It makes noise
(2) It scratches the floor
(3) It requires wide space not to hit someone and furniture

When the user exercises rope-skipping, s/he must select the location in the above points the user. The above problem can be solved by getting rid of the rope. However, rope-skipping without the rope is different from the normal rope-skipping. Thus, getting rid of the rope is not appropriate.

In this research, we focused on the "air jump rope". It has unconnected short rope and grip. In addition, it has the hardware in order to measure the number of rotations. Consequently, we think that "air jump rope" has the potential to solve the above problems.

B. Necessity of Supporting Air jump skipping

The measure function of the number of times facilitates user's motivation and support to manage the training. However, it records the number of the rotation only one time. Therefore, it is necessary to develop the environment which manages the record. Moreover, it supposes the user experiences a high motivation for training. The measuring method of air jump rope checks only the motion of the rope's rotation. Therefore, if the user just waves air jump rope in the air, it will count the rotation. When the air jump rope is introduced to school as an educational material, the learner will get lazy about the training. So we think that air jump rope is not suitable for self-training style for low-motivated learner and require the instructor in order to monitor the user's behavior.

C. Our approach

We focused on the Kinect in order to solve the above problems. Kinect can measure the skeleton information about the human body in real time. A training support system with Kinect can check the jump of the learner by measuring the movement of the learner's skeleton information. However, it is important that it makes the learner aware of flying the rope. If it is possible to check the synchronization between the learner's jumping motion and the movement of air jump rope, it can expect to enhance the learner's motivation and skill.

The system must recognize the movement of air jump rope in order to realize the function. However, Kinect can recognize the human's skeleton information in a basic function. Therefore, Kinect cannot identify the object such as an air jump rope.

III. System Implementation

In this study, we have developed a system for quantifying the movement of the air jumping rope using the Kinect.

A. System configuration

Our system consists of the following equipment in this research.

- Microsoft Kinect (with Windows PC)
- Air jump rope
- Styrene-ball

Figure 1 shows the Air jump rope with the styrene-ball. The ball mounts to the end of the air jump rope in order to recognize the movement of the air jump rope (Figure 1)

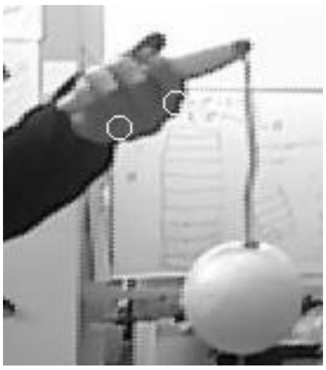

Fig 1. Air jump rope with Styrene-ball

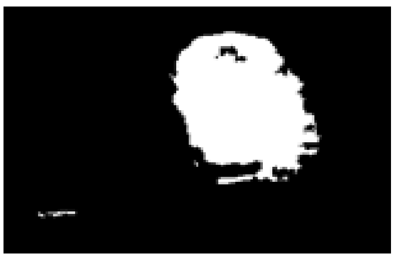

Fig 2. Detection of styrene-ball

B. Method of Recognizing rope rotational motion

Our system recognizes the jump rope action using the motion of polystyrene-ball. The kind of recognition is “forward rotation" and "backward rotation". It is better that Kinect measures the polystyrene ball from the front in order to recognize the rotational motion of the polystyrene ball. However Kinect cannot recognize the human skeleton from the side. Therefore, in this study, we set up a Kinect to the front. We utilize the IR camera of Kinect in order to recognize polystyrene balls [Figure 2]. Our system identifies the direction of rotation by tracking Y coordinate of the polystyrene ball,

Figure 3 shows Y coordinate of styrene ball in the case of forward rotation and backward rotation. The Y-coordinate pattern is going down in the case of forward rotation. On the other hand, it is going up in the case of backward rotation. The both trajectories are different like this. Our system detects the direction of the rotational motion from this pattern.

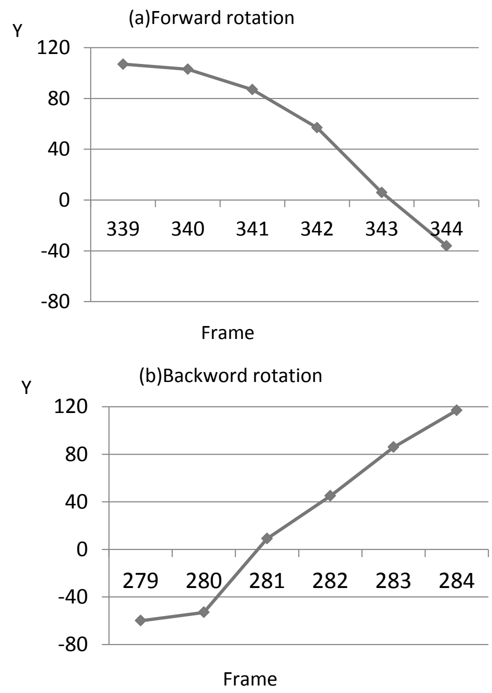

Fig 3. Trajectory pattern of styrene-ball

IV. Evaluation

A. Purpose

The purpose of this evaluation is to clarify the usefulness of our system. We fix the following experiments.

(Exp. 1) Relationship of accuracy and size of polystyrene ball

(Exp. 2) The accurate evaluation of trial uses

The first experiment clarifies the appropriate size of the polystyrene ball. The second experiments show the accuracy of the rotational motion recognition in the prototype system.

B. Method

(Exp. 1) We investigate the relationship between the average pixel values of three polystyrene ball (diameter 4cm, 6cm, 10cm) and four standing positions from Kinect (1m, 1.5m, 2m, and 2.5m). Before the experiment, we got the result if the size is 500 pixels or more, the recognition rate is improved, but too large size leads to the lower recognition rate. Therefore, we investigated whether the pixel size of polystyrene ball (pixel average value) is over 500 pixels in each condition in order to consider the suitable distance from the Kinect and polystyrene ball.

(Exp 2) Seven examinees used our system in the trial. As the experimental conditions, we set the Kinect at the 1 [m] from the floor. The examinees stood in 1.5 [m] away from the Kinect. They skipped rope until the system counted 10 times. We counted the number of actual rotations and compared the count with the system's count (10 times).

(Exp 3) After Exp 2, we asked them their comments about the usability of the systems and the evaluation result. This answer is optional.

ISBN: 978-988-19252-5-1
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

TABLE I
THE NUMBER OF EXAMINEE'S ROTATIONS

Examinee	The number of actual rotations	margin of error
1	10	0
2	17	7
3	11	1
4	11	1
5	12	2
6	13	3
7	11	1

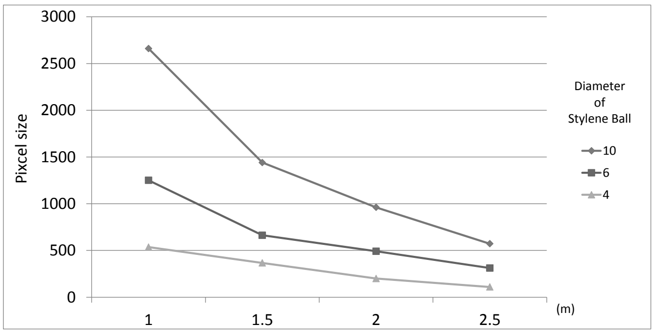

Fig 4. The size of styrene-ball

C. Results and Discussion

(1) Experiment 1

Figure 4 shows the pixel values with the relationship between the size of styrene ball and standing position. The pixel size of the ball decreased with distance from the Kinect. About 10cm ball in diameter; the all standing position is suitable for the recognition, because all pixel size of the styrene ball is more than 500 pixels. In the case of 1.0 m away, all pixel size of the styrene ball is more than 500 pixels. However, getting too close from Kinect, Kinect cannot capture the whole body of the user. It makes the system bad recognition rate.

In the case of 1.5 m away, our system was able to recognize the rotation of all styrene balls. Kinect was able to capture the whole body of all users. In the case of 2.0m over away, our system could sometimes recognize 10 cm and 6cm ball, but not recognize 4.0cm ball in many cases. In the case of 2.5m away, the system could not often recognize the rotation of 10cm and 6.0 cm styrene ball and not recognize any rotation of 4.0 cm ball.

Changing the minimum sensitivity threshold of recognizing the ball area is one way in order to solve the above problem. However, it often increases the noise and decrease the recognition rate.

From the above result, we think that standing 1.5m away from Kinect is good in order to get a high recognition rate free of influence from the styrene ball size and user's body height.

(2) Experiment 2

Table1 shows the number of actual rotations in each examinee and margin of error. About most examinees (Except examinee 1) the error occurred. We have discussed the reason from here.

We investigate the trajectory of a styrene ball of all examinees. Trajectory of examinee3 and 4 is interrupted in the midstream of styrene ball rotation.

First, styrene ball faced toward the front of Kinect sensor. However, blurring of images due to hand movement occurred to the left and right slowly. Therefore Kinect lost the styrene ball and the system could not count. Then the use's actual rotation increased. The examinee 7 could not swing the rope properly at first. Therefore, the user's count is more than the system's count.

About examinee 2, since he moved his hand widely with the air jump rope, the movement of the ball was blurred from side to side. Therefore his error became more compared with the other examinees (Figure 5). The same situation occurred about the examinee 5 and 6. Our system could not sometimes recognize the styrene ball (Figure 6).

(3) Experiment 3

Four examinees left their comments. Here lists their comment.

- I swung the air jump rope like a normal jump rope in my senses. However the error is increased. (Examinee 2)

- I could not feel the rotation of the air jump and it was difficult for me to rotate the air jump rope. Because it is lighter than normal jump rope. It is good to be able to check the number of rotations in real time. (Examinee 3)

- It was good to be able to check my movement with air jump rope. However, the operation of the system was heavy.

- I felt it is better to use something other than Air jump rope. (Examinee 3)

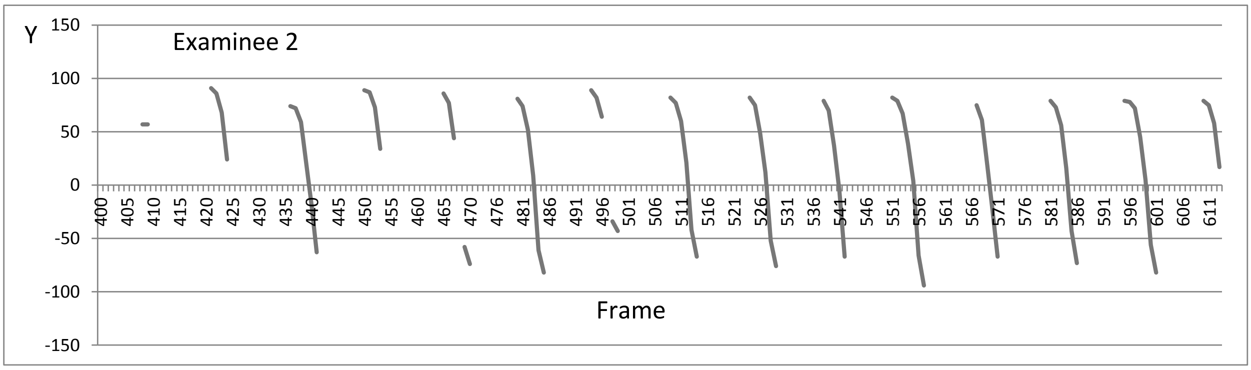

Fig 5. The trajectory pattern of a styrene ball about Examinee 2

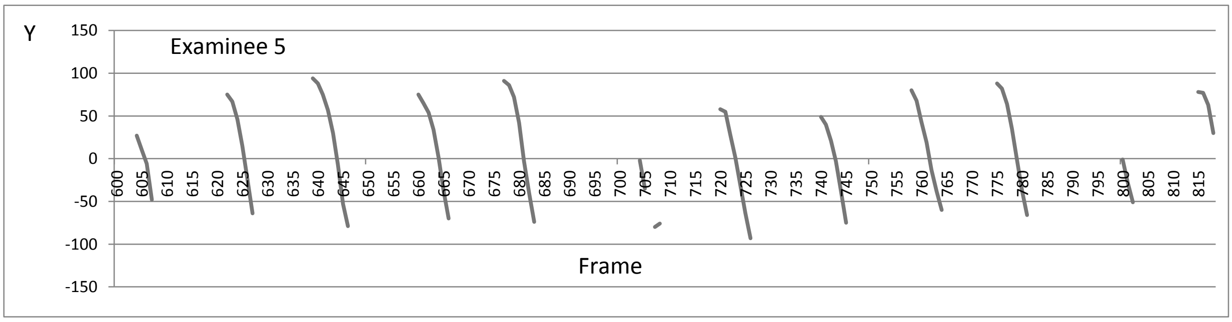

Fig 6. The trajectory pattern of a styrene ball about Examinee 5

V. CONCLUSION

In this study, we implemented the function of recognizing jump rope rotational motion. It used the depth information from the Kinect. The result of evaluation shows that the best location is 1.5m away from the Kinect. In the location, our system can be recognized that all polystyrene balls and capture the whole body of the user. However, the system could not recognize the jump rope rotational motion about some examinees. This is our future works.

REFERENCES

[1] Helen C. Miles, Serban R. Pop, Simon J. Watt, Gavin P. Lawrence, Nigel W. John, A review of virtual environments for training in ball sports, Computers & Graphics 36 (2012) 714–726,

[2] Cao Nguyen Khoa Nam, Hee Jun Kang, and Young Soo Suh, Golf Swing Motion Tracking Using Inertial Sensors and a Stereo Camera, IEEE Transactions on Instrumentation and Measurement, 10.1109/TIM.2013.2283548

[3] Naka GOTODA, Kenji MATSUURA, Koji NAKAGAWA& Chikara MIYAJI, Design of Tennis Training with Shot-timing Feedback based on Trajectory Prediction of Ball, Workshop Proc. of ICCE2013,pp.196-201,2013.11

[4] Hui-mei Justina Hsu, The Potential of Kinect in Education, International Journal of Information and Education Technology, Vol.1, No. 5, pp.365-370,2011

[5] Yasuhisa TAMURA, Masataka UEHARA, Taro MARUYAMA & Takeshi SHIMA, Feedback of Flying Disc Throw with Kinect: Improved Experiment , Workshop Proc. of ICCE2013,pp.209-216,2013.11

[6] Kuo-Jen Chao, Hui-Wen Huang, Wei-Chieh Fang and Nian-Shing Chen, Embodied play to learn: Exploring Kinect-facilitated memory performance, British Journal of Educational Technology, Vol 44, No 5, E151–E155,2013

[7] Tsung-Yen CHUANG, Lan-Yu KUO, I-ChingLEE, Wei-FangTSENG, &Yen-Wei HSU, The Design of Kinect Posture Game in Treating Sensory Integration Dysfunction, Proc. of ICCE2013, pp.608-612,2013.11

[8] Youji Ochi, Yuya Takeda, Human Motion Mining Supporting System using Microsoft Kinect, , Proc of LTLE2012, pp.299-300

[9] Youji Ochi, Development of An Air-Squat Support System Using Microsoft Kinect, Proc of ICCE2012, pp.520-522(2012.11)