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Development of training software for elderly persons practicing a squat exercise

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Abstract. This paper describes the development of an exercise support software by using Kinect sensor. Contactless sensing of squat was performed using the coordinates of the shoulder acquired by Kinect sensor. We implemented measurement mode and game mode in the application. In the measurement mode, it is possible to obtain the optimal exercise time of the game mode. At the same time, the threshold for recognizing squat movement can be derived by up and down reciprocation of shoulder movement in this mode. In the game, the user operates the position of the character to hit the ball flowing from left to right. As the user's shoulder position moves up and down, the game character moves up and down. The score is evaluated on a scale of hundred points. The score of playing the game can be saved for each individual. The experiment was conducted to verify the characterization of the squat movement and the practicality of the application. As a result, the utility of the application was shown.

1. Introduction

At present, the increase of elderly people is a serious social problem in Japan. An increase in the burden on current working generations due to the increase in the number of elderly people is an unavoidable social problem, one of which is the shortage of labor in facilities for the elderly. The work at the facility is diverse, but one of them is exercise assistance for the elderly, and it is one of the heavy tasks. Therefore, there is a need to develop a tool to reduce the burden on staff in facilities for the elderly and to support exercise for the elderly. In this study, we developed an exercise support application for elderly people [1]. Among the exercises, we focused on the squats adopted in many nursing homes and constructed the system. The squat movement of the elderly has been clarified about the effectiveness for the elderly requiring care [2, 3], and inverse dynamics analysis [4] and analysis of the characteristics of squat exercise in the elderly [5, 6] have been performed. On the other hand, with regard to the support equipment for squat exercise for elderly people, it has been considered to use a training machine a machine with only concentric contraction [7], but developing a software application to support it simultaneously with exercise measurement has not been done yet. So we have been developed this kind of software for elderly persons. The application developed in this research aimed to perform the contactless sensing of the squat movement and the movement efficiently and continuously, and used Kinect as a sensor. Kinect can easily recognize the skeletal information of the operator, and this system has performed contactless sensing of squats using the recognized coordinate values of both shoulders. In addition, by giving the game nature, we aimed for the application that elderly people can continue the exercise without difficulty.

2. Developed system

2.1 System configuration

Fig. 1 shows an outline of the system configuration. In this research, in order to acquire human behavior without contact, human skeletal information is acquired using Kinect for Windows (hereinafter referred to as Kinect) of Microsoft Corporation. The developed system was designed to assist the user in exercising and, due to the characteristics of the game, the display was provided separately from the laptop. Application development uses Microsoft Visual Studio 2019 C # and the system is controlled by GUI tools. In this system, Kinect was connected to a PC and the operator was photographed, the operation was recognized, and the operation was reflected in the application.

2.2 Operation mode

We prepared two mode, one is measurement mode, and another is game mode. The actual application is shown in Fig.2 and Fig.3.

In the measurement mode as shown in Fig.2, user performs squat exercise for ten times at a reasonable pace for each individual. By performing this measurement, it is possible to acquire the following data.

(i) Exercise time duration for ten times squats
(ii) Maximum value of right shoulder coordinates at squat implementation
(iii) Maximum value of left shoulder coordinate at squat implementation

Here, the exercise time of (i) was set to reflect the time of one set of squats in the game mode. The

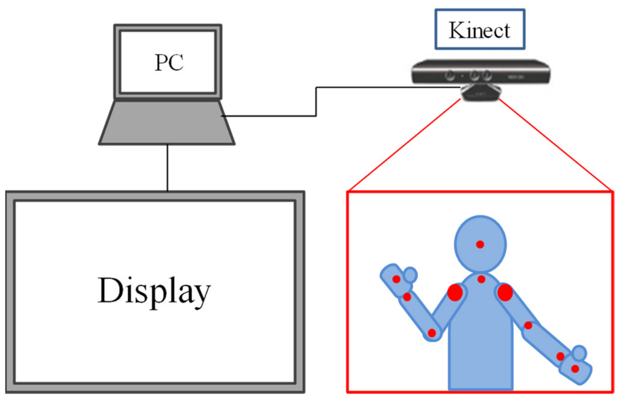


Fig.1 System structure

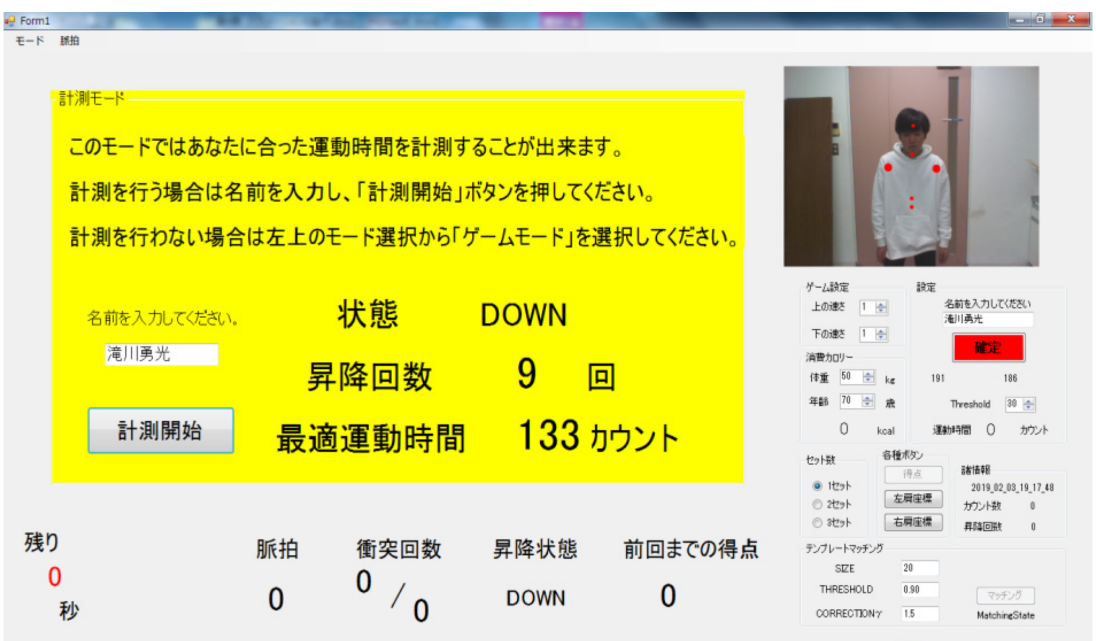


Fig.2 Developed GUI tool (Measurement mode)

maximum values of both shoulder coordinates in (ii) and (iii) were used to set the threshold for determining the elevation state in game mode, and the value obtained by multiplying each acquired coordinate value by 0.7 was used as the threshold. When the coordinates of both shoulders exceeded the threshold value, it was in the rising state, and in the case of less than the threshold value, it was in the falling state, and the lifting state was judged.

In the game mode as shown in Fig.3, the elevation status of the squat is reflected in the character's position. The character moves up and down if it is up and down states, respectively. As a game, the score is added when the character breaks the circle that flows from the left to the right side, and it is a system that is scored on a 100 point perfect score in the end. As a method of breaking the circle, it was decided to break by colliding with the circle. The display on the actual application is shown in

Fig.3 Developed GUI tool (Game mode)

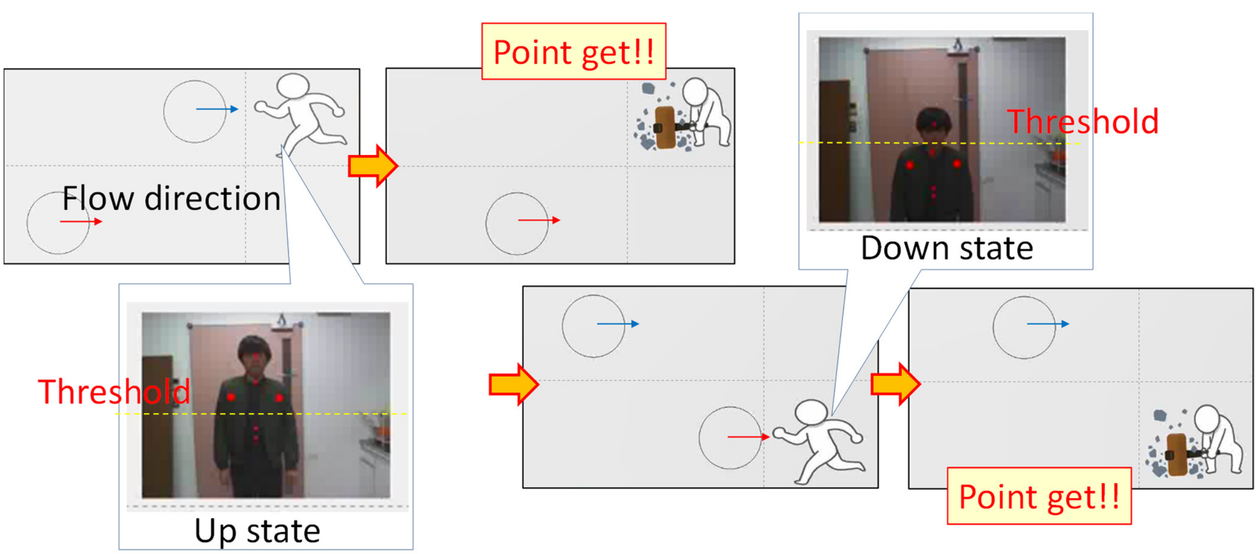


Fig.4 Practice scene and GUI motion

Fig.4. By using the data acquired in the measurement mode, the play time was set for each individual, so that the game could be performed without difficulty. Specifically, one set of up to 10 squats is set, and the time is set so that a total of 20 circles (upper 10, lower 10) flow during the exercise time acquired in the measurement mode. Each user can perform the same number of squats at individual timings.

3. Experiment

3.1 Experimental Method

The experimental environment is shown in Fig.5. Half squats were selected as the type of exercise. Firstly, the measurement mode of the application starts before playing the game. In the game, half squats were performed 10 times, and the coordinate values of both shoulders were acquired for each individual. The participated subjects are ten men and women in their 70s and 90s and ten men in their 20s.

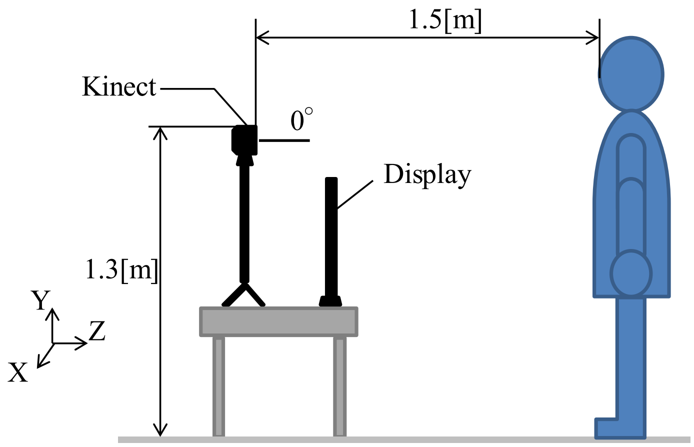
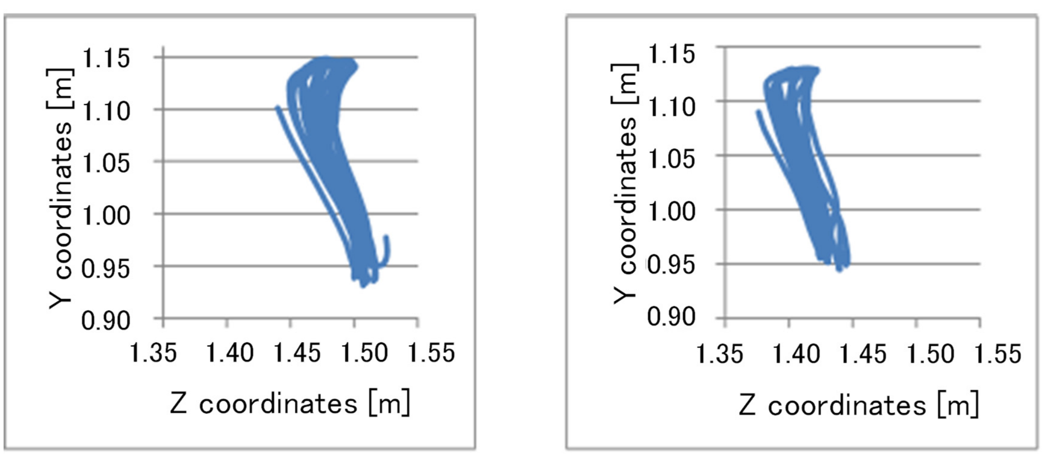


Fig.5 Experimental situation

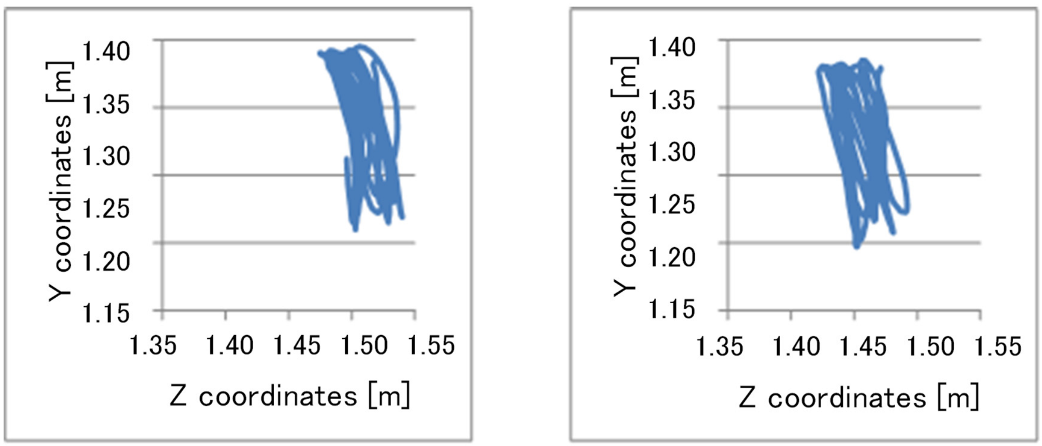
3.2 Results

Because it is a half squat, the change in the *X* axis direction is small. Therefore, the graph of *Z*-*Y* coordinate system was created from the coordinate value acquired for each subject. The graph created two types of right shoulder coordinate values and left shoulder coordinate values for one subject. An example of the graph is shown in Fig.6, Fig.7, and Fig.8. Since the shoulder trajectory in Fig. 6 has



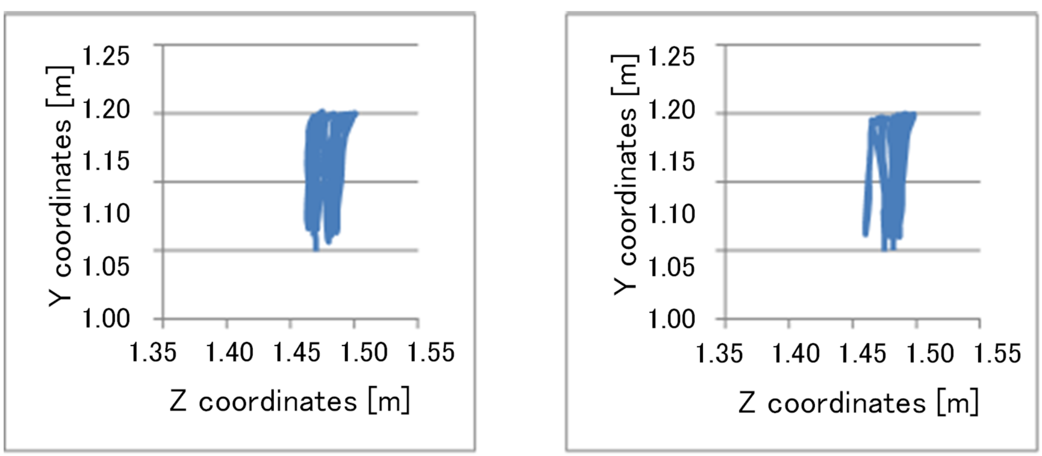
Left shoulder Right shoulder

Fig.6 Experimental results Senior subject A (90s, Male) rounded corners, it can be seen that the shoulder has come forward during the half squat. When the shoulders come forward, there is a time when the muscles are not stressed, which is considered to be insufficient for exercise. In the trajectory of Fig. 7, the approximate shape of the graph is a straight line or a shape close to a circular arc, and is a graph with a falling edge. It can be seen that the movement is a half squat that sticks out the buttocks. Such a half squat can be considered as a correct squat because it can put enough stress on the lower body muscles and there is little risk of injury. The trajectory in Fig. 8 is a graph whose outline is close to a straight line or a circular arc, and is a graph rising to the right. It can be seen that the exercise is a half squat that brings the knees forward. It is thought that such a half squat places a heavy load on the knee and leads to injury. As understood from these results, it is possible to easily analyse the motion of squats by using this system. Also, it is thought that the practicality of the application was shown in this experiment because many positive opinions were received from the elderly people.



Left shoulder Right shoulder

Fig.7 Experimental results Senior subject B (80s, Female)



Left shoulder Right shoulder

Fig.8 Experimental results Senior subject C (20s, Male)

4. Conclusions

In this study, we developed an exercise support application for elderly people. In this system, Kinect sensor recognizes human skeleton information and noncontact sensing of squats can be performed using coordinate values of the recognized skeleton. By implementing two modes, measurement mode and game mode, and measuring in measurement mode, we built a system that can play games at individual pace. In the experiment, the practicality of the application was verified in a real elderly facility. As a result, it could be confirmed that practicality was shown. As future tasks, we will build a system that can give feedback to the operator when doing an inadequate exercise. We will also pick up not only squats but also various exercises that are actually performed in facilities for the elderly.

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References

[1] Nobuaki Nakazawa et al., Development of support system for elderly persons practicing a squat exercise, ***Proc. of International Conference on Technology and Social Science 2019***.

[2] Eiji Fujita, Effectiveness and effect of squat exercise using its own weight in the elderly requiring care (in Japanese), ***Japanese Journal of Physical Fitness and Sports Medicine***, Vol.64, No.1, pp.9, 2015.

[3] Mari Hashimoto et al., Feasibility study of locomotion training in a home-visit preventive care program, ***Nippon Ronen Igakkai Zasshi. Japanese Journal of Geriatrics,*** Vol.49, No.4, pp.476-482, 2012.

[4] Tatsuya Maruge et al., Inverse dynamical analysis on squat operation of the elderly (in Japanese), ***Rigakuryoho-Rinsho, Kenkyu, Kyoiku,*** Vol.24, No.1, pp.73-76, 2017.

[5] Satoshi Kasahara et al., The Characteristic of the Squat in the Elderly II: Comparison of the Leg Joint Movements Between Males in Their 60s and 70s (in Japanese), ***Rigakuryoho Kagaku,*** Vol.29, No.6, pp.911-915, 2014.

[6] Chihiro Yuhara et al., The Characteristics of the Squat Motion in the Elderly(in Japanese), ***Rigakuryoho Kagaku,*** Vol.29, No.5, pp.765-769, 2014.

[7] Chihiro Yuhara et al., Effect of the squat training using a machine with concentric contraction on muscle strength and postural control measures in the elderly (in Japanese), ***Japanese Journal of Physiological Anthropology,*** Vol.10, No.2, pp.45-51, 2005.