The Application of a New Type of Depth Camera to Teach Gymnastics

Tsanming Ou[1], Tomoki Miyamoto[1], Yuki Kurosawa[1], Takahide Otomo[1], Yuko Hoshino [1], Mitsuho Yamada [1]

[1] Graduate School of Information and Telecommunication Engineering, Tokai University, Tokyo, Japan

Keywords: depth camera, robot, sensor, gymnastic support

ABSTRACT

As Japanese society increasingly ages, there are more and more people who do sports to improve their quality of life, and there have been a number of studies on the use of humanoid robots to teach gymnastics. We attempted to use a new type of sensor in this kind of system and tested its performance. This paper presents the method we used to obtain the motion and posture data when a user imitates the motion performed by the robot, and the experiments we performed to determine whether the depth camera works well.

1 INTRODUCTION

As of November 1, 2018, elderly people aged 65 and over accounted for 28.2% of the total population of Japan [1]. As Japanese society increasingly ages, there are more and more people who do sports to improve their quality of life. The elderly, for example, are able to do gymnastics at home without going to a nursing facility or gym if they can practice exercises by viewing television, but their exercise may be improved with more personalized instruction. Therefore, we examined a robotic system that can teach a user gymnastics.

We developed a system of gymnastic support using a new type of depth camera and humanoid robots. Much research has considered gymnastic robots and support systems, so we combined these technologies to develop a complete system. The robot first demonstrates the movements, and the trainee then repeats it. The camera captures the motion of the trainee and compares it with the standard motion data in the database. Finally, the system points out any differences.

2 SYSTEM

2.1 Device

(1) Depth camera

Kinect by Microsoft has often been used for studies that support gymnastics, but since Kinect stopped production in 2017, we decided to use Intel® RealSenseTM D435, a new type of Intel® with full-depth camera functions [2]. While both the Intel® RealSense™ D435 and Kinect are depth cameras, the methods they use to detect depth data are different. Kinect v2 uses the time-of-flight method for depth sensing, while the Intel® RealSense™ D435 uses stereo image sensing technologies. Stereo depth works both indoors and outdoors under a wide variety of lighting conditions. The D435 also has a sufficiently wide range for capturing objects, and the device is smaller in volume and easier to install.

(2) Robot

We used a NAO robot from Softbank Robotics to perform the gymnastic motions instead of using video from a television gymnastics program. The system features inertial units to maintain balance, multiple NAO joints for smooth movements, and it can perform various operations such as biped walking, rising, and dancing. It also has a variety of language functions, and so can also give advice to the user. It is currently used in the fields of medical care, nursing care, and education.

2.2 System Configuration

This system has two parts. The first records the motion or posture of the instructor with a depth camera and saves it in the database to a set of standard motions and postures. The NAO then moves according to the standards in the database. The second part captures the practitioner’s motions when they perform the exercises and compares it with the standard motions in the database to determine differences. The system will point out these to the user.

3 SOFTWARE

We captured skeleton data using Nuitruck™ SDK [3], a 3-D tracking middleware developed by 3DiVi Inc. This skeleton tracking and gesture recognition software

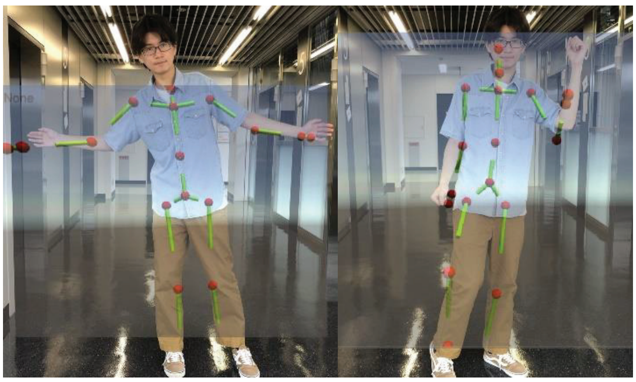

Fig. 1 The skeleton extracted by our system

enables a natural user interface (NUI) on Android, Windows, and Linux. Nuitrack could support the Intel RealSenseTM Depth Camera D435 to compute the position of human joints. The Nuitrack SDK helped us to detect 19 joints in a human skeleton in 3-D space. FIG. 1 shows an example of the extracted skeleton. We use the angles of joints to determine the correctness of the posture instead of position data, in order to reduce the impact of body differences between humans [4].

4 EXPERIMENT AND RESULTS

4.1 Experiment method

While the function to evaluate the performance of gymnastics is the core in our system, we first checked the correctness of the data taken from RealSense.

We tried to capture the movement of participants' feet and recorded the angle data of knee joints. We focused on the positions of hips, knees and ankles, which are necessary to compute the knee angle. If even one of them were lost, the angle of knee would be unavailable. When participants were walking normally, we captured the movement with the system. Each participant was asked to walk in the same place for 10 s. The distance between the camera and an examinee was about 2 m. The camera shot 10 times per s, so we could get about 100 frames of data on each participant. There is a set of 19 joints data in a frame. However, this time we focused on the movement of the feet. For the purposes of the present study, if the angles of both knees could be computed, the data of this frame was considered available. We computed the available frame rate of each participant to judge the performance of the motion capture part on this system.

4.2 Results

Participants in the experiment were 20 university students (3 female, 17 male). All were about 20 years old. In the results, 13 had an available frame rate over 95%, while the rates of others were 89.3%, 59.6%, 48.5%, 6%, and 3 of them were 0%. Fig. 2 shows the bar graph of the results.

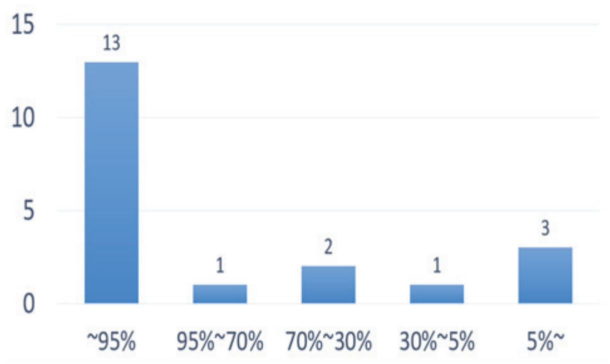

Fig. 2 Available frame rate

5 DISCUSSION

We inferred that participants' clothing had a substantial impact on the available frame rate. All participants with 0% available frame rate were females wearing skirts. While the system computes positions of joints by analyzing the human shape, if the shape becomes unclear the system cannot work well. Clothing like a skirt breaks the human shape, becoming an obstacle for our system. Two participants with poor results were also wearing short pants, while all the participants with the over 95% available frame rate were wearing long pants. Therefore, we consider that long pants are more suitable when using our system, and that if trainees are wearing suitable clothing, the motion capture part of the system performs well.

In this study, we focused on whether the Nuitruck SDK with the Intel® could capture a trainee's motion with an acceptable miss rate. The results showed that under certain conditions, the system worked well enough to analyze the posture or motion of trainees. We also discovered that trainees should avoid wearing skirts, short pants, or other forms of clothing that break the features and shape of the body. Moreover, in this experiment we found out that when more than one person appeared in the field, the system produced a poor result. During home use, there are often other people in the background and a trainee may sometimes wear casual or sports clothes to do gymnastics. Therefore, we will continue to work on solving these problems.

6 CONCLUSIONS

While an elderly person can now practice gymnastics with television instruction at home, we propose a more detailed and personalized system that can teach trainees gymnastics through the use of a humanoid robot. In the present study, we used a new type of depth camera to support this function and tested its success. Our device is easier to install than those used in other systems and can work with a smaller camera. We hope to develop a system to improve gymnastics performance that is fun, gentle, easy to use, and safe for the elderly.

Acknowledgment

Part of this work was supported by JSPS KAKENHI Grant Number 19K12902.

REFERENCES

[1] Japan Ministry of Internal Affairs and Communications Statistics Bureau, population estimation, http://www.stat.go.jp/data/jinsui/pdf/201811.pdf

[2] Intel RealSense stereo-depth camera, https://www.intelrealsense.com/stereo-depth/

[3] 3D BODY (SKELETAL) TRACKING MIDDLE-WARE NUITRACK SDK, https://nuitrack.com/#rec247 57506

[4] Yuki Tayama, Misaki Hagino, Ken-ichi Okada: Remote Pose Instruction Support System Using a Humanoid Input Device, DCON, 1, 1-9, 2015