A New Athlete Performance Analysis Method Using 4K Video and Wireless Eye Movement Measurement Device

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ABSTRACT

It is thought that analyzing line-of-sight movement during sports may provide insight into exceptional athletic skill. In this study, we propose a method to analyze the athlete's performance using the athlete's line of sight measured by a wireless eye movement measurement device, and his/her movement taken by 4K images.

1 INTRODUCTION

Because of the upcoming 2020 Tokyo Olympic and Paralympic Games, sports science research is actively being conducted. [1-4] Many conventional eye movement measurement devices are large and difficult to use outside the laboratory. [5-7] For this reason, most research on eye movement during sports involve showing the subject a video of a competition and measuring his/her eye movement. In an experiment by Kikumasa et al., the subjects were asked to watch a video of a baseball catcher instructing play, and eye movement was measured.[3] Kikumasa's results confirmed the following three points: (1) the catcher makes an excellent judgments of the situation compared to fielders and inexperienced ball players; (2) baseball players have a judgment strategy to avoid scenarios with a high possibility of losing; and (3) the catcher pays attention to the ball at the time of its impact with the bat, and points to a player, such as the pitcher or a runner, when making a judgment.

A wireless device is indispensable to measure gaze during competition. It has been said that analyzing eye movements during sports may provide insight into superior motor skills. Additionally, in the case of athletes who exercise vigorously, the calibration of the device may shift during the experiment. It would therefore be ideal for the experimenter to be able to remotely control the device during measurement. Prior to the present study, however, to the best of our knowledge, there was no wirelessly controlled eye movement measurement device that could be worn by an athlete during sports. We recently developed a wireless eye movement measurement device. [8] Here, we describe our analysis method and present an example of how an athlete's performance can be analyzed by measuring line of sight using our wireless measurement device and 4K video.

2 EXPERIMENT

In the present study, we focused on the eye movement of a dancer while rotating. The experiment was conducted at our 4K studio. In this experiment, we asked an expert dancer to wear the measuring device and rotate at high speed in front of four cameras. A person wearing the device is shown in Fig.1. Fig.2 shows the operation screens displayed on the external display. The experimental set-up is shown in Fig.3 and Fig.4. An athlete's movement may not be fully confirmed solely by field of view camera images from the wireless eye movement measurement device. However, by taking video of the performance with different cameras, it is possible to correlate eye movements and performance. For this reason, the dancer in the present experiment not only wore the wireless eye movement measurement device, but also was filmed from the front, left, right, and top (Fig .5).

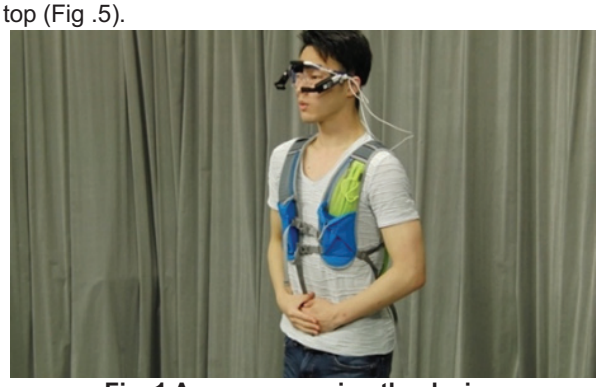

Fig. 1 A person wearing the device

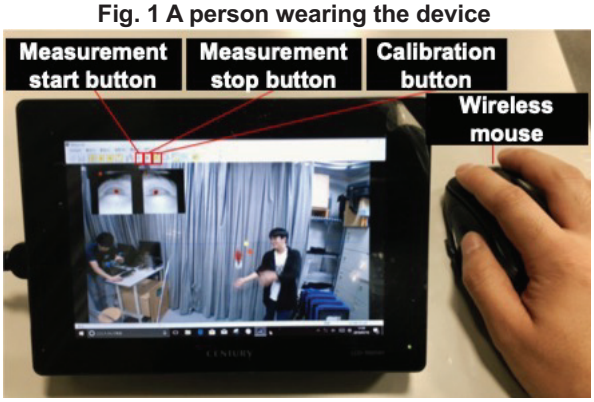

Fig. 2 The operation screen to be displayed on the external display

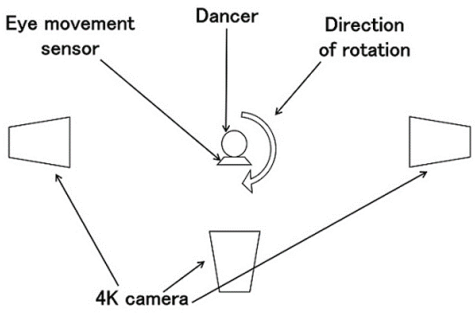

Fig. 3 Arrangement of devices during the experiment, top view

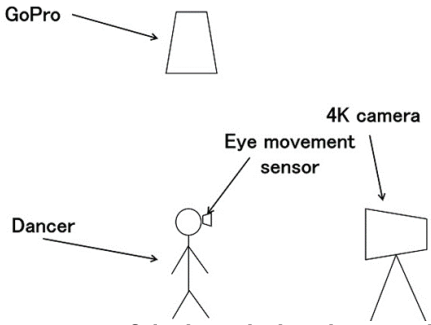

Fig. 4 Arrangement of devices during the experiment, side view

Fig. 5 Experimental set-up

3 RESULTS AND DISCUSSION

The video was edited after the experiment for analysis. Fig.6 shows an example of the edited video. Since editing is performed at 4K resolution, each wipe maintains high resolution. Fig.7 and Fig.8 show the rotation of the dancer from the top and front, respectively. Note that the direction of the head is clear and easy to understand. The pictures were taken at every 45° of body rotation angle. The yellow arrows in Fig.7 indicate the direction of the dancer's line of sight, as measured by the wireless eye movement measurement device. Fig.9 shows the rotation angles of the right eye, head, and body, and Fig.10 shows their rotation angle velocities; in both figures, the horizontal axis represents the video frames captured by the wireless eye movement measurement device, and the figure below the horizontal axis shows the head, body, and line of sight. The numbers correspond to those in Fig.7 and Fig.8. At the time of frames ⑤ and ⑥, the dancer blinked his eyes, and we were therefore unable to acquire line-of-sight data.

In Fig.7 and Fig.8, the dancer is looking forward at ①-③, but he turns his head suddenly after the rotational angle of the body exceeds 90° (③) and looks forward again when the rotational angle of the body reaches 225° (⑥) to 270° (⑦). As shown in Fig.9, the body rotates at a roughly constant speed, while the head begins rotating rapidly at the 9th frame, overtaking the body at the 12th frame. It can be seen from Fig.10 that the angular velocity of the head at this time exceeds 1900 deg/sec. In addition, Fig.9 shows that the right eye was turned to the left until the head was rotated, at which point it turned greatly to the right after blinking (⑦). This is thought to be because the subject tried to keep his eyes on the front camera while rotating, and indeed, responding to a post-experiment question, stated that he was aware that he was looking at the front camera. Generally, when a person is spun on a rotating chair, the vestibulo-ocular reflex (VOR) is activated and dizziness may occur. However, it is known that dancers can maintain a stable posture without dizziness by gazing at a certain point while rotating; [9-11] the results of the present study support this idea.

Fig. 6 Video output after editing

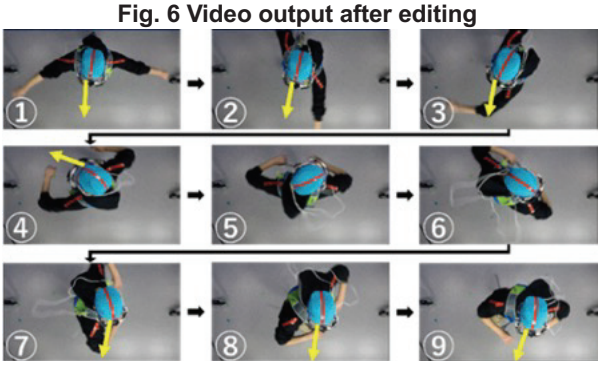

Fig. 7 View from the top

Fig. 8 View from the top

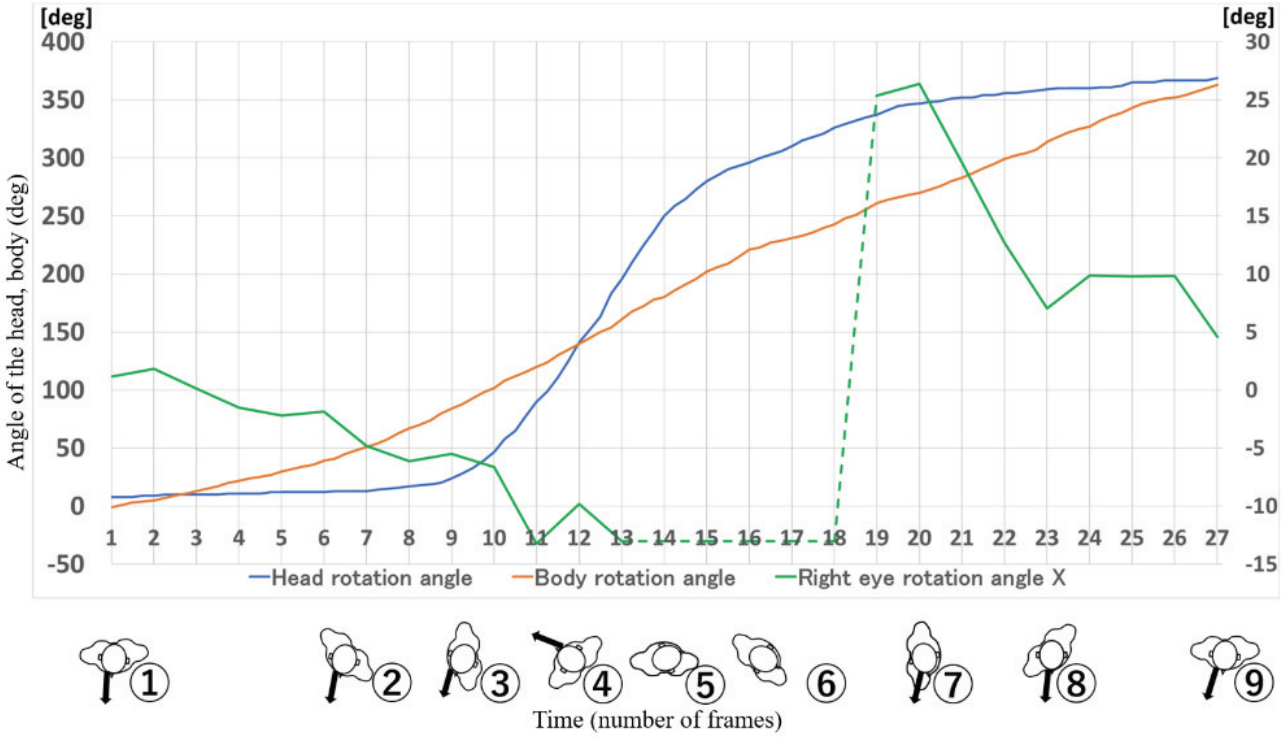

Fig. 9 Angles of gaze, head, body

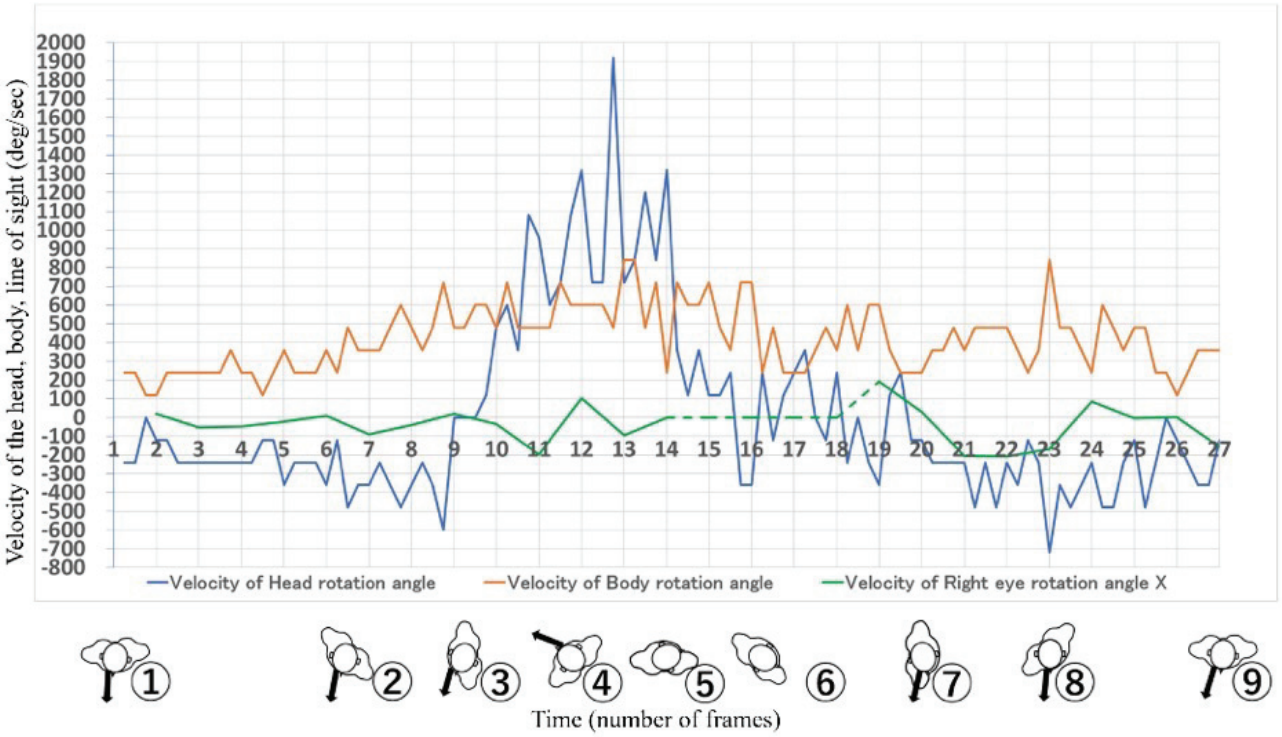

Fig. 10 Velocity of gaze, head, and body rotation angles

4 CONCLUSION

Research on sports science is actively being conducted in preparation for the 2020 Tokyo Olympic and Paralympic Games. Most previous studies on eye movement in sports present the subject with a video of sports performance and measure eye movement while the subject watches it.[2-3] There have been few studies that measure line of sight during competition. We believe that being able to measure eye movements in sports that involve intense exercise such as gymnastics will help to elucidate the superior performance of athletes. However, if the movement is excessively strong, the video may be interrupted. It is therefore difficult to measure eye movement in performances that involve rotation, such as dance, and a wireless device is essential.

In the present study, even if the dancer was rotating at high speed, our wireless eye movement measurement device made it possible to acquire eye movement during rotation without interrupting the image. Additionally, by using our proposed method of editing the 4K video, which compiled the measured line of sight and the high-resolution videos taken from four shooting positions, the fact that the dancer keeps watching a single point while rotating was confirmed for the first time. Furthermore, the relationships among the line of sight, head, and torso were clarified, and it was shown that dancers turn their heads at a speed exceeding 1900 deg/sec during rotation. An expert dancer can use these motions to suppress the VOR and rotate without dizziness. Previous research on dance has reported on the line of sight of a viewer watching a video of dance, [4] but to the best of our knowledge, there has been no previous measurement or analysis of the line of sight of an expert dancer while rotating. The present measurement results are therefore very valuable. In the future, we will use this method to measure and analyze other sports events in order to elucidate the excellent performance of superior athletes.

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