TRAJECTORY STUDY OF BALLROOM DANCE USING MILLISECOND VIDEO ANALYSIS

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A short video (3 s) of the natural turn movements of ballroom dance was analyzed using two-dimensional trajectory analysis to demonstrate precise verification of the movement. The movements were recorded with a high-speed camera (240 Hz), and the trajectory was plotted at 4 ms intervals. The precise trajectories of test subjects' movements were successfully monitored by making them wear LED lights on their necks, elbows, waists, and knees. The differences between the trajectories of an experienced subject's movement and that of a beginner were clearly indicated, even when those movements occurred over short durations. The differences were also evident from a velocity analysis of the same video data. Our low-cost method can be applied to ballroom dance education, even in a personal dance studio.

KEYWORDS: natural turn, velocity, centroid mode.

INTRODUCTION: Innovations in computer and digital camera technology have resulted in breakthroughs in sports education. Qualitative analysis of movement task in sports can be achieved with using digital video camera to analyze the quality of movement and/or technique (Chueh-Wei and Suh-Yin, 1997; Bebie & Bieri, 2000; Xinguo et al., 2009; Ricardo et al., 2010). In particular, trajectory analysis has been applied to various sports (Theobalt et al., 2004; Yu et al., 2006; Graham, 2007; Chen et al., 2008; Ren et al., 2009). When considering applying video analysis methods to various sports, there are at least two different approaches that can be taken. One approach is to seek out the best instrumentation, even though it increases the cost and time required, while another is to establish a convenient approach that can be applied without special instrumentation such as an exclusive studio for video recording. In the latter case, the resultant low-cost method such as the use of a compact video camera can be applied even for personal training at home.
Ballroom dancing has a long history, beginning in the 12th century. It is a popular sport that is adopted in an official event of the World Games that is supported by the Olympic committee. Especially, in Japan, dancing became a required subject even at junior high schools in 2012. Considering the above mentioned popularity of ballroom dance, it is obvious that applying the video analysis to ballroom dancing field is an important research subject. We think that movement techniques of ballroom dance can be assessed using a digital camera to conduct a simple two-dimensional (2D) video analysis (Murase et al., 2011). Nevertheless, although ballroom dance is a major sport, no previous research applying video trajectory analysis to ballroom dance was found in the Web of Science. With ballroom dance supported by many small dance studios, applying video analysis across many dance studios may provide a convenient and low-cost approach to analyze movement technique. Therefore, the purpose of this study was to establish a simple method of verifying basic movement of ballroom dance, natural turn, using a digital video camera and a personal computer. The method can be demonstrated even at a small dance studio and a junior high school.

METHODS: Two male ballroom dances with 2 (Amateur standard C) and 7 (Professional Standard C) years experience of ballroom dance were recruited. Each participant performed a five trials of a natural turn, which was recorded at 240 Hz using a digital camera (EXILIM EX-FH25, CASIO Co., Tokyo, Japan).Figure 1 shows an overview of the experiments. The subject demonstrated a natural turn movement from their left to right side. The period of the movement was 2.5 to 3 s. A camera was located at the center of the opposite side of the room. The height of the camera was 110 cm from the base. The shutter speed of the camera was 1/240 s per frame, so very minute movement could be monitored.

Light emitting diodes (LED) places (GENTOS LED HELP LIGHT, HC-12SL, SAINT GENTLEMAN Co. Ltd., Tokyo, Japan) on each participants their fifth cervical vertebra (neck), olecranon (elbow), fifth lumber vertebra (waist), and knee cap (knee). The illumination from the LED lights was very effective, enabling the calculation of the exact positions of the neck, elbow, waist, and knee, using 2D video analysis software. Precise analysis was not easy to achieve without the LED lights (data not shown). To determine the position of each LED using the software, first, the target LED was centered in a small square grid on a computer display. The LED and surrounding area were then separated via binarization. Then, the centroid of the LED was calculated using the software. Finally, the positions of the neck, elbow, waist, and knee were plotted over time, as trajectories. The trajectory clearly traced the movement of every part of the subjects. Further, the positions of the neck, elbow, waist, and knee were connected by lines.

Two-dimensional kinematic analysis was performed with Move-tr/2D 7.0 (Library Co., Tokyo, Japan). Position of LED lamps were automatically determined by the software, and trajectory of each lamp was drawn using the position data. Further, velocity of each lamp was calculated with position data.

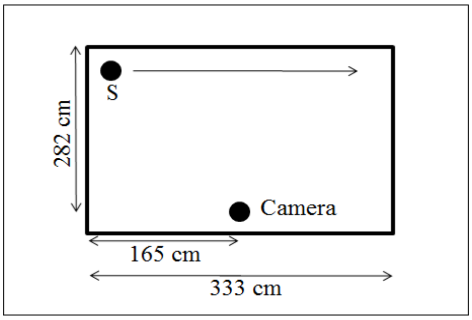

Figure 1: Overview of the experiments. S indicates the test subject.

RESULTS AND DISCUSSION: Figure 2 show a series of images that were extracted from the video data, which was an accumulation of many still images. The upper and bottom series show subject 1 (the professional license) and subject 2 (the amateur license), respectively. Subjects' necks, elbows, waists, and knees were well illuminated by LED lights, as indicated by the arrows in Figure 2(a). The LED lights were small, cheap, and not heavy.

At the start point (Figure 2(a) and (d)), subjects 1 and 2 stood at almost same position. However, at the middle point (Figure 2(b) and (e)), a clear difference appeared between the two subjects. In the case of subject 1, his elbow appeared ahead of his knee. On the other hand, subject 1's elbow was behind his knee. Finally, at the end point, the line which links neck and knee of subject 1 was almost vertical (Figure 2 (c)). However, that of subject 2 was inclined to the left.

Distance between neck and elbow shows another difference between subject 1 and 2. In the case of subject 1, the distance was rather short, and was not constant. In the case of subject 2, it was long, and was almost constant. It suggests that the use of arm was different between subjects 1 and 2.

When we repeated the similar analysis using five individual data recordings, the difference was repeatedly emerged (data not shown). This result revealed that our trajectory analysis could visualize the precise movement of each subject, and each that subject has his own style. When we repeated similar experiments one month later, the style differences were still reproduced. This suggests that such minute habits are not easy to change. Our analysis is probably applicable for educating ballroom dancers about precise movements.

Figure 3 shows the change in the velocities of subjects' necks and waists over time. In the movement of subject 1's neck there were two peaks, while there was only one peak in the movement of subject 2's neck, as indicated by the arrows in Figs. 3(a) and (c). In the movement of the subjects' waists, there were three peaks for both. In general, subject 1's peaks were much clearer than those of subject 2. The clear ups and downs of the velocity probably reflected the accent of the dance. Therefore, we think that subject 1 exhibited sharp movement, even when those movements were short in duration. High reproducibility of these findings was confirmed for this analysis.

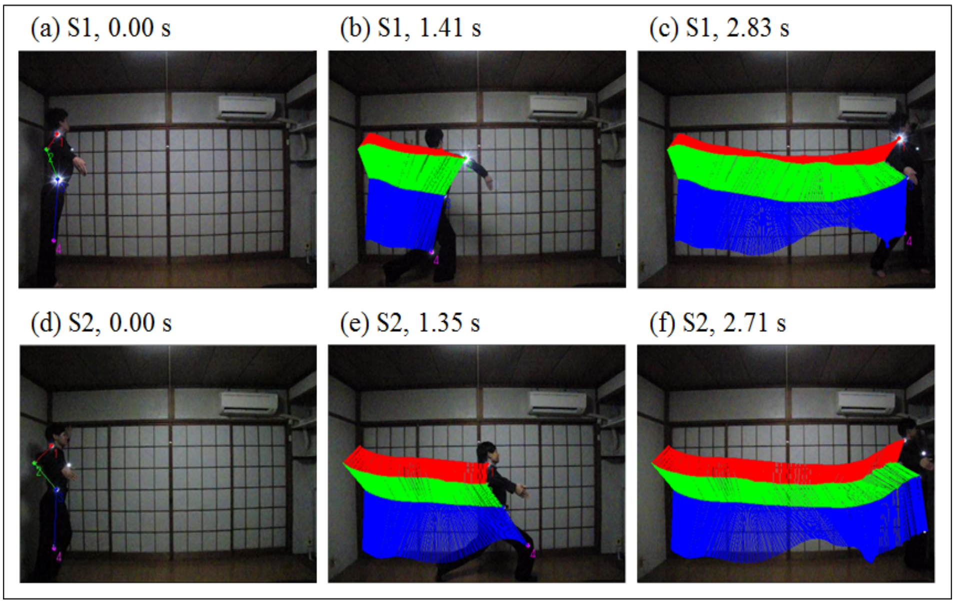

Figure 2: A series of snap shots from the trajectory analysis. (a) to (c) and (d) to (f) show subject 1 (professional license) and subject 2 (amateur license). The neck, elbow, waist, and knee of each subject were illuminated by small LED lights. The position of each LED was drawn as a trajectory. Further, the positions of the neck, elbow, waist, and knee were connected by lines.

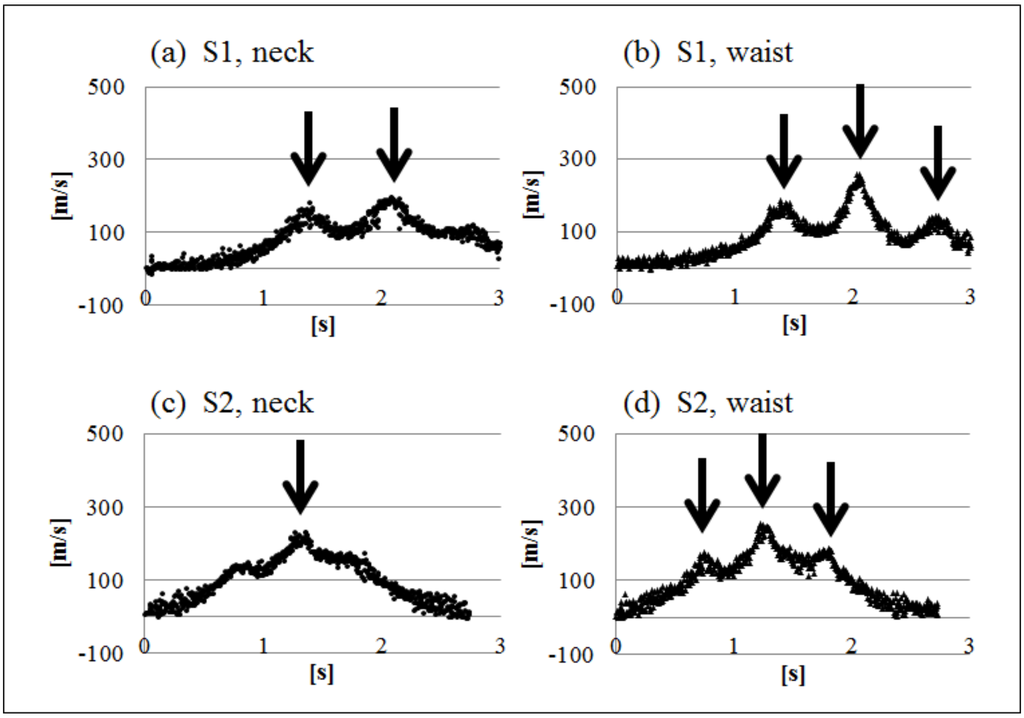

Figure 3: Change in velocity over time. Velocity was calculated using the same video data that was used in Figure 2.

CONCLUSION: We succeeded in visualizing the minute differences between the movements of two subjects who respectively held professional and amateur ballroom dance licenses. Using a high-speed camera, the characteristic style of each subject could be monitored as a trajectory, even for short-period movement. By this way, minute fluctuation of the movement can be easily verified. It is applicable for training of professional ballroom dancers who is required accurate tracing. In addition, visual analysis may be attractive to educate young dancers even at a junior high school.

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Acknowledgement: We thank to Mr. Niinuma Issei for participating in our experiments as subject 1.