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Short Paper

Anaglyph Stereo Visualization of Rhythmical Movements

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1. Introduction

Rhythmical movements are usually evaluated from planar images using an analog video system. They reproduce the temporal and spatial variations of the flow of movements, but some information, such as the dynamics, reality and artistic impression, are lost due to the planar nature of the images. By contrast, three-dimensional (3D) visualization using anaglyph stereo images has evoked interest in imaging science due to the simplicity and low cost (Glen, 1985; Ideses and Yaroslavsky, 2005), and has been widely used for the general 3D visualization purposes including the application to the visualization of art (ex. Nakayama et al., 2004; Hertzberg, 2005; Takizawa et al., 2005; Fujisawa et al., 2007). However, such stereo images have not been introduced into the evaluation of the performance of gymnasts undergoing rhythmical movements, in spite of the potential interests in the application.

The purpose of this paper, therefore, is to compare the impressions of planar images and anaglyph stereo images undergoing rhythmical movements using the factor analysis.

2. Experimental Methods

The present stereo imaging system consists of two color CCD cameras (759 x 494 pixels, 8 bits, 30 frames/s), a personal computer with frame grabber and a monitor. Two CCD cameras were placed side by side over the gymnasium floor with a horizontal spacing equivalent to human eyes ($\approx$64 mm). The anaglyph images are generated from two captured images with a minor manual adjustment. The planar images of the same movement can be obtained from one of the stereo images. Examples of anaglyph stereo image in jump-turn motion are shown in Fig. 1. The depth information of the anaglyph stereo image can be seen through red-cyan glasses.

Ten typical snapshots were selected from the rhythmical movements. These movements were body wave motion (M1), side-step motion (M2), jump-turn motion (M3 ~ M7), and horizontal movement (M8 ~ M10). The subjects in this study were 51 PE students who took gymnastic class. Of these students, 26 evaluated the anaglyph stereo images and 25 evaluated the planar images. The

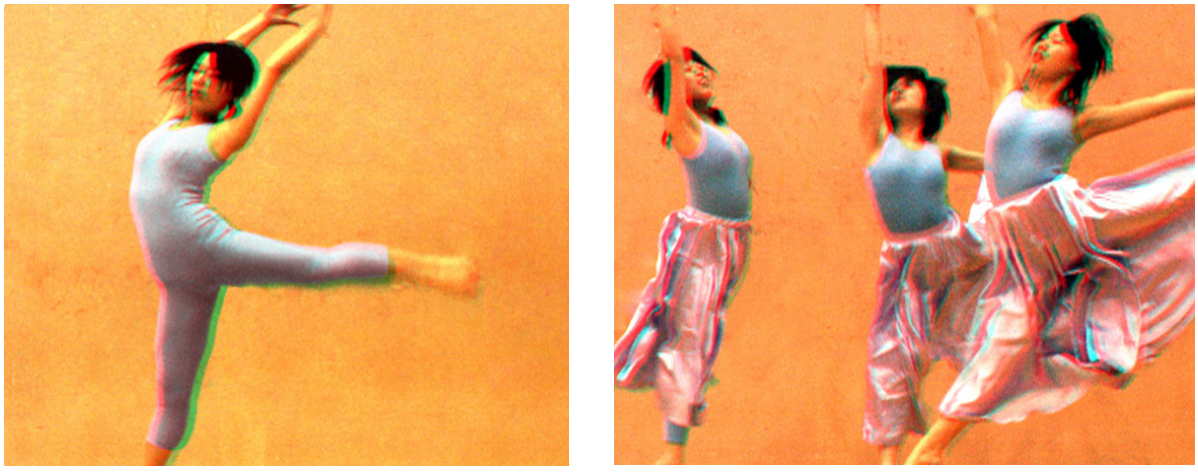

Fig. 1. Examples of anaglyph stereo image in jump-turn motion.

25-item questionnaire was designed with reference to the aspects of movement in gymnastics (Sakashita and Izaki, 2001). Responses were scored on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree).

3. Results and Discussion

Principal-components factor analysis followed by Promax rotation were conducted on the responses to the questionnaire. Then, the differences in impressions between anaglyph stereo images and planar images were analyzed using a t-test, which assesses whether the means of two groups are statistically different from each other. There are seven major factors to be analyzed from the point of view of gymnastics. The factor of stretching (F1) reflected aspects of the stretching movement. The factor of dynamics (F2) is the item of intensity, forcefulness and liveliness. Movement anticipation (F3) reflected aspects of movement, flow and impulse transmission. The factors 4 to 7 (F4 ~ F7) were relaxation, balance, bodyline and natural movement, respectively. The results of analysis are summarized in Table 1. Note that the differences are evaluated from the p-value, showing the probability of significant differences in the hypothesis. When the p-value is smaller than 0.05, the hypothesis is considered true. For example, the statement "M4 Anaglyph > Plane (0.006)" in the Table 1 means that the anaglyph image of Movement 4 is better recognized than the planar image with a p-value of 0.006.

Significant differences between the impressions of anaglyph stereo images and planar images were found for seven items in the jump-turn motion (M4), four of which were in F1. It is noteworthy that M4 was the complex movement to predict the depth of information by planar images. This result indicates that the sensuous and aesthetic aspects of stretching were better recognized by the anaglyph stereo images than by the planar images. In F2, anaglyph stereo images were evaluated more highly than planar images, as shown in M7 and M8. Note that these postures were rather simple compared with M4. Thus, the stereo images revealed the impression of intensity and forcefulness. On the other hand, anaglyph stereo images were lower evaluated than planar images (M3, M7) on F4. It is considered that the loss of depth information in the planar images reveals the weakness of the motion, which may be considered as the relaxation of movements. In F5, anaglyph stereo images were evaluated more highly than planar images (M3, M6) in the item "To see the direction of the knees". Although it was difficult to understand the directions of body parts on the jump-turn motion (M6), the depth information of the anaglyph stereo images helped the interpretation of the movement. These results indicate that the anaglyph stereo images provide effective tool for evaluating the rhythmical movements.

Table 1. Factor analysis and significant differences in impression.

Factor	Item	Significant differences (p-value)	
F1	Stretching movement	M4 Anaglyph>Plane (0.006)	
	Pliability of movement	M4 Anaglyph>Plane (0.046)	
	Total body movement	M4 Anaglyph>Plane (0.039)	
	Curve in the body	M4 Anaglyph>Plane (0.016)	
F2	Feeling the intensity of the movement	M7 Anaglyph>Plane (0.005)	
	Feeling the force of the movement	M8 Anaglyph>Plane (0.048)	
F3	Interpreting the movement	M2 Anaglyph>Plane (0.033)	
F4	To relax		M3 Anaglyph<Plane (0.025)
	Not to strain at the shoulders	M4 Anaglyph>Plane (0.016)	M7 Anaglyph<Plane (0.048)
F5	To see the direction of the knees	M3 Anaglyph>Plane (0.025)	
		M6 Anaglyph>Plane (0.027)	
	To see the direction of the face		M10 Anaglyph<Plane (0.035)
F6	To see the body lines	M4 Anaglyph>Plane (0.040)	
F7	To feel the stability of the movement	M4 Anaglyph>Plane (0.005)	

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