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Automatic Generation of Visual Effects from Movement of Athletes in Sports Videos

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Abstract

Sports broadcasts can be made more entertaining by adding visual effects. Currently, such effect animations are added manually in a real-time or post process. Or many cases require depth information. Here, we automatically add visual effects to sports videos by extracting optical flow and automatically adjusting the brightness of regions that include athletes. The proposed method can be used to easily and quickly add effects to make sports broadcasts more enjoyable without depth information.

1. Introduction

There are some attempts to bring out the appeal of sports through digital media and to extend sports viewing as entertainment. For example, there is a virtual baseball stadium that participants can access their own avatars and enjoy watching a baseball game from the ground [1], or visual and sound effects are added to a sumo match video, and the audience watches it in the venue or on the internet [2].

There are also many examples of the use of digital technology to visualize information in order to convey game information to viewers of sports video in an easy-to-understand manner. For example, real-time display of the speed and trajectory of a ball in ball games, play analysis by tracking players [3][4], and real-time display of player names and swimming speed in swimming races [5]. However, these examples require equipments such as multiple cameras or data sets for machine learning to estimate the posture of the players. Our research does not require any depth sensors and prior data. CG for displaying information is popular in sports videos in TV, but there are few attempts to add effect animations automatically for sports videos. Using simple sports videos as input, we aim to add entertainment to sports videos by automatically adding visual effects that match the movements of the players.

2. Related Works

The addition of effects to videos of dance and other performing arts by capturing human motion in real time has received increasing attention [6,7,8,9,10]. In such works of dance performances, motion capture devices are applied, which is different from our method. In addition, in dance enhancement, feedback is often given to the actual space by projection mapping in real-time. However, since our method synthesizes effects to the input video, we need detailed brightness adjustment of the entire frame. Our user also can edit effect animations.

For sports, the Fencing Visualized project [11] attempts to make fencing, for which the rules are complicated and where movement is fast, easy to understand and enjoy for casual viewers. The movements of the

Figure 1. Results of generating effects using proposed method for videos of figure skating and gymnastics events.

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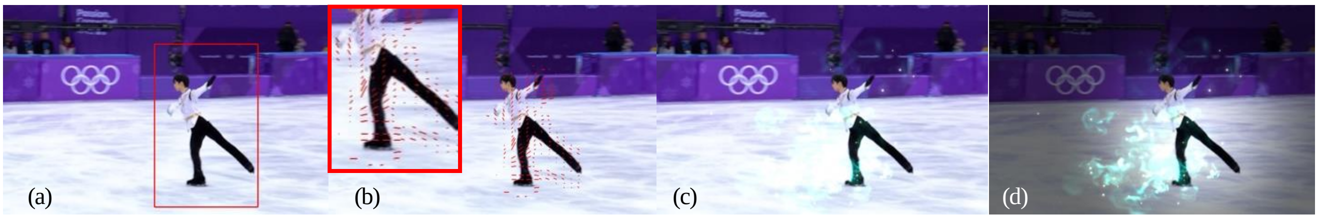

Figure 2. Results of generating effects using proposed method for videos of figure skating and gymnastics events.

sword tip and athletes as well as athlete eye movement, step force, and heart rate are visualized. In SONY's Sports & AI project [12], which visualizes the trajectory and rotation of a ball and athlete movements in a table tennis match, pose estimation and high-speed vision sensors with object recognition and tracking functions are applied to perform real-time analyses of ball and athlete movements. The above projects and similar studies require the installation of sensors and the acquisition of three-dimensional information. Few studies have considered using the two-dimensional information in videos. In addition, previous studies require huge datasets for deep learning and the use of high-speed cameras. Here, we aim to enhance sports entertainment by automatically adding visual effects to athletes using only sports videos as input (Fig. 1).

3. Our Method

Our method takes a sports video as input (Fig. 2a) and outputs a video with added visual effects. The following process is repeated for each frame. First, we obtain the optical flow of the input video image (Fig. 2b). Then, visual effects are generated based on the optical flow (Fig. 2c). Finally, brightness is adjusted to highlight the athlete and the visual effects (Fig. 2d).

Our input video is not restricted to specific sports but should not involve multiple athletes crossing each other. So, basically our targets are single-athlete videos. Also, the target athletes should be successive in terms of the time and space between frames of the videos because we apply the optical flow. In our assumption, only athletes are tracked, excluding tools such as balls.

3.1 Selection of Optical Flow

Our method extracts the optical flow only around the athlete from the input sports video. It is assumed that the optical flow in the background part of the video is similar. First, a rectangular region that contains the athlete in the frame is manually selected at frame $t = 0$ (such as in the red rectangle in Fig. 2a). After $t = 0$, the optical flows and those angles of the video frames are calculated (Fig. 3a). Angles that occur frequently are assumed to be caused by camera movement during shooting. Our method generates an angle histogram of the optical flows every frame to detect the optical flows in the background. More than five optical flows with a same angle are considered to be part of the background. (Fig. 3a, white lines). The athlete region is tracked using the Channel and Spatial Reliability Tracker (CSRT) method [13]. The remaining optical flows (Fig. 3a, b, red lines) outside the human region are excluded (Fig. 3c). CSRT uses a discriminative correlation filter with a channel and spatial reliability map. The map represents the probability that a region is the target region through segmentation.

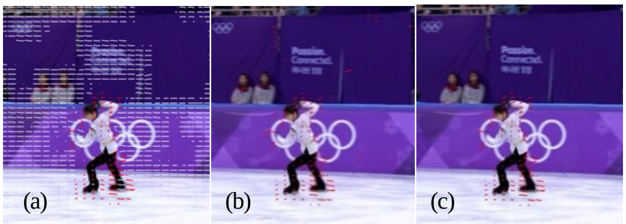

Figure 3. Process of selecting the optical flow of target area.

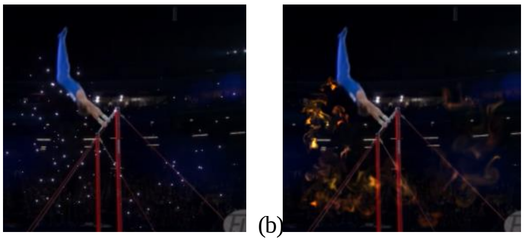

Figure 4. Visual effects. (a) Particle effect and (b) fluid effect.

3.2 Generation of Effects

In this study, we generate two types of visual effect, namely particle and fluid effects. The visual effects are generated by calculating the magnitude and angle of the optical flow of the obtained target region for each frame and applying an external force to particles or a fluid on the basis of the results.

For the particle effect, one particle is generated at each position of the optical flow whose magnitude is in the top m in each frame (Fig. 4a). The optical flow is then scaled to be in a range of 1 to p, which is a constant. Those vectors are given to these generated particles as the initial velocities. Scaling is performed to prevent particles from dissipating as a result of extremely large optical flows. They are updated by adding their velocities for each frame. The velocity is reduced by air drag. A particle disappears when its velocity drops below a certain threshold.

For the generation of the fluid effect, we use fluid simulation of Jos Stam's Stable Fluids method [14]. The fluid particles are added at each optical flow whose magnitude is in the top n and it is larger than the threshold (Fig. 4b). The magnitude of the optical flow is multiplied by

Table 1: Values used to generate result images.

Result image (Fig. 4)		(a)	(b)	(c)
Particle effect	Number of particles *m*	3	5	5
	Maximum value of optical flow *p*	1	1	1
	Hue (0~360)	60~100	320~360	240~280
	Saturation (0~1)	0.3	0.5	0.3
Fluid effect	Number of fluids *n*	3	3	4
	Optical flow magnitude factor *q*	150	150	150
	Hue (0~360)	155~175	248~268	15~35
Lightness average threshold *V*		80	50	20

the constant *q* and the value is added to the fluid as the external force.

The values of *m*, *n*, *p*, and *q*, the size of the particles and fluid, the hue, and the saturation are given by the user to adjust the amount, speed, and color of the visual effects. The hue takes a random value in the range of the specified values. See the appendix for the values used to generate our results.

3.3 Automatic Color Adjustment

To enhance the effects, we adjust the saturation and brightness of the input video (Fig. 2d). In each frame, the average brightness value $\bar{v}$ of the input video is first calculated. If $\bar{v}$ is larger than the threshold value V specified by the user, the brightness of each pixel is transformed so that $\bar{v} = V$. The radius of the circumscribed circle of the tracking rectangle area at frame t is denoted as r_t, the distance between pixel i and the center of the rectangular area is denoted as c_i, and the brightness of pixel i before and after the conversion is denoted as v_i and v_i', respectively. The brightness v_i is calculated as follows.

$$v_i' = \begin{cases} v_i \left\{ \frac{1}{2}\left(1 - \frac{V}{\bar{v}}\right) \cos \frac{\pi c_i}{r_t} + \frac{1}{2}\left(1 + \frac{V}{\bar{v}}\right) \right\}, & c_i \leq r_t \\ v_i \frac{V}{\bar{v}}, & c_i > r_t \end{cases}$$

In this way, the brightness becomes gradually reduced as the distance from the position of pixel i to the center of the rectangle increases (Fig. 3c). In addition, by correlating the average value of the brightness within the rectangular region with the transparency of the particles and the brightness of the fluid, the brightness of the effect and the person is adjusted.

4. Results

To confirm the effect of the added visual effects, we conducted experiments using videos of gymnastics (floor and horizontal bar) and figure skating as inputs (Fig. 5). These videos included a single athlete. The video of the horizontal bar routine was filmed with a fixed camera, whereas those of the floor routine and figure skating were filmed with a moving camera. We added particle and fluid effects by our method. The resulting images confirmed that the visual effects were generated in accordance with the movements of the athletes. The visual effects enhanced the movements of the athletes, adding power and flair.

In addition, by changing the parameters as shown in Table 1 during video playback, we were able to easily add effects to create the desired look. It takes about 2~3 minutes for users to specify the athlete by a rectangle and adjust those parameters.

Our experiments using videos including more than one athlete were successful despite our system focuses on a single athlete. Sometimes, the visual effects were not generated, or the brightness was not adjusted in the proper region because of failed tracking of the target area when the camera was switched or when the athlete was moving quickly in the frame.

In the future, we would like to conduct user experiments to verify the ease of adding effects and increase the number of effect types so that users can generate effects of their choice. Also, we would like to verify the which sports we can apply our method. To consider tools such as balls in some sports, we should consider how to deal with them apart from the athletes. Our method may also be used for dancing and other activities.

5. Conclusion

In this paper, we proposed a video expression by automatically adding effects to match the movements of players in sports videos. Our system enables to adjust effect appearances by few parameters and enhance the athlete by partial brightness control. Other than visualization purpose, there was little research on automatic effect generation for simple sports videos for entertainment. Our results show the usefulness for some sports scene.

Acknowledgements

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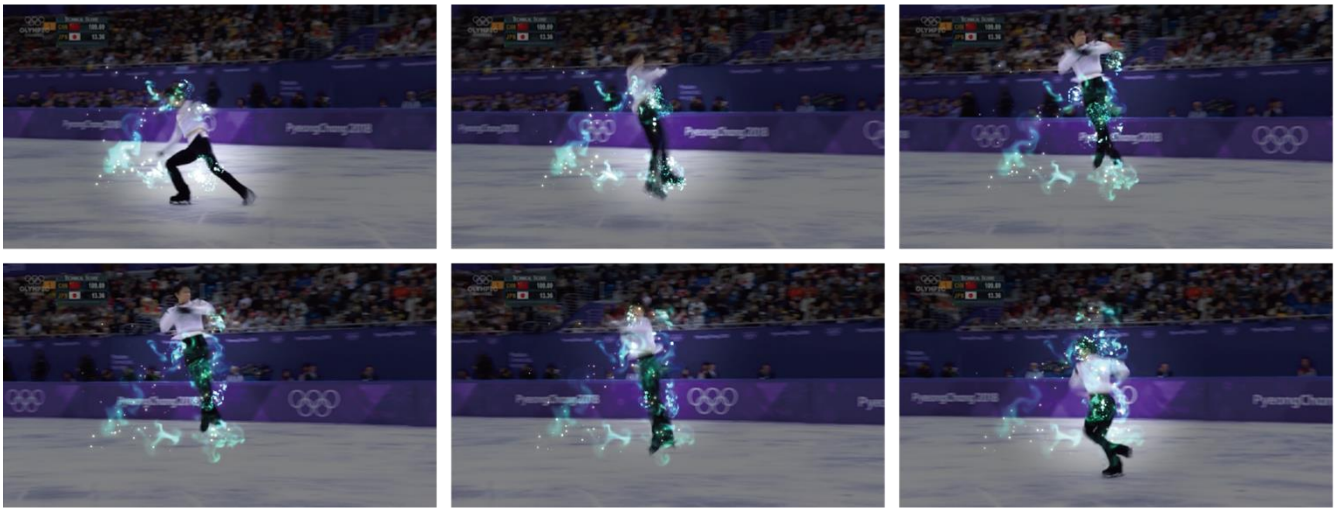
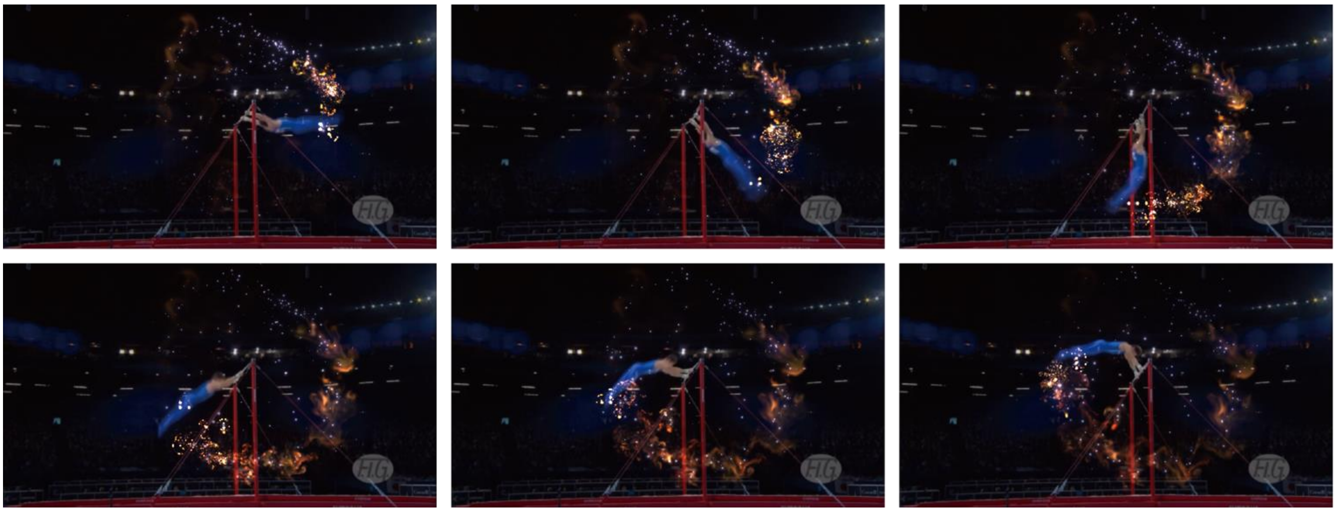


(a) Results of adding effects to a figure skating video.

(b) Results of adding effects to a gymnastics (floor) video.



(c) Results of adding effects to a gymnastics (bar).

Figure 5. Results of adding effects to sports videos using our method.