3—22 Optimized Camera Viewpoint Determination System for Soccer Game Broadcasting

Keisuke Matsumoto Satoshi Sudo Hideo Saito Shinji Ozawa
Department of Information and Computer Science
Keio University *

Abstract

In this paper, a new method for determining an optimized camera viewpoint for soccer scene by tracking a ball is proposed. Soccer scene is taken by multiple fixed cameras. First, template matching is implemented for images taken with each camera to detect and to track a ball. If the ball is occluded in one of images, the ball is tracked by using the position of the extracted ball in other camera. After the detection of the ball is done for all images, information of each ball position are integrated by using the geometrical relationship between cameras that is represented by Fundamental Matrix. For determining the optimized camera viewpoint, we define an evaluation function of camera selection based on the trajectory of the ball. The system selects camera viewpoint of each frame automatically by finding the camera that gives maximum evaluation of camera selection. Experimental results demonstrate that the optimized viewpoint is successfully selected for soccer scene by using the proposed system.

1 Introduction

Recently, soccer is the most popular sport in all over the world and has been broadcasted abundantly. Broadcast stations try to come up with various means of satisfying a televiewer for a soccer relay program. For example, broadcast using the video sequences taken from various angles, the slow motion sequences and CG is performed. However, since the viewpoint change of a camera is usually performed manually, the important scene might be overlooked by the mistake of a viewpoint decision. The viewpoint decision also tends to become subjectivity of the broadcaster.

In this situation, researches using moving image processing about soccer relay program have been developed. For example, an intelligent robot camera system is introduced for automatic camera control so that the players and the ball can be captured in a single camera[1].

Moreover, there are many reports about moving image processing for soccer scene[2][3]. In those researches, the main purpose of their reports is tracking or motion analysis of players and a ball for soccer scene taken by one camera mainly.

Meanwhile, the technique of determining the optimized camera that is suitable for the soccer scene and changing a camera viewpoint automatically is hardly studied. In the most of actual broadcasting, a number of cameras are used for capturing images of various viewpoints. One camera image is selected for sending the game progress effectively. The selection of viewpoint is also manual, but automatic selection is required for reducing the broadcasting cost.

In this paper, we propose a new method for automatic viewpoint decision from multiple-view video sequences of soccer scene. For determining the viewpoint, the ball is simultaneously tracked in every viewpoint image sequence. For tracking the ball occluded by the players, the ball position tracked in other cameras is transformed into the occluded ball position with the epipolar geometry between cameras represented by F-Matrices. The viewpoint is decided according to the ball trajectory tracked in the cameras.

2 System Environment

Soccer scene is taken by four fixed cameras installed 2 every sets each for both the sides of a ground. Cameras are aimed at the penalty area which needs to determine an optimized viewpoint as shown in Fig. 1.

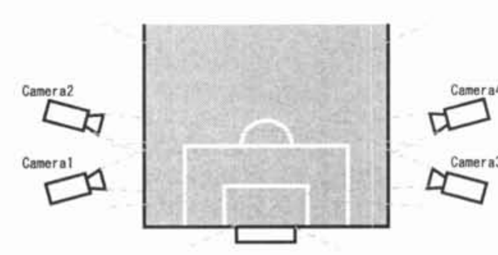


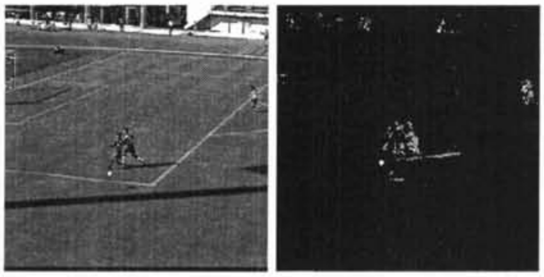
Figure 1: System environment

*3-14-1 Hiyoshi, Kohoku-ku, Yokohama 223-8522 Japan.
E-mail: {ksuke,satoshi,saito,ozawa}@ozawa.ics.keio.ac.jp

3 Ball Tracking in a Single Camera

3.1 Background-Region Removal Image

In order to reduce incorrect detection of ball and calculation cost in the template matching, the background is removed from the input image using the difference image between frames as shown in Fig. 2. In the difference image, when value of pixel is large, it is referred to gray value of an original image. Otherwise, gray value of pixel is set to 0. By using this background-region removed image, it is possible to search a ball in moving region.



(a)Original image (b)Background-region removal image

Figure 2: Background-region removal image

3.2 Ball Detection

This technique attempts to detect a ball using template matching. However, the feature point that has the smallest difference value with template isn't necessarily the ball. So, template matching is performed and five feature points that have small difference value with template are extracted as ball candidates. Each ball candidate is evaluated the total of the speed and the acceleration of the ball between frames and the difference of value between template and current frame.

If the evaluation value is the smallest and smaller than threshold, it is regarded as a ball. When current frame is first frame or the first ball that has been included in the image, evaluation value is computed 2 frames after. In addition, template of ball will be updated if a ball is detected in the current frame.

4 Ball Tracking in Multiple Cameras

Because the ball is often occluded by the players, the tracking is frequently failed by using only one camera image. For tracking the ball continuously even in the occluded case, the detected ball positions in multiple cameras are integrated according to the epipolar geometry, so that the occluded ball position can be estimated by the ball position detected in the other cameras.

We assume that Fundamental Matrix (referred to as F-Matrix below) between each camera is previously calculated. F-Matrix provides the straight line (Epipolar Line) corresponding to the ball position in other cameras. Therefore, even if the ball detection is failed in a certain camera, the detected ball position can provide ball position in the ball-occluded camera. The intersection of each Epipolar line by F-Matrix can be considered as a ball position in the camera (shown in Fig. 3). In Fig. 3, it is assumed that the ball is detected in Camera A and B, but the ball is not detected in Camera C. Even in such case, the ball can be tracked.

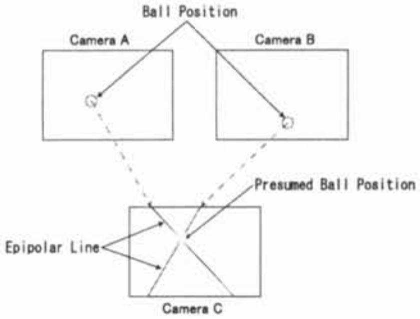


Figure 3: Presumption of ball position in ball-occluded camera

5 Automatic Selection of Camera Viewpoint

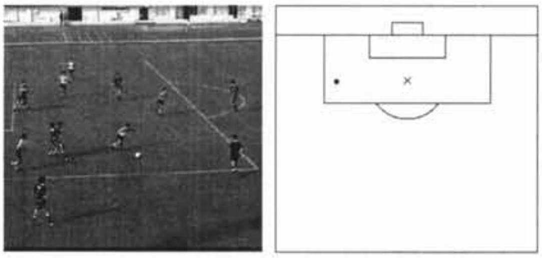
In this section, we describe the way to determine of expected camera viewpoint based on the trajectory of the tracked ball in the multiple cameras as described in the previous section.

5.1 Limitation of Camera Viewpoint

When the ball is too far from a certain camera, the camera isn't good viewpoint in a scene. Accordingly, the ball position limits the number of the camera used for the viewpoint selection.

For evaluating the position of the ball relative to all cameras, we consider the virtual viewpoint image from the upper direction of the soccer field. The ball position from the virtual viewpoint can be estimated by finding the intersection of epipolar lines corresponding to the ball positions in the cameras, in the same way described in the section 4. Fig. 4(a) shows the original image. Black circle in virtual viewpoint image (Fig. 4(b)) shows the estimated ball.

According to the ball position from the virtual viewpoint, the number of the candidate cameras is



(a)Original image (b)Virtual viewpoint image

Figure 4: Virtual viewpoint image

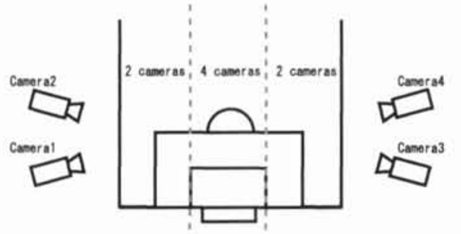


Figure 5: Limitation of camera viewpoint

limited as shown in Fig. 5. When the ball close to one side in virtual viewpoint image, candidate cameras is limited to the 2 cameras on the same side as the ball position.

5.2 Importance Value

We define importance value of each camera. It is computed as total of the importance value of the trajectory, the importance value of the ball position, and the importance value of occlusion with each candidate camera described above. It represents fitness for the present scene. Each importance values are explained below.

Importance Value of the Trajectory The scene can roughly be judged from motion of the ball. When the total length of the trajectory on image of each camera for some frames (10 frames in this method) is short, the scene is judged as dribbling. The ball trajectory is not important for camera selection in this case. Therefore, importance value of the trajectory of each camera is set to 0. When the total of the trajectory is long, the scene is judged as shooting or passing. In this case, the motion of the ball becomes important for camera selection. Therefore, the importance value is determined based on the type of the ball trajectory, so that the trajectory can be considered for the camera selection. It is judged either the ball is moving straightly or curvedly. When the motion is straight, the importance value of the trajectory is enlarged so that a length of the trajectory of some frames (10 frames) is short. On the other hand, when it is curved, it is enlarged so that a trajectory is long. Fig. 6 shows the flow of determining the importance value of trajectory.

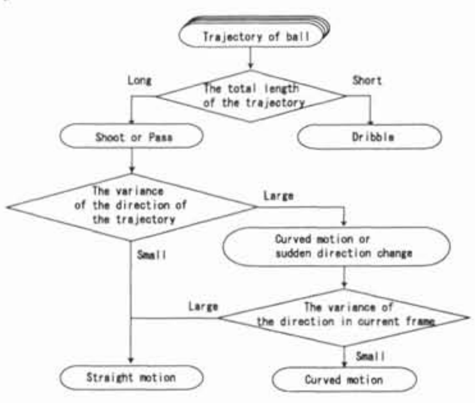


Figure 6: The flow of determining the importance value of trajectory

Importance Value of the Ball Position The viewpoint which captures a ball in the center of an image is better. Therefore, importance value of the ball position is relative to the inverse of the distance from the image center to the ball.

Importance Value of Occlusion The importance value of occlusion becomes small, when a ball becomes not visible to the camera by players or a referee. However, if a viewpoint is frequently changed by occlusion, it will be hard to see. Therefore, importance value of occlusion is weighted so that value may become small.

The camera that gives the maximum of the important value of each camera is determined as optimized camera viewpoint. The system selects camera viewpoint of each frame automatically by finding it.

6 Experimental Results

An experiment result is shown in Fig. 7. The image sequences of the soccer game in the multi-viewpoint are input. They are digitized image of 256x240 pixels, 30frames/sec, and 256 gray scales.

In the Fig. 7, white line is trajectory of ball, and the white cross mark indicates that the ball is occluded and its position is estimated from other cameras by using F-Matrix. Camera 1 is difficult to track the ball by one camera, since the ball is too far, and is often occluded by players. However, we are able to track accurately shown in Fig. 7(camera1). Judging from an experiment result, this system successfully performs the smooth viewpoint change suitable for the motion of a ball. Smooth viewpoint changes had also been done for other scenes.

7 Conclusion

In this paper, a new method for determining an optimized camera viewpoint for soccer scene by tracking a ball is proposed. In the experiments shown in this paper, the viewpoint is only selected from the real camera's viewpoint. In the future work, we aim to build a system for determining the optimized viewpoint where the real camera does not always exist. For realizing such system, we also need to develop the way to virtually generate the image from the optimized viewpoint, or dynamically control the active moving camera for placing the optimized viewpoint.

References

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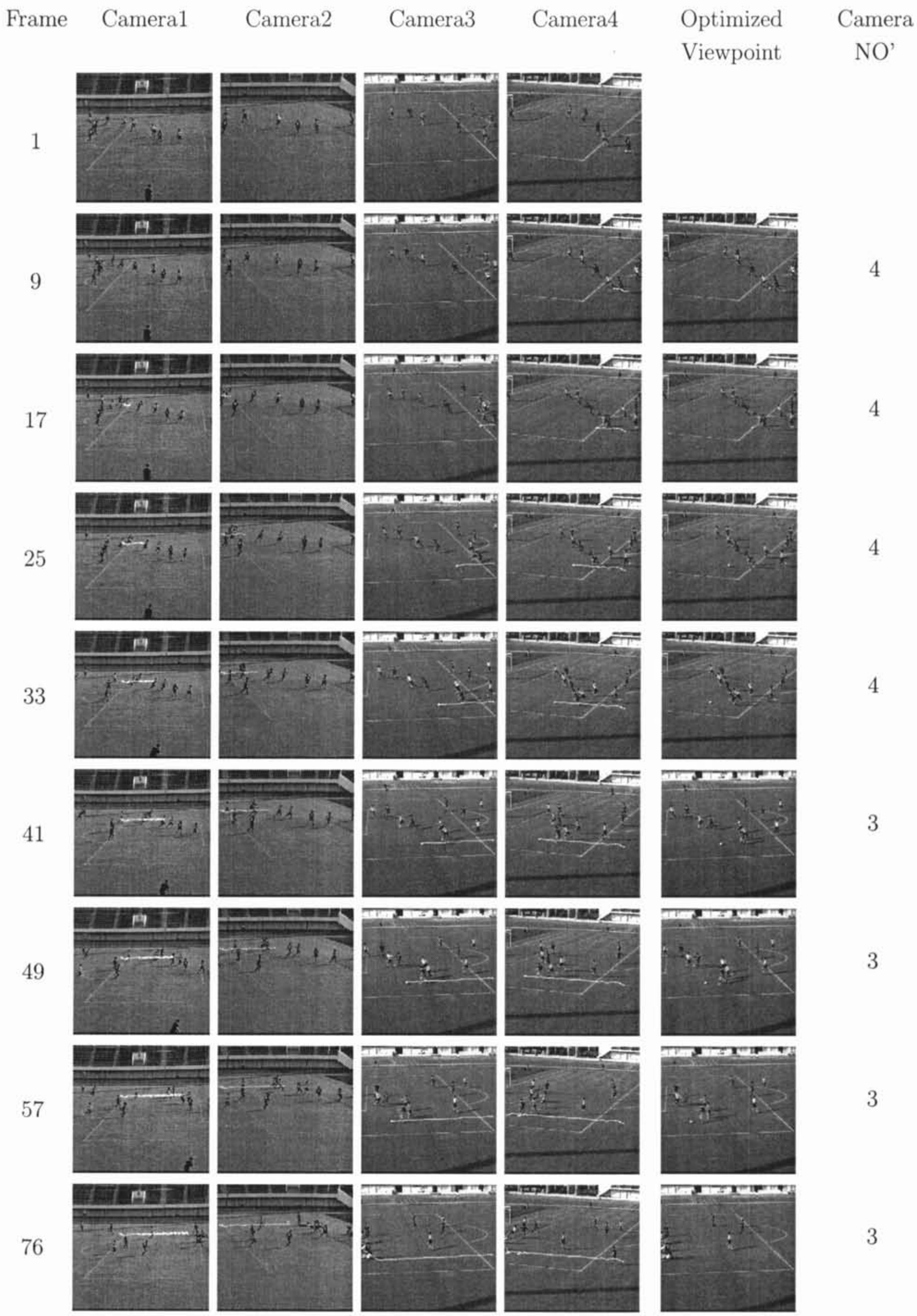

Figure 7: Image sequences of tracking the ball and optimized camera viewpoint