# 3D Position Estimation of Badminton Shuttle Using Unsynchronized Multiple-View Videos


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## ABSTRACT

In this paper, we introduce a method to estimate 3D position of a badminton shuttle using unsynchronized multiple-view videos. The research of object tracking for sports is conducted as an application of Computer Vision to improve the tactics involved with such sports. This paper proposes a technique to stably estimate object's position by using motion blur that used be considered as observational noise in the ordinary works. Badminton shuttle has a large variation of the moving speed, the motion trajectory is unpredictable and moreover the observation size is very small. Thus, it cannot be grasped correctly with human eyes. We apply our proposed technique to badminton shuttle tracking to confirm the ability of our method to enhance the human vision. We also consider that there is some contribution to augment sports in future.



## Keywords

3D Trajectory Estimation; Visual Object Tracking; Motion Blur; Anomalously Moving; Badminton Shuttlecock;


## 1. INTRODUCTION

Object tracking processing using the image information is one of the most important research topics of Computer Vision. Particularly, object tracking in sports videos attracts attention for the purpose of the improvement of the tactics. The object tracking in sports videos captured at some large-scale space has to process objects (several players or balls) with complicated and high-speed movement [1,2]. When an object moves too fast in comparison with shutter speed of the capturing video camera, it is observed with motion blur along with its moving direction. The uncertainness of the direction is included in the estimated position. However, we can acquire the position and the speed of the spherical object by analyzing the shape of the motion blur region. In this paper, we analyze the aforementioned shape to suggest a tracking method that utilizes the position and speed information using multiple-view videos. However, ordinary works using multiple-view videos assume that the all cameras are synchronized and the problem of the unsynchronized image is not settled. Therefore, we suggest one technique that estimates a fast and anomalously moving shuttlecock by using unsynchronized multiple cameras.

## 2. 3D POSITION ESTIMATION UTILIZING MOTION BLUR

We introduce a technique to improve the position estimation precision of a fast moving object by utilizing the motion blur observed in captured images. In ordinal methods, by the disposal of the blur related to the estimated position of objects, it is common to assume motion blur as an observation noise.

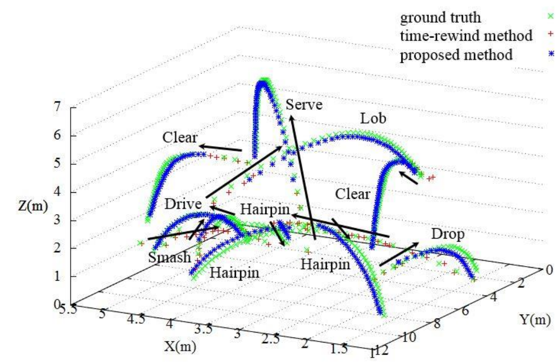


**Figure 1. Trajectory estimation result for badminton shuttlecock utilizing motion blur.**

On the other hand, the shape of the motion blur is known to include information of the speed of the object. We focus on this characteristic. Both the position and the speed of the object can be observed from an image at the same time. These are applied to the Kalman filter. Thus, this is strong tracking techniques. Using the badminton captured image in two viewpoints as an applied example of the technique, we realize the estimated position of the shuttle in the 3D space as shown in figure 1.

With a tracking start frame, or the frame which lost sight of a shuttle, we detect a movement object region by background subtraction. When the shuttle is moving slow, the 3D position is estimated from the object position that is detected in two images captured at different viewpoint using Stereo Vision. The velocity is calculated by the moving distance in 3D space and the frame rate of the capturing camera. The 3D position and velocity values are used as the input for the Kalman filter. Then, a position and the velocity of the moving object are predicted in the next frame.

When the shuttle moves fast, around a predicted 3D position, some positional particles are scattered. The particles range is transformed into an ellipsoid by using a velocity vector predicted by the Kalman filter. We perform a projection of the particles placed all over the 3D space on each image and calculate a likelihood. The resolution of the object is generally low. In addition, the likelihood calculation using the image characteristics is difficult because motion blur occurs. In this research, we calculate a likelihood only using the observation's color information. It is necessary to reposition the usable particle area as heaviness in a likelihood to acquire the badminton shuttle position stochastically. Furthermore, it must get the moving velocity of the shuttle from the distribution shape of the particles. When the velocity is slow, we input into the Kalman filter the current observed position and as observed velocity, we input the distance between the positions observed in the former and present frames.

## 3. 3D POSITION ESTIMATION USING MULTIPLE EXPOSURE TIME IMAGES

The long exposure camera is located to be at right angles to the Y-axis and the X-axis (as shown in figure 2). The short exposure camera is located to be at right angles to the Y-axis. Each camera is calibrated beforehand. The badminton shuttle moves very fast, but when the image is captured in short exposure time, the image has no motion blur. The estimation of the 3D position having high precision can only be possible if we use an image without the motion blur observed in multiple viewpoints. However, influence of the estimated precision is large when each camera captured images with time difference, like in the case of unsynchronized cameras. On the other hand, if a long exposure camera captures an image, large motion blur occurs, and the shuttle is observed as a line. There is uncertainness generated by the motion blur at the 3D position estimated using such an image. But asynchronous influence has relatively little estimation error. In this paper, we can estimate a fast and anomalously moving shuttlecock by using unsynchronized multiple cameras.

At first, using the image which we captured in Camera1 and Camera3, It apply Shape-From-Silhouette [3] and get the badminton shuttle region (3D observation line). A background difference and binarization divide a shuttle region in each image as preprocessing. The element (attention pixel) with the voxel is reflected to each image. The element is checked to see whether a shuttle region exists. A 3D observation line of the shuttle is estimated by the observation of the long exposure image as shown in figure 2(blue group). Then, the 2D position of the shuttle detected by an image of Camera2 is projected on the 3D observation line. The position where they cross is a 3D position of the shuttle. The shuttle region is detected in the short exposure image which was captured in Camera2. The observation point is found from the shuttle region. It calculates a straight line of the lens center and defines the shuttle's position. By this straight line and point of intersection with the 3D observation line that was mentioned above, we can estimate the 3D position of the shuttle of the time captured by Camera2.

## 4. EXPERIMENTAL RESULTS

We confirmed the effectiveness of our proposed method using badminton shuttle videos. The acquisition of the exact ground truth of the shuttle is difficult with the video. Therefore, we carry out a proof experiment of the suggested technique using a CG simulated image. We made a badminton racket and the CG model of the shuttle. It carried out many rigid simulations using a physical engine (blender2 .73) put on blender. The CG model of the shuttle: Mass (5g), Size (7cm), 'acceleration of gravity' and 'initial velocity' is given, and we have a simulation of the trajectory of 1 coming and going cycle of the shuttle (as shown in figure 3). In the simulation a virtual camera is placed just like the ones in the environment that captured the badminton shuttle. In blender, a setting item of the shutter speed of the camera does not exist. Therefore, we generate a shuttle with its motion blur using 4 frames in the past. As a result of the experiment, we estimated a 3D position in both video sequence and CG simulation with precision.

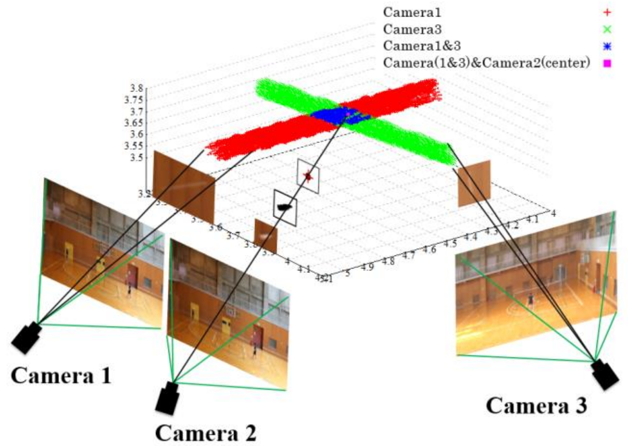


**Figure 2. 3D position estimation result of a badminton shuttlecock using unsynchronized multiple-view videos.**

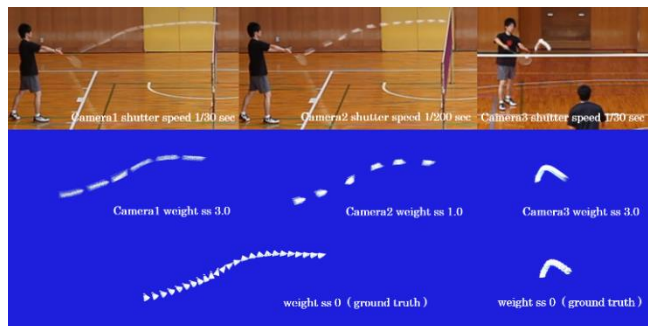


**Figure 3. CG simulation of a badminton shuttlecock.**

## 5. CONCLUISION

This paper proposed a method to estimate the position of a badminton shuttle with high precision by using motion blur which used to be considered as an observation noise. Our method estimated a fast and anomalously moving shuttlecock using unsynchronized multiple-view videos. We confirmed the effectiveness of the suggested technique using a video sequence and CG simulation image.

## 6. REFERENCES

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