Acta Technica 62 No. 3A/2017, 295–302 © 2017 Institute of Thermomechanics CAS, v.v.i.

# Design and research of basketball fixed-point shooting automatic test system based on background difference method

Min Zhou[1], Tian Zhou[1,2]

**Abstract.** In this paper, aiming at the problem of current fixed-point shooting test system of inconvenient installation, missed detection and false detection, we propose to use the method of moving target detection technology to detect the shooting. In this paper, we study and compare the optical flow method, interframe difference method and background difference method. Finally, we choose the background difference method as the shooting detection method. Based on the background difference method of basketball fixed-point shooting automatic test system, we compare the accuracy of the system with the accuracy of the current detection system. The results show that the automatic determination system of basketball based on background difference method still needs to be further strengthened in accuracy, but the stability is significantly better than the current detection system.

**Key words.** Background difference method, fixed point shooting, test system.

## 1. Introduction

In the fixed-point shooting test project, it is very important to get the position information of basketball [1]. Because the traditional detection method has many shortcomings, we must adopt a new method to detect the location of the basketball or other features. As we all know, human beings are mainly through visual, auditory and tactile to access external information [2]. However, in these perceptual organs, human eyes are the important sense organ that can gain the outside information by the light stimulation primarily [3].

This paper designs and develops a set of basketball shooting automatic recognition systems based on moving target detection technology. The method is realized by using the camera to capture the scene image, and from the video image sequence

[1]Sichuan University, Sichuan, 610000, China
[2]Corresponding author; E-mail: `marktianzhou@163.com`

to obtain the current location and characteristics information of the basketball, so as to judge whether the ball drops into the basket. The main advantage of this method is stability, convenience and reliability.

## 2. The background difference method

At present, the main shooting monitoring methods are the following: light flow method, frame difference method and background difference method. The background difference method and the frame difference method are also suitable for the camera in the case of static installation, and has the characteristics of accurate detection, simple algorithm, easy to implement and so on. If the background model is known, the method can extract the feature data completely and can extract the moving target feature quickly and accurately through the subsequent processing. It is very important to establish a good background reference model in the process of extracting the moving region by using the background difference method [4–5]. As the calculation of the optical flow is relatively large, it takes a lot of time in the calculation process, and the feedback signal of the fast moving target cannot reach the real-time requirement of the subject. However, since the inter-frame difference method is not sensitive to the target of fast or slow motion, it cannot extract the target completely, so the method cannot be used. The main advantage of the background difference method is that the calculation is simple and the detection results are accurate. Therefore, in this system, we use the background difference method to design and develop basketball shooting automatic identification system.

The basic idea of the background difference method is to match the current frame image with the known background model reference image, and calculate the similarity measure of the point of the image and the point in the background model. We can use formula (1) for foreground/background classification.

$$I_{\text{object}}(x,y) = \begin{cases} 1\, |I_{\text{current}}(x,y) - I_{\text{background}}(x,y)| \geq \text{Threshold}, \\ \\ 0\, |I_{\text{current}}(x,y) - I_{\text{background}}(x,y)| < \text{Threshold}. \end{cases} \tag{1}$$

In the above formula, point $x, y$ is any pixel in the image, $x = 0, 1 \ldots, M-1$, $y = 0, 1 \ldots, N-1$, where $N$ and $M$ represent the vertical resolution and horizontal resolution of the image, respectively. Symbol $I_{\text{background}}(x,y)$ is the eigenvalue of the pixel $x, y$ in the background reference model, $I_{\text{current}}(x,y)$ is the eigenvalue of the pixel $x, y$ of the currently captured image frame, and Threshold is the set or adaptive segmentation threshold.

$I_{\text{object}}(x,y) = 1$ represents $x, y$ points for pre-exercise points, $I_{\text{object}}(x,y) = 0$ represents $x, y$ points as background points. If the difference between the gray value of the background reference point and the gray value of the point to be measured exceeds a certain range, then the change point can be judged as the image movement front point, otherwise it will be regarded as the image back point.

## 3. Shooting monitoring algorithm

Through the determination of the position of the camera and the characteristics of the basketball in the shooting process, the algorithm of the basketball position detection in the system is realized by the above research and learning on the background difference method. Figure 1 shows the basic flow of the shooting algorithm in this system.

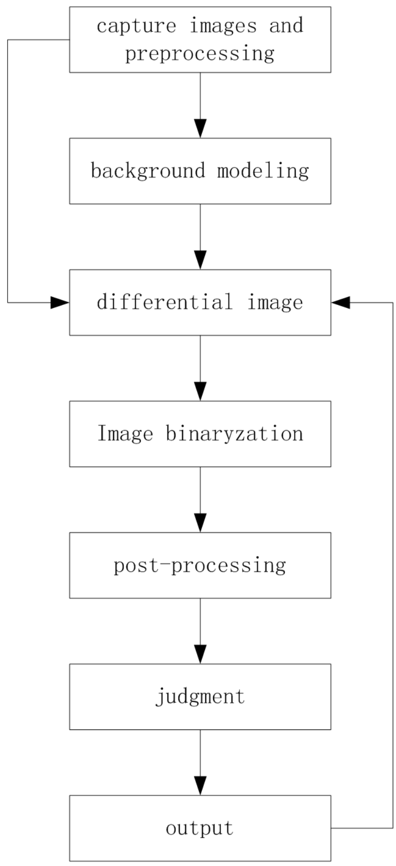


Fig. 1. Algorithm flow chart

### *3.1. Image capture and preprocessing*

In the process of detection, first of all, there is a need for live video, with the use of recorded Test One video detection.

Test One video parameters:

- Resolution: 320×240,
- Frame rate: 18 f/s,

• Format: RGB24.

Because the video format is RGB24 [6], the color space parameters are not required during the detection process, so the RGB image is converted to a grayscale image after the image is acquired. The purpose is not only can reduce the use of system memory, but also can improve the processing speed. The image captured by the camera is susceptible to noise interference and contamination during transmission, conversion and storage, which can lead to the inability to extract useful information in the image, so that the image is denoised by the neighborhood averaging method after capturing and converting the image.

### *3.2. Background modeling*

When using the background difference method to detect the motion area, we must first prepare the background reference model. After the background reference model is determined, the image difference can be performed. In this paper, the background of the scene is relatively simple and other objective factors are less affected. In this subject, we use the mean method for background modeling. Its principle is to use the continuous image of the image, and then the continuous frames of the image are summed to get the background reference model.

### *3.3. Image difference*

With the reference model, we can make the difference in the video image, so as to get the moving area in the image, and separate the background from the image. It is shown in Fig. 2.

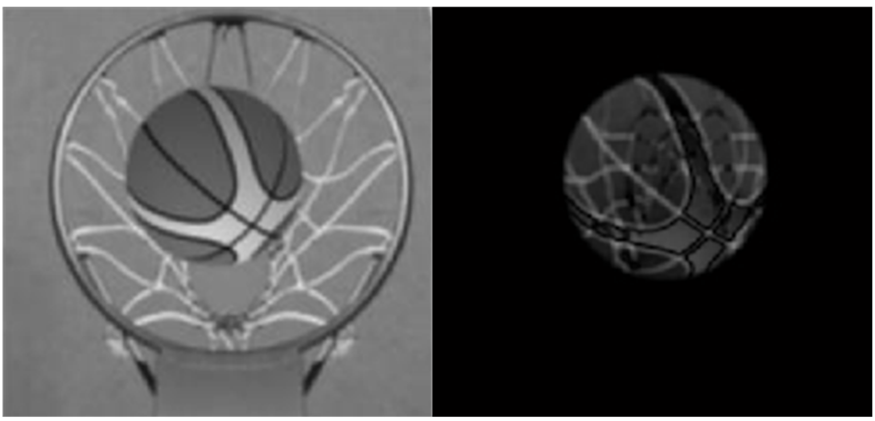

Fig. 2. The capture image (left) and differential image (right)

### *3.4. Extract features*

In the extraction of features, the most critical is the image of the basketball $X$ and $Y$ direction of the coordinates of the detection, all the calculations are based on the four coordinate points for analysis. Here are some of the above parameters of the calculation method:

$$\begin{cases} \text{BallInfor}x = \max(x) - \min(x), \\ \text{BallInfor}y = \max(y) - \min(y). \end{cases} \tag{2}$$

In the above formula, $\min(x)$, $\min(y)$, $\max(x)$ and $\max(y)$ represent the minimum and maximum pixel coordinate values in the basketball $X$ direction and $Y$ direction, respectively. Symbols BallInfor$x$ and BallInfor$y$ represent the total number of pixels in the $X$ and $Y$ directions.

$$\text{Ball}R = \frac{\text{BallInfor}x + \text{BallInfor}y}{2} \times m\text{CamDis}\tan(ce)\,. \tag{3}$$

In the above formula, $m$CamDis $\tan(ce)$ represents the calibration factor, Ball$R$ is the diameter of the basketball.

$$\text{BallCenter}(x, y) = \left(\frac{\max(x) - \min(x)}{2}\right), \left(\frac{\max(y) - \min(y)}{2}\right). \tag{4}$$

In the above formula, BallCenter$(x, y)$ are the spherical coordinates.

$$K = \frac{\text{BallInfor}x}{\text{BallInfor}y}\,. \tag{5}$$

In the above formula, $K$ is the ratio of the difference between the $X$ direction and the $Y$ direction pixel coordinates. BallInfor$x$ and BallInfor$y$ represent the total number of pixels in the $X$ and $Y$ directions.

$$\begin{cases} \text{Ball}X = \text{BallInfor}x \times m\text{CamDis}\tan(ce), \\ \text{Ball}Y = \text{BallInfor}y \times m\text{CamDis}\tan(ce). \end{cases} \tag{6}$$

In the above formula, BallInfor$x$ and BallInfor$y$ represent the total number of pixels in the $X$ and $Y$ directions. Ball$Y$ and Ball$X$ are the actual size of the basketball in the $Y$ direction and $X$ direction in the image, respectively.

## 4. System design

Basketball shooting automatic identification system is divided into four parts: input part, processing, output and graphical interface. The block diagram is shown in Fig. 3.

The main functions consists of the four parts:

• Input section: The input section provides the video frame for the system, including the image preprocessing and capturing the image [7].

• Shooting detection: to capture the image frame for some processing, and then through the differential image and post-processing to extract and calculate the bas-

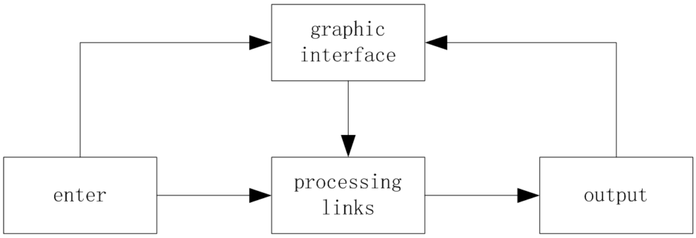


Fig. 3. System frame diagram

ketball feature information and determine whether it is scored.

• Graphical interface: used to display the current system status, the results of the display and the current video stream data [8].

• Output: The output section is the output.

## 5. Performance testing

The performance of the system is compared with the automatic test system (A system) based on the background difference method and the 30 groups of tests are carried out through the continuous test of the groups. The results are shown in Fig. 4 and Table 1.

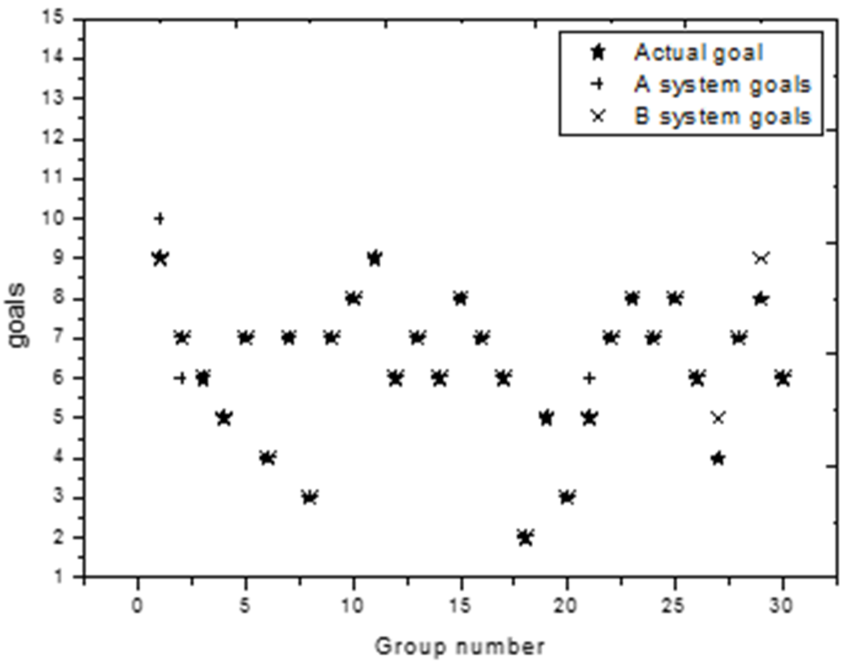


Fig. 4. Accuracy comparison between A system and B system

Table 1. Detection accuracy evaluation

| Name | False rate | | Missed rate | | Accuracy | |
|---|---|---|---|---|---|---|
| | A system | B system | A system | B system | A system | B system |
| 30 sets of data | 6.66 % | 6.66 % | 0 % | 3.33 % | 93.34 % | 90.01 % |

As can be seen from Table 1 and Fig. 4, the accuracy of the A system is higher than that of the B system, and the accuracy rate is up to 93.34 %. However, the A system error occurred mainly in the back of the data, that is, in the process of shooting, the number of basketball hit more and more, the accuracy of the A system will decline sharply. The B system error detection and missed seizure is random, and will not be because of the increase in the number of shooting and its accuracy decreased. If the more the system detected, the B system accuracy will be higher than the A system. In terms of accuracy, the B system still needs to be further strengthened, but the stability is significantly better than the current detection system.

## 6. Conclusion

In this paper, combined with the characteristics of basketball during the shooting process and the background difference method, we determine the shooting detection algorithm and testing process. Through the experiment and analysis, we verify the feasibility and accuracy of the shooting detection algorithm, and use the shooting detection algorithm to achieve the shooting automatic recognition system in MATLAB. Through the analysis and comparison of the 30 sets of test data of the existing test system and the background difference method, we analyze and evaluate the results of the automatic shooting system from the aspects of accuracy.

### References


[1] S. Avugos, M. Bar-Eli, I. Ritov, E. Sher: *The elusive reality of efficacy–performance cycles in basketball shooting: An analysis of players' performance under invariant conditions.* International Journal of Sport and Exercise Psychology *11* (2013), No. 2, 184–202.

[2] F. Chen ,C. de Vleeschouwer: *Personalized production of basketball videos from multi-sensored data under limited display resolution.* Computer Vision and Image Understanding *114* (2010), No. 6, 667–680.

[3] D. I. Ellis, H. Muhamadali, S. A. Haughey, C. T. Elliott, R. Goodacre: *Point-and-shoot: rapid quantitative detection methods for on-site food fraud analysis – moving out of the laboratory and into the food supply chain.* Analytical Methods *7* (2015), No. 22, 9401–9414.

[4] J. Han, L. Shao, D. Xu, J. Shotton: *Enhanced computer vision with microsoft kinect sensor: A review.* IEEE Transactions on Cybernetics *43* (2013), No. 5, 1318 to 1334.

[5] K. X. Zhao, D. J. He: *Target detection method for moving cows based on background*

*subtraction*. International Journal of Agricultural and Biological Engineering *8* (2015), No. 1, 42–49.

[6] P. C. Wen, W. C. Cheng, Y. S. Wang, H. K. Chu, N. C. Tang, H. Y. M. Liao: *Court reconstruction for camera calibration in broadcast basketball videos*. IEEE Transactions on Visualization and Computer Graphics *22* (2016), No. 5, 1517–1526.

[7] N. Rezazadeh, H. Zarrabi: *Using adaptive approach to enhance the accuracy of forward and backward algorithms in solving the evaluation problems of non stationary environments*. International Journal of Computer Science and Information Security *15* (2017), No. 1, 80–89.

[8] R. R. D. Oudejans: *Effects of visual control training on the shooting performance of elite female basketball players*. International Journal of Sports Science & Coaching *7* (2012), No. 3, 469–480.

Received May 7, 2017