Research for Digital Video Image Processing of Table Tennis

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Abstract. The paper proposes a new method How to obtain the placement on the table. The article adopts the technology of image process and computer's instrument to compute the coordinates of table corner. It will be appropriate for description of the track with the center computed with three-step search and precise match. This process could be modeled as two parabolic curves. The intersection would be seen as the placement in the image. Then it is feasible to transform the placement in the image into the placement on the table with Perspective Transformation. As a result, the method by this article accelerate the process make the traditional more unnecessary and not desirable.

Preface

The rapid development of computer technology enables the researchers to combine the computer technology with sports analysis that results in a new field -- physical calculation. Meanwhile, athletes and coaches have more and more requests on analysis of sports video. For this, the need for sports video is only the simple viewing and browsing but also the analysis, understanding, classification and summary of the specific technical tactics. It is difficult to meet above requirements by the human eyes and hands due to intensity and complexity of sports. Therefore, it is necessary to use computer technology to automatically compute and analyze the technical tactics for sports. And, image detection technology is the route one to solve these problems. Specific to the analysis of ball game video technical tactics, the main content and focus of image detection is how to identify and describe the direction of movement of the ball and the track and to identify the motion region and the relative position of relative to the stadium (table). Image detection technique can get rid of the traditional methods that rely on eyes and handwork. It can be finished by the modern computer technology [1].

The ball motion detection is mainly divided into three parts as ball detection, field testing and ball tracking [2].

For the ball detection and matching, the stadium (table) is computed by means of computing the relevant line section. In Singapore, some people use Kalman filters to match and track the ball [3]. In UK, some people use the space-time transformation to filter and specifically determine the sphere movement track in combination of color and motion law of ball. In Japan, some people use particle filter to ball movement for modeling. Intel center also conducted related research on the related detection. It mainly has the following several methods: methods based on modeling matching and region tracking which have high accuracy on algorithm. However, the treatment efficiency of algorithm processing is not sufficient due to the high computational complexity [4]. In China, Harbin Institute of Technology used Vertibi algorithm to detect the ball and Kalman filtering to match the movement track [5]. The Chinese Academy of Sciences has used thick-thin methods and combined condensation algorithm to detect the sphere [6]. Northwestern Poly-technical University has used Kalman filter to detect multiple motion track and then to remove the excess and idle track by retrospective method to form one motion track eventually. There has the following several ideas to carry out compute in the field:

Methods based on edge detection are including the Laplace operator, Sobel operator and Canny

operator etc. The feature of this method is simple arithmetic. But, it is susceptible to debris interference, and the effect is not very ideal. [8]

Methods based on corner detection are used in coordination with others. Although it has good effect, the complexity is a little bit of higher.

According to the need of statistical analysis of technical tactics of sports, in this topic, image detection technology is used for modeling of the placement and route of ball in the video acquisition system and used to accurately positioning the movement line of table tennis and establish the mapping model of the movement track at different camera angles. It automatically generates the script and human judgments and artificial join is not necessary.

Detection of table tennis behaviors

During motion of table tennis, it always bounces back from the table side of contact platform and contact the platform on the other side. There, many behaviors of table tennis could be understood from the point of origin and placement. Therefore, the paper mainly introduces the placement point detection scheme of table tennis. The main detection processes of placement are shown in fig. 1.

Figure 1 shows the whole testing processes. Where, the video could be input into specific script description language by the 3 steps. The following is the specific description of each part: input: video source or camera capture video

Output: containing tactics script description language video.

Detection of table tennis table: it is mainly including canny edge detection and corner detection.

Table tennis detection: it is mainly including template matching, the ball mark tracking and placement compute

The mapping scheme: the affine transformation.

After compute of the technical tactics script description language, it could be incorporated into the specific video station. It shall be corrected by comparing with the original script description language.

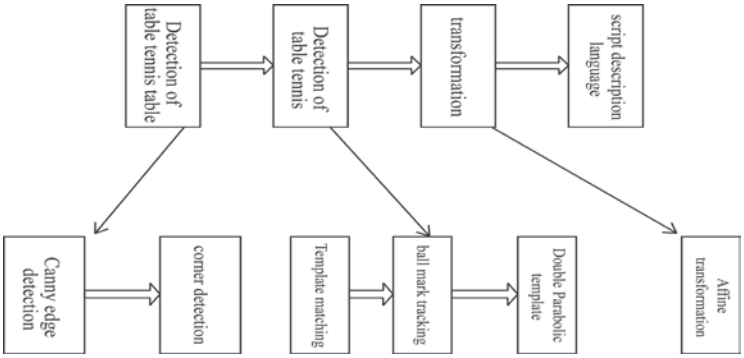

Fig. 1 Detection procedures for placement of table tennis

Detection of table tennis table. As shown in figure 2, the shape of table is a quadrangle and there is a green blue area. It is enhanced by the Retinex image. Length of the two edges could be obtained by Hough transformation. And then, some important corner shall be detected by corner detection. If the corner ends in the two lines can be regarded as four angular coordinate of table tennis table, coordinates of table could be obtained. Under normal circumstances, it shall be segmented by the color threshold and better segmentation results could be achieved. However, in low light mode, color information will be seriously missing if table color has a little difference with around which cannot separate out the table area. Therefore, it is difficult to carry out segmentation by color threshold. A new detection scheme is proposed in the paper based on contour. Table edge detection: detect the operator by canny edge, after normalization; the threshold used in this paper is 0.2. The detection effect is shown in figure 2, the basic principle of edge detection technology is to select the image Gauss filter for the smoothing filtering first and then obtain the last edge image by non maxima suppression technology. Steps are as following:

1) Gauss filter smooth image is applied.

$$H(x,y)=\exp\left(-\frac{x^2+y^2}{2\sigma}\right), G(x,y)=f(x,y)*H(x,y)$$

2) To calculate the gradient magnitude and direction by means of finite first-order partial derivative

$$H_1=\left|1^{-1}1^{-1}\right|, H_2=\begin{vmatrix}1-1\\1-1\end{vmatrix}$$

$$\varphi_1(x,y)=f(x,y)*H_1(x,y), \varphi_2(x,y)=f(x,y)*H_2(x,y)$$

$$\varphi_1(x,y)=\sqrt{\varphi_1^2(x,y)+\varphi_2^2(x,y)}, \theta_\varphi=\tan^{-1}\frac{\varphi_2(x,y)}{\varphi_1(x,y)}$$

3) Determine the position of the ball.

Difference the image computed from fig. 2 and the background image computed with the same threshold. If only the color threshold segmentation is carried out, it could not eliminate the area which has the similar color with region in the fig. Therefore, it must be differenced.

$$\{H(x,y),\mathrm{S}(x,y),\mathrm{I}(x,y)\}=\begin{cases}0,(H(x,y)\in\Theta\\ \hline same,(H(x,y)\notin\Theta\end{cases}$$

$$I_{diff}(x,y)=I(x,y)-I_{background}(x,y)$$

Fig.2 Detection of table tennis position

Image smooth could remove the Gauss white noise. In the shooting process of image, there must be influenced by the Gauss white noise which could be effectively eliminated by smooth processing. As shown in figure 3.

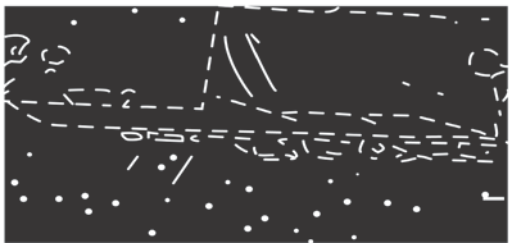

Fig. 3 edge detection (normalized threshold 0.2)

4) Template matching

In the paper, accurately positioning the table tennis by template matching and description of ball template is as following: the position of ball in each frame could be determined by combination of spherical template and color template. Reverse projection of template matching are basically the same.

Determine placement of table tennis. It is usually very difficult to capture the out moment of table tennis due to the sampling frequency setting and high-speed flight of table tennis in the process of the image acquisition, placement of table tennis shall be determined by other methods. Through a lot of observation and repeated experiment: the intersection could be determined by means of double parabola. As shown in figure 4:

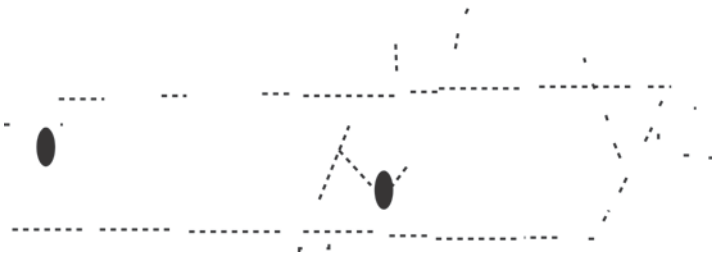

Fig. 4, first time ball

Through observation, the ball has about 9 -14 frames each time, one divides into two, it has about 6-8 frames for each contact stage and the 6-8 frames could be fitted a parabola. Finally, seek the intersection point by parabolic equation. The intersection point is regarded as the placement of table tennis. If there hasn't the rebound point on the above detected frame picture (maximum on the Y axis, not at the two ends of the curve), the table tennis leaves the table. After leaving, the leaving point (the endpoint of leaving end) shall be regarded as the area of the intersection point, and it is regarded as the placement of table tennis. Where, three parabolas intersect the two intersection points for service. The two parabolas intersect "J "intersection point for non-service, it is the placement of table tennis. In the calculation, the near point of intersection of two parabolas shall be applied. Near point of intersection means the intersection point of the two ends of the two parabolas, not the one far away from it.

Placement mapping. The main contents of the mapping transformation are to keep parallel of the original parallel line and coplanarity of point. In simple terms, point – point transformation and line – line transformation, parallel line is still parallel line. In fact, images seen by people are the imitation color conversion image with certain forms. It is treated by human eyes and the image in human brain is now normal enough. Therefore, it is necessary for carrying out study on affine transformation. It is also the very obvious matters. The affine transformation is briefly introduce as following: take two-dimensional plane as example, for the straight line in the two-dimensional plane, there has parallel and intersection, we can see that partial straight lines are still parallel and changes of other parts is relatively large compared with the previous changes after transformation. The scale of the parallel line is invariant compared with the previous one. But, change of the angle of intersection of straight line is very big. Some included angle is larger and some included angle is smaller. It depends on the shooting angle. The included angle of near endpoint is always larger. The included angle of the endpoint which is far away from the endpoint is relatively larger. Specific analysis and description are detailed in the following paragraphs and fig. 5.

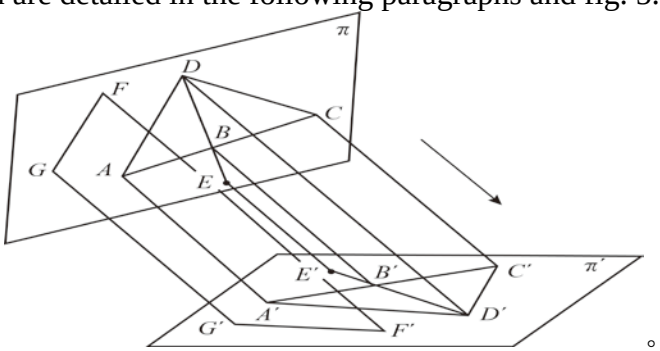

Fig. 5 the affine transformation

Through the analysis, we can know that the affine transformation has changed and unchanged parts. Changed parts mean changes of angle between the length of some side line and other side line by affine. Unchanged parts mean some side line still keeps the projection properties of affine line.

System design and Implementation

The theoretical background and key technologies of all stages of placement detection are introduced above. Detailed design and description of system shall be carried out in combination of

the related theory requirements and characteristic of image detection technology, including the related algorithm placement detection and system interface.

In the detection video, there are 9-13 frame images for each ball and testing shall be carried out according to these frame images. About 9-10 frame table tennis matching points could be obtained. Integrate these detection points and select 6 points which could be integrated into two parabolas. And finally, calculate the intersection point through the two parabolas, namely the rebound point (placement) of table tennis on the table as shown in Figure 6. The first 6 frame is the track of table tennis on the table. And the second 6 frame is the track of table tennis on the table after rebound. Establish equation to obtain the root of square, placement. The followings are the images of tested single table tennis; the table tennis is in the red rectangular box. It can be found that the main motion area of table tennis is limited in the area of table tennis table. It provides certain rules for tracking of the following table tennis and provides f relatively smaller range for the initial values of the Kalman filter.

Figure 6 table tennis matching process

Conclusion

The paper adopts the related methods in image processing for its treatment, computes table corner coordinates of table, motion track and models the whole flight process of the ball. Find out the intersection points by the double parabolas and project it to the detected table tennis table by means of transformation. The placement and flight tracking of table tennis could be determined in real conditions and it provides a prerequisite for the subsequent processing tactics.

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