Application Analysis of Table Tennis Performance Based on Image Moving Object Detection and Analysis

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ABSTRACT: *Table tennis, as a highly competitive sport, requires athletes and equipment to have a high level of performance. However, traditional table tennis performance testing methods mainly rely on manual testing, which is inefficient and susceptible to subjective factors. This article studies the application analysis of table tennis performance based on image motion object detection analysis. Firstly, the research background and significance were introduced, and the research objectives and direction were clarified. Next, the methods and principles of image-based motion object detection and analysis were introduced, including steps such as image preprocessing, object detection, and feature extraction. Then, based on the application analysis of table tennis performance, a machine vision-based table tennis performance testing method and experimental plan were proposed. Finally, the feasibility and effectiveness of this method were verified through experiments, and the experimental results were analyzed.*

Keywords: Background Difference Method; Image Technology; Table Tennis Mechanics

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1. Introduction

Table tennis is the most popular ball sport in the world today. Table tennis is mainly based on skill-based sports, with the body as a supplementary technical project [1]. Table tennis originated in the United Kingdom because the ping pong ball in the blow will issue a "ping pang" sound name. After its creation, it spread rapidly around the world [2]. In the 1988 Seoul Olympic Games, table tennis was officially listed as the Olympic Games project; since then, table tennis in various countries is beginning to flourish. Therefore, our study of the running track of table tennis plays an important role in promoting the development of table tennis technology [3]. For all countries, the growth of table tennis has a good lead.

Table tennis, as China's national ball, is not only because table tennis has won numerous honors in numerous international

competitions. Another reason is that table tennis has a broad mass base in our country, but table tennis is a sport of considerable technical difficulty [4]. For most table tennis fans, the flight path is extremely complex and varied during table tennis. People's cognizance of table tennis trajectory is based on intuition and sensibility, and there is no scientific and reasonable method of calculating the trajectory of table tennis [5]. It can be found in the combination of table tennis players' feelings on their own, through scientific methods to predict the trajectory of table tennis and then make a timely response to batting.

2. State of the Art

In this series of studies, we need to target the detection of moving objects. [6]. Moving target detection technology originated in developed countries in Europe and America; after years of scholars and researchers carrying out research, advancing target detection technology has developed rapidly. The application of this technology to our country, mainly in universities and institutes, has not been widely used in daily life [7]. Therefore, our research is also a major step toward applying target motion detection technology.

After the moving object detection, the background subtraction method analyses and processes the moving images. The background difference method uses the background model and the current number of image frames to compare the difference of the image to obtain the detection of moving objects. Using the camera at rest, a good background reference model is obtained and the motion trajectory is altogether distinguished [8]. This will be real-time and can be widely used to study the trajectory of the movement. Due to the early start of foreign countries and the rapid development, so this study draws on many examples of foreign applications [9]. The current detection technology for table tennis in the market is far from meeting the needs of the recent table tennis test. The table tennis trajectory model is simulated from the mechanics of the table tennis technique [10]. Then, the relationship between the force of the table tennis and the track of the table tennis is calculated.

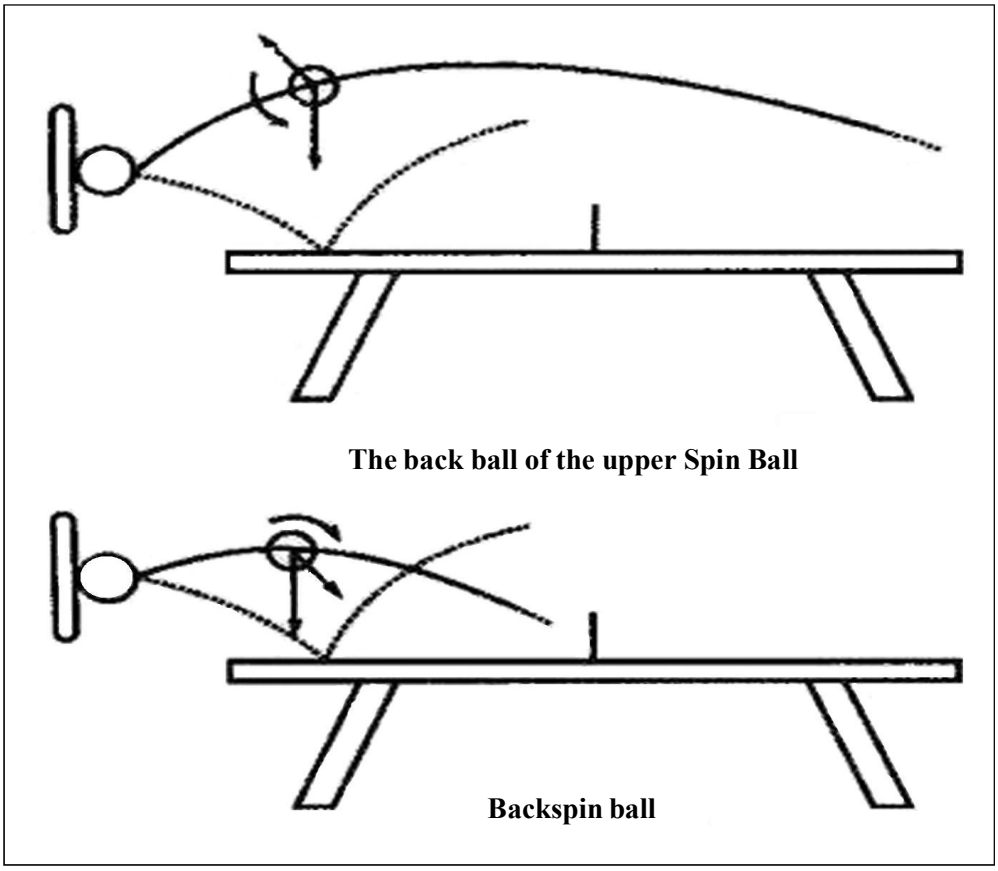

Figure 1. The movement of table tennis on the top and bottom of table tennis

3. Methodology

3.1. Analysis of Table Tennis Mechanics Simulation Based on the Image

In this study, we use the background difference method. We need to conduct a path analysis of the table tennis track this time, so our main operation flow is based on the background difference method, establishing the basic idea, the basic process and the background. Then, the state of table tennis is analyzed and compared in the process of hitting the ball. Combining the characteristics of table tennis, we can use the following formula to calculate.

$$I_{\text{object}}(x,\ y)=\begin{cases}1 & \left|I_{\text{Current}}(x,\ y)-I_{\text{background}}(x,\ y)\right|\geq T\text{hreshold}\\ 0 & \left|I_{\text{Current}}(x,\ y)-I_{\text{background}}(x,\ y)\right|<T\text{hreshold}\end{cases} \tag{1}$$

In the above equation, the point (x, y) refers to the pixel point at any point in the image. We use the set to represent $x = 0$ ..... M-1, $y = 0$ ..... N-1. I background (x, y) as the background reference model of the reference eigenvalue. I Current (x, y) is the current real-time snap photo pixel. The threshold is considered a function of the adaptive set of segmentation thresholds. Among them, when $I_{object}(x, y) = 1$, it means that the movement is at the base point. When it is equal to 0, it means that the difference between the grey value of the background point and the dribble point reaches a certain range, and the trajectory of the hitting ball and the place where the ball is to be run later can be determined. Our algorithm is the most effective method of the current background difference method, and it is also the most able to reflect the actual use of our research object. So, our current research will adopt the most advanced research methods and the most advanced computer processing. We made the virtual table model shown in Figure 1 by simulating the specific data of the table.

After the above formula, we need to establish the algorithm flow. The main advantage of background subtraction is that it can segment a target's complete trajectory in terms of positioning accuracy and computation speed. However, this method is comparatively analyzed mainly by the pixels on the background image, so his change of the background image is not worth the effort. The background image of the background model needs to be updated in real-time. Therefore, we need to process the background image before detecting the target moving object of the image. The so-called pre-processing is the image conversion, and then it uses the model established before as a reference background image, and finally, in the existing image and background reference to distinguish the differences in each frame. The specific process is shown in Figure 2:

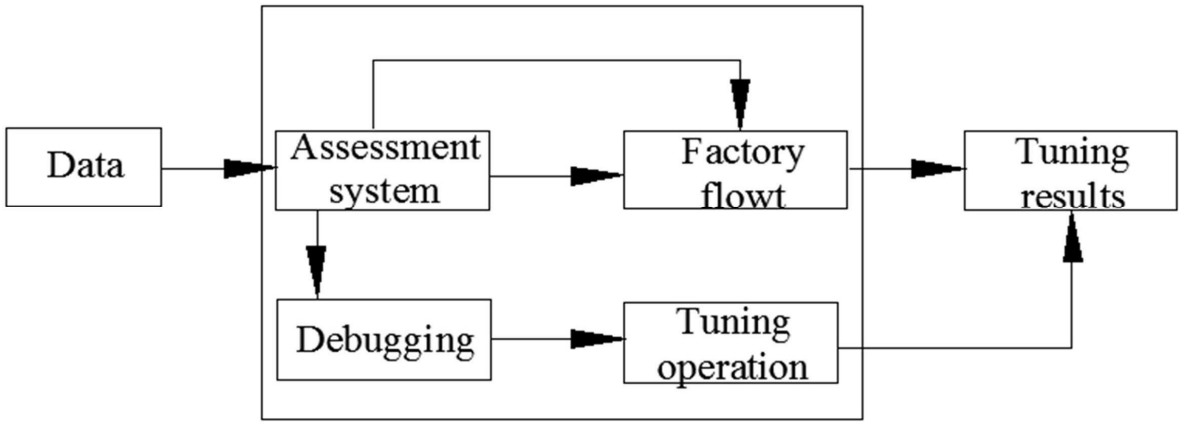

Figure 2. Simulation analysis of the mechanical movement of table tennis based on Image Technology

As the scene changes over time, we need real-time updates of the background model and the image. Therefore, the model we are studying this time must be improved and optimized based on the original to better serve our task. This time, the mean background modelling method is used because the table tennis ball, in the case of the movement model, is relatively simple. The averaging method is a method of statistical filtering based on the image captured by a high-speed camera over some time, and then dividing the accumulated value by the frequency of the capture, we get an average. Then, this average is used as our

background model. We can use the following formula to calculate:

$$B_{\mathrm{n}} = \frac{1}{N}(\mathrm{f}_{\mathrm{n}} + \mathrm{f}_{\mathrm{n\text{-}1}} + \ldots + \mathrm{f}_{\mathrm{n\text{-}N+1}}) \tag{2}$$

In the above formula, N is the average number of frames of the current target movement and $(f_n + f_{n\text{-}1} + \ldots + f_{n\text{-}N+1})$ is the image that can be saved by the coefficient, including the current number of frames. Bn is the background of the model of the image acquired according to the current n frame. Changes influence the scene model in lighting and other factors, so our background model needs to be updated after the moving target has been in operation for a while. The updated formula is as follows:

$$B_{\mathrm{n}} = B_{\mathrm{n\text{-}1}} + \frac{1}{N}(\mathrm{f}_{\mathrm{n}} - \mathrm{f}_{\mathrm{n\text{-}N}}) \tag{3}$$

The above formula explains that each new background model is based on the last calculated background model. The background model can be updated by recursion of the images of the current frames *fn* and *fn-N*. It's obvious that in this algorithm, we can choose the maximum number of image frames for the current background reference.

To accurately extract the location of the ping pong ball and the appearance information of the ping pong ball through the pixel sequence of the image, we need to binarize the image before and after the difference. The binarization of the image is to set the grayscale value of the pixel point on the image to 0 or 255; that is to say, the entire image shows apparent black-and-white visual effects. An image includes the target object, the background and noise. The most common method to extract directly from the multi-valued digital image of the target object is to set a global threshold *T*. The image data is divided into two parts through *T*: a pixel group larger than *T* and smaller than *T*. The pixel value of the pixel group larger than *T* is set to white (or black), and the pixel value of the pixel group smaller than *T* is set to black (or white). We need to deal with a binary image before the grayscale determines a threshold; the threshold is the meaning of the threshold, also called the critical value. It refers to the effect that can produce a minimum or maximum value. At the same time as the conversion, selecting this threshold is very important. Choosing the threshold is a complex operation that can extract much less work. The selection method we adopted this time is the latest threshold segmentation method proposed by Kapur in 1988, defining and segmenting the threshold by entropy. All occurrences of all sources of information occur in a single probability. Suppose this entropy is the largest when the source of information for the general trend is uncertain; we will use the method of maximum entropy value segmentation. The sum of the entropies obtained by comparing the foreground and the background is the largest. We can use the following mathematical expression:

$$P_{\mathrm{i}} = \frac{N_{\mathrm{t}}}{M \times N} \tag{4}$$

$M \times N$ in the above expression is the size of the grayscale image. Ni denotes the total number of dots in the grey image where the grey level is *i*. *pi* is the probability of the appearance of grayscale. So, we can express the entropy of the target and the background region by the following mathematical expression:

$$H_{\mathrm{f}} = -\sum_{\mathrm{i\text{-}1}}^{T} \frac{P_{\mathrm{i}}}{P_{\mathrm{t}}} \log \frac{\mathrm{p_i}}{\mathrm{p_t}} \tag{5}$$

$$H_{\mathrm{b}} = -\sum_{\mathrm{i}=T+1}^{L} \frac{P_{\mathrm{t}}}{1-P_{\mathrm{t}}} \log \frac{\mathrm{p_t}}{1-\mathrm{p_t}} \tag{6}$$

$$P_{\mathrm{t}} = \sum_{\mathrm{i}=1}^{T} \mathrm{P_i} \tag{7}$$

In the above formula, Hf represents the entropy value in the target area, where L represents the grey level in the image. We use Hb to represent the entropy of the background area. We can calculate appropriate entropy by the above method, then use the entropy as the threshold to divide the collected data. The entropy method determines the degree of dispersion of a mathematical indicator method. The greater the degree of dispersion is, the greater the impact of this indicator on the comprehensive evaluation. You can use entropy to determine the degree of dispersion of an indicator. The average entropy calculation results are shown in Table 1 below:

Grey level	Entropy	Over-dispersion	Average entropy	Threshold
0-40	3.6	2.2	2.9	2.9
40-80	7.3	3.4	5.35	5.35
80-120	2.3	5.3	3.9	3.9
120-160	1.4	4.7	3.05	3.05
160-200	2.3	5.3	3.8	3.8
200-250	7.3	3.4	5.35	5.35

Table 1. Table of Calculation Results of Average Entropy

Background subtraction is a method of detecting moving objects by comparing the current frame in the image sequence to the background reference model, the performance of which depends on the background modelling technique used. In the moving object detection based on the background difference method, the accuracy of the background image modeling and simulation directly affects the detection effect. Regardless of any moving object detection algorithm, the processing requirements of any image scene should be satisfied as much as possible. However, due to the complexity and unpredictability of the scene, the existence of various environmental disturbances and noises, such as sudden changes of light, the actual background image of some objects in the fluctuations, the camera jitter, moving objects into the scene on the original scene impact, making the background modeling and simulation becomes more difficult. The background differential method detects moving targets faster and more accurately, and it is easy to implement. The key is the background image acquisition. In practice, background is still hard to obtain directly. At the same time, due to the dynamic changes of the background image, the background needs to be estimated and restored through the inter-frame information of the video sequence. Therefore, the background should be selectively updated.

After the above series of modeling, we will use *MATLAB* software for our algorithm model method. In the hardware and software environment to build a platform for human-computer interaction, the model of the algorithm studied in detail the design of each module. Through the high-speed camera, we can capture the table tennis after moving images and comparatively analyze each frame of the screen. Then, after analyzing and comparing the data obtained, we get the results of the hit ball test. Compared with the previous algorithm, this result has the advantages of accuracy, effectiveness and stability.

4. Result Analysis and Discussion

In designing the whole algorithm, the self-built different overlap rules and the impact of each module are considered. In the validation of the algorithm, the experiment was conducted at a local university indoor table tennis court and selected as a design-only algorithm. This time we made him a series of series by analyzing the data in the video image. The ping pong position and the characteristic information carry on the analysis, thus judging whether hits or not to reflect the data algorithm in the course of the actual situation. First, data query is one of the important applications of the database, so we first test according to the query function. Because the entire information processing carried out within the coverage, so the task has a large number. We can pass the 500 tasks, 1000 tasks, 1500 tasks, 2000 tasks and 2500 tasks at the same time to process results. The results obtained as follows Table 2 shows.

As shown in the above table, when the overall task load is only 500, the entire feedback time of the algorithm is 3*s*. When the task volume increases to 2000, the feedback time of the entire algorithm information processing is 7*s*. The difference

Project	500	1000	1500	2000	2500
Information acquisition time	3	6	9	11	14
Information processing time	3.1	3.2	3.3	3.4	3.5
Feedback result time	2.2	2.2	2.6	2.8	3.0
Correct evaluation of time	7	7.1	7.2	7.3	7.4

Table 2. The Relationship Between the Quantity of Work and Practice

between the whole time is very small, almost negligible. It is easy to see that as the amount of tasks increases, the feedback time of the whole algorithm increases little. Therefore, the system is completely stress-free in the entire feedback time and efficiency, and the whole algorithm is feasible.

To further investigate the data accuracy of the algorithm, since our algorithm is associated with the test data, the data we derive must be correct. Because our starting point is to catch the result of providing the test answer, we adopted 40 sets of image data analysis and statistics are shown in the following Table 3:

Name	Layup times	Actual goal	Judgement goal
4	21	9	10
8	19	8	9
12	20	9	10
16	22	7	8
20	18	10	10
24	23	15	15
28	17	8	8
32	22	11	11
36	21	16	16
40	20	11	12

Table 3. Image Data Analysis and Statistics

As seen from the above table, the system's accuracy can be as high as 90% to meet our testing requirements. The main reason for missed and false positives is that the test system used in the above test has some loopholes. Therefore, we in the follow-up work, increase the system to determine the conditions and improve the system above method.

This algorithm model requires a real-time test, so this study solves the problems that existed in previous systems. We draw the schematic diagram shown in Figure 3 above through the statistics. It is believed that our current research and the application of motion capture technology will greatly facilitate our vigorous use and make up for the shortcomings of the current table tennis detection technology. Only in the event of an incident can it be made to make timely analysis and processing, so the length of the processing time determines the algorithm model in real time. We need to test the following. Through the Test One and Test Two videos in the operation of the various modules, the system in the processing time of each frame is the time of each module synthesis. From the figure, we can see that this time, the two image processing tools we use, have Good graphics capabilities.

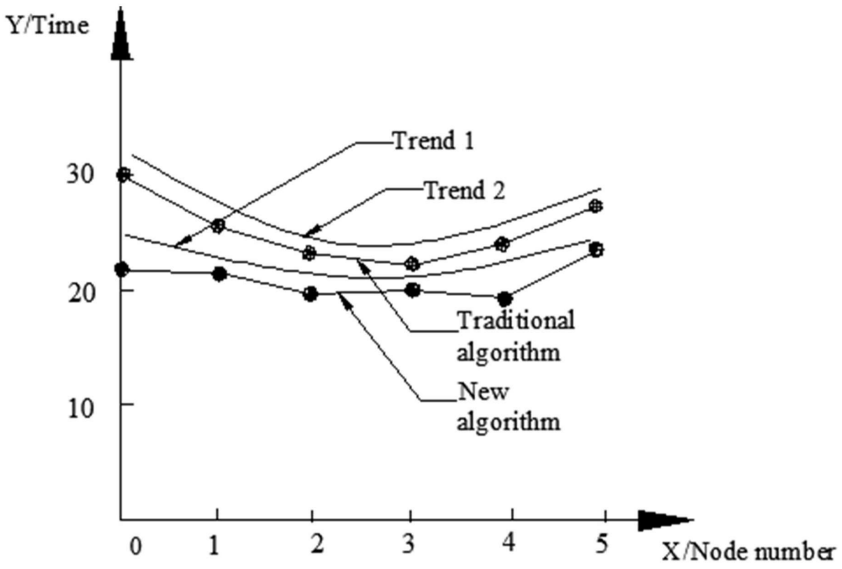

Figure 3. Image processing speed of two different video segmentation

5. Conclusion

In recent years, with the rapid development of computer technology, we can capture the moving target technology through an important branch of computer technology that has been widely used in real life. Also, it is used in many high-tech fields. Table tennis, as China's national ball, is not only because table tennis has won numerous honours in numerous international competitions. More reason is able tennis has a broad mass base in our country, but table tennis is a sport of considerable technical difficulty. For most table tennis fans, the flight path is extremely complex and varied during table tennis. People's cognizance of table tennis trajectory is based on intuition and sensibility, and there is no scientific and reasonable method of calculating the trajectory of table tennis. In this paper, we will study the current simulation analysis of table tennis mechanics and use moving target detection technology in this study. Then, the background difference method is used to study and compare. In this study, the above techniques is used to test the mechanics of table tennis mechanics. The research proves that our method can effectively record and evaluate table tennis mechanics accurately and in real time. From the research results, our research is feasible.

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