www.cadanda.com
Computer-Aided Design AND APPLICATIONS

# Video Analysis Method of Basketball Training Based on Deep Learning in the Context of Online Gaming

Li Qiushi[1*]

[1]Henan Polytechnic Institute, NanYang, China

Corresponding author: Li Qiushi, liqiushi09@163.com

**Abstract.** In order to tackle some issues of the inadequate data clustering in the original basketball shooting track capture and counter-capture method, a novel approach is proposed. This method utilizes the background differentiation technique for automated capture of basketball shooting trajectories. A sensor network is designed to capture the trajectory, ensuring improved accuracy and data integrity. The design process emphasizes the careful placement of sensors and the post-acquisition data processing. Real-time and effective data acquisition is achieved through the use of inertial sensors. The trapper module handles data processing and trajectory capture. By employing the background differentiation technique, the target trajectory is detected and processed, enabling automatic capture of the shooting trajectory. This method significantly enhances track capture accuracy. Upon widespread adoption, it holds the potential to greatly improve the track capture impact in the field of basketball.

**keywords:** Data tolerance; trajectory data; basketball training; motion capture; Context of Online Gaming
**DOI:** https://doi.org/10.14733/cadaps.2024.S5.83-90

## 1 INTRODUCTION

With the swift progress of basketball, the acquisition of basketball trajectory has encountered numerous challenges due to its distinctiveness. In the process of capturing, the trajectory is often incomplete [2],[11]. Therefore, it is necessary to design a new trajectory capture method. At present, the commonly used motion track capture methods include frame difference method, background difference method, optical flow method and so on. In this method for capturing basketball shooting tracks, the background differentiation technique is employed to enhance the limitations of the basketball shooting capture method. A basketball shooting track automatic capture method is devised based on the background differentiation technique. This approach aims to address the shortcomings and optimize the performance of the basketball shooting capture method. [7],[5],[9]. Background subtraction is an approach that detects moving objects by contrasting the

current frame in the sequence of images with the background reference model. The effectiveness of motion trajectory capture is directly influenced by the precision of background image modeling and motion simulation when employing the background subtraction method.[3].

Basketball shooting path follows a parabolic trajectory, and the background differentiation approach can fulfill the requirements of capturing basketball track in any setting. The conventional method for capturing basketball shooting trajectory often yields suboptimal results due to improper sample selection. [4]. Hence, in this design, the implementation of the Gaussian mixture model background differentiation technique is employed to enhance the conventional approach and elevate the tracking precision in intricate scenarios. This design methodology can effectively enhance the accuracy of automated basketball shooting trajectory capture, enhance adaptability to intricate scenes, and ameliorate the limitations of the capture method. Video analysis has become an essential tool in basketball training, enabling players and coaches to identify strengths, weaknesses, and areas for improvement. Deep learning techniques have proven to be effective in analyzing large amounts of video data, providing valuable insights into player performance. However, the traditional video analysis methods often fail to capture the dynamic and interactive nature of the game, which is crucial in the context of online gaming. By incorporating elements of online gaming into the video analysis process, we can bridge this gap and provide a more immersive and effective training experience.

## 2 AUTOMATIC CAPTURE METHOD OF BASKETBALL SHOOTING TRAJECTORY BASED ON BACKGROUND DIFFERENCE METHOD

In this design, we will use the method of background difference and sensor to complete the design of basketball shooting automatic capture method. Due to the complexity of the basketball competition environment, the selection of sensors and the model used in background subtraction method are very important, which directly affect the accuracy of trajectory capture [8],[10]. Therefore, the construction of the model and the selection of sensors are more time-consuming. With the aim of ensure the orderly construction of shooting trajectory automatic capture method, its operation process is set, and the specific process is shown in Figure 1.

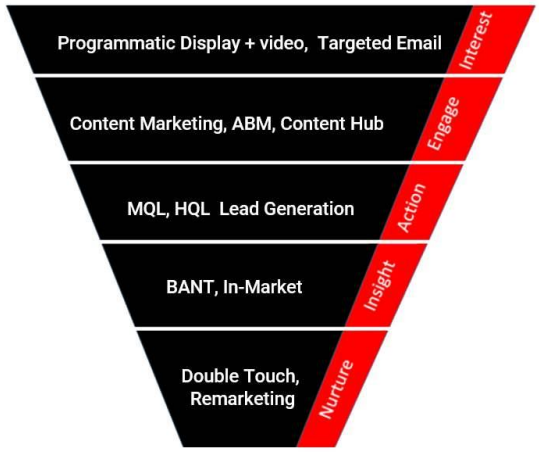



**Figure 1:** Design Process of Automatic Capture Method of Shooting Trajectory.

Using the above-mentioned process to complete the design process of shooting trajectory automatic capture method, the model construction and calculation process are emphasized in the design to ensure the accuracy of trajectory capture and improve the capture effect.

## 2.1 Capture Device Track Setting

According to the past research on trajectory capture equipment, the selection of sensors is the most important part, in order to ensure the correctness of sensor selection [1]. The most suitable sensor type is selected by comparison. The details are shown in Table 1.

| *Sensor* | *Capture accuracy* | *Integration effect* | *Computational efficiency* | *Cost* | *Defect* |
|---|---|---|---|---|---|
| *Inertial-type* | *Grade I* | *Grade I* | *Grade I* | *Low* | *Sensitive to sound* |
| *Magnetic type* | *Grade II* | *Grade II* | *Grade I* | *Low* | *Susceptible electromagnetic effects* |
| *Sound type* | *Grade II* | *Grade II* | *Grade I* | *Low* | *Sensitive to sound* |
| *Mechanical type* | *Grade I* | *Grade III* | *Grade III* | *High* | *The equipment is large and inconvenient to carry* |
| *Standard type* | *Grade I* | *Grade III* | *Grade III* | *Secondary* | *High price and inaccurate marking* |
| *Nonstandard* | *Grade I* | *Grade I* | *Grade III* | *Low* | *The real-time performance is not high* |
| *Combined* | *Grade I* | *Grade III* | *Grade I* | *High* | *A lot of precise calculations are needed* |

**Table 1:** Sensor comparison results.

Taking into account the comparative outcomes and the basketball setting and athletic attributes, the selection is made to utilize the inertial sensor for the design. It exhibits remarkable adaptability to environmental elements, cost-effectiveness, and suitability for this environment of basketball. With its reduced in the dependence on these environmental factors, it also demonstrates a relatively stable level of robustness. Consequently, the sensor is employed to fulfill the design requirements. Among the inertial sensors, MEMS sensors are extensively employed due to their wireless transmission capabilities, cost efficiency, exceptional track capture efficacy, and user-friendly operation. So, the MEMS inertial sensor, in this design, is chosen to carry out the design. The sensor parameters are shown in Table 2.

| | *Parameter item* | *Parameter value* | *Company* |
|---|---|---|---|
| *Accelerometer* | *Range* | *±10* | *s* |
| | *Sensitivity* | *1024* | *LSB /g* |
| | *Noise* | *±1.0* | *s-rms* |
| *Gyroscope* | *Range* | *±1500* | *s* |
| | *Sensitivity* | *130* | *s* |
| | *Noise* | *0.1* | *s* |

**Table 2:** Parameter setting of MEMS sensor.

Use the parameters in the table above to set the track capture framework. The track capture framework consists of three components: track retriever, relay, and server. Based on the aforementioned framework, a stationary track retriever is installed within the basketball court to gather the basketball trajectory and carry out the capture task. To ensure the reliability of the trajectory capture process, the relay is devised. The relay is responsible for the processing and forwarding of trajectory data. In this relay design, a rechargeable power source, ARM1176-S core processor, wireless network communication interface and Bluetooth communication transmitter are employed. The data processing module of the relay adopts the Samsung ARM1176 core, which handles the data received by the relay for floating-point calculations.

Through the connection between track collector, repeater and server, the shooting track capture equipment network is formed. After the network is fixed, the network is divided into two layers by using one to many topology structure to ensure the real-time and coherence of the capture process.

## 2.2 Acquisition and Preprocessing of Shooting Action Data

In this design, to guarantee the timely capture of track images, the adoption of an inertial sensor is implemented for shooting trajectory capture, which is rooted in shooting motion detection. Apart from the stationary gatherer affixed to the backboard, a miniature inertial sensor is positioned on the athletes to ensure the precision of track acquisition.

Taking into consideration human kinematics, the corresponding skeletal framework is established, serving as the foundation for capturing shooting actions. With the waist and legs as reference points, the postures of all human joints are determined in relation to the main node. The inertial sensor is positioned on the athlete's lower arm. [1]. Through the capturing of shooting action is the shooting action captured by the corresponding body position and relative posture. [12]. The specific sensor placement points are shown in Figure 2.

The sensor data of the mannequin is read through the above settings, and the acquisition time of the backboard collector is adjusted according to the motion data of these nodes. To guarantee precise motion capture, the sensor is adjusted through the server interface. In the inertial sensor, after the data acquisition results are uploaded, the repeater is driven, and the sensor information and motion information are saved in txt file format. The above data is stored in the server and processed.


**Figure 2:** Position of Inertial Sensor.

During the basketball sports data collection process, even the standard movement process and sophisticated acquisition equipment can not directly get the shooting trajectory data. The data acquired in the aforementioned steps primarily consist of actual human body movement data,

basketball gravity and material force-generated data, ambient noise in the movement environment, and inherent random noise associated with sensor zero drift. According to the above contents, the formula of shooting track noise is obtained as follows:

$$a(n) = b(n) + c(n) \tag{1}$$

In the formula, a (n) is the original data obtained by the sensor, b (n) is the real movement data of shooting, and c (n) is the noise in the movement. In the process of data acquisition, it is impossible to extract b (n) directly. Therefore, noise reduction technology is needed to eliminate c (n) to a certain extent. The value of a (n) is the same as that of b (n), which improves the applicability of the data.

### 2.3 Using Background Difference Method to Construct Shooting Trajectory Model

Through the inertial sensor to obtain the shooting action data of the players, combined with the data and time nodes of the basketball into the basket obtained by the backboard, the model required by the background difference method is constructed. Because there are many models covered by the background subtraction method, by comparing the content of the model with the form of defects, the suitable form of automatic capture of shooting trajectory is selected. The specific comparison results are shown in Table 3.

| *Name* | *Content* | *Malpractice* |
|---|---|---|
| *Median method* | *In a fixed time region, a continuous multi frame image sequence is taken, and the intermediate value is taken as the gray value of pixels.* | *The sorting process is long, the acquisition time process is not convenient.* |
| *Mean method* | *Take the average value of pixels for consecutive frames, and set the average value as the gray value of pixels.* | *It is responsive to variations in environmental lighting conditions and dynamic background alterations..* |
| *Kalman filter* | *Based on Kalman filtering theory, the results of image transformation are predicted, and the background image that can be maintained is obtained.* | *It takes a long time to eliminate noise interference, and the processing process is not easy to control.* |
| *Single Gaussian distribution* | *The gray value of each pixel in the image follows a random process that adheres to the Gaussian distribution..* | *It is easy to calculate and has poor effect on complex scenes.* |
| *Multi Gaussian distribution* | *According to Gaussian distribution superposition modeling, the multimodal situation of the review scene is obtained.* | *The process of model superposition is more, but the operation is simple.* |
| *Advanced background model* | *Time series model of each pixel or group of pixels.* | *Consumes a lot of memory.* |

**Table 3:** Comparison results of background subtraction model.

## 3 SIMULATION ANALYSIS

Through the above steps, the automatic capture method of basketball shooting trajectory based on background difference method was completed. To ensure the efficacy of the design and its ability to address the issues encountered by the original method, an implementation environment is established and the capture effect is examined. Through a comparative experiment, the effectiveness of the designed automatic capture method is evaluated in relation to the original trajectory capture method. This evaluation is manifested through a comparison of the clustering effects.

### 3.1 Constructing Experimental Environment

In this experiment, it is necessary to collect the track image through sensors and cameras. The acquisition is completed by sensors, and the acquired image files are converted into AVI format and saved. The saved files are used as data for comprehensive processing.

In order to ensure the consistency of the experimental process, the hardware used in the experimental process is set. In the process of data processing, the processor is Intel (R) Core (TS) i3-2350T, the hardware is designed as dual core processor, and the running memory is 50GB. Under WIN10 system, the application program written by C++ language is used to load automatic data for simulation experiment. The capture setting of simulation experiment is shown in Figure 3.

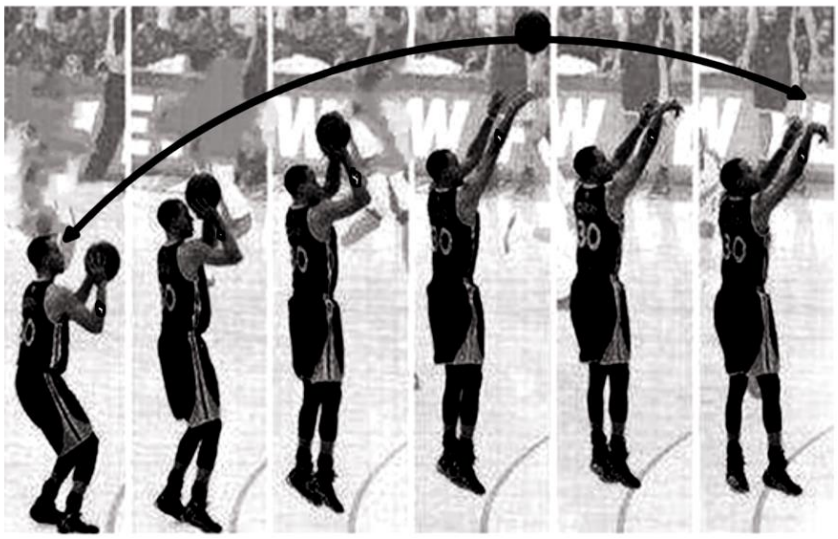
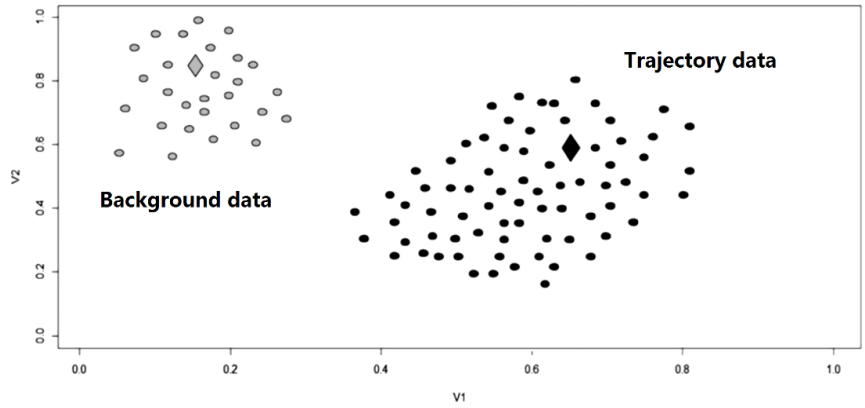


**Figure 3:** The Capture Setting of Simulation Experiment.

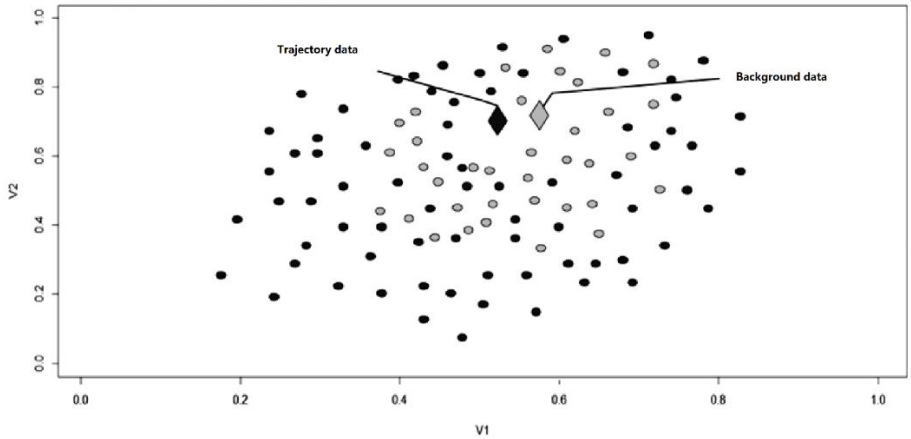
Through the above settings, Use sensors to analyze relevant data from basketball shooting actions. Cluster the obtained data using the original capture method and the capture method designed in this article, and compare the clustering results.

### 3.2 Analysis of Experimental Results

Through the above settings, the simulation experiment is completed, and the simulation results are counted, as shown in Figure 4.




(a) The clustering results of this method are as follows




(b) Clustering results of the original method

**Figure 4:** Comparison of Clustering Results.

Through the clustering results, we can see that using the design method of this paper to cluster the collected data, the data clustering results are more concentrated, and can better peel off the background data. The overall trend is around the centroid activity, which shows that the data clustering effect of this method is better. From the clustering results of the original capture method, it can be seen that the track data and background data are poorly separated, the clustering effect of the data is relatively scattered, and the overall trend is unknown. Using this clustering result, it is easy to cause some data missing in the captured trajectories. To sum up, the accuracy of the capture method designed in this paper to capture the basketball shooting trajectory will be significantly higher than the original estimation capture method. Therefore, the design method in this paper is more effective in capturing the shooting trajectory.

## 4 CONCLUSION

On the basis of studying automatic trajectory capture, a basketball shooting trajectory automatic capture method was designed using inertial sensors combined with background difference method.

Through the utilization of this method, the precision of automatic capture for basketball shooting trajectories is enhanced, ensuring data integrity. During the design process, careful attention is given to the sensor's installation position and the post-data acquisition processing procedure. Using inertial sensors to ensure real-time and effective data collection. The trapper module is utilized to carry out data processing and trajectory capture. The background difference method is used to detect and process the target trajectory, making it easy to automatically capture the shooting trajectory. This method significantly improves track capture accuracy. Upon widespread adoption and implementation, it effectively enhances the track capture impact in the realm of basketball.

*Li Qiushi,* https://orcid.org/0009-0007-6788-4479

**REFERENCES**

[1] Chi, J.: A Preliminary Study on the Change form of Load Intensity in Basketball Training, Sports Science, (03), 1990, 30-33.
[2] Feng, Q.; Zhao, P.; Feng, M.: Realization of 3D Simulation Animation of Basketball Technology Based on Moven, China Education Informatization, 10, 2016, 74-76.
[3] Guo, Y.; Zheng, Y.; Bi, Z.: et al. The Formation and Influence of Basketball Training Guiding Ideology in China, Journal of Beijing Sport University, (7), 2004, 980-982.
[4] Jiang, C.; Wu, G.; Shi, F.: Reconstruction of Juvenile Basketball Training Organization System In China, Journal Of Beijing Sport University, (03), 2011, 128-130.
[5] Liu, Z.; Zhang, W.; Li, S.: et al. Application Research of Basketball Training System Based on Kinect and Nine Axis Sensor, Computer Fan, 11, 2017, 35.
[6] Shan, S.; Lian, B.; Cui, X.: Research on the Application of Auxiliary Equipment in Basketball Technical Training, China Sports Science and Technology, 000 (005), 2015, 35-39, 59.
[7] Song, X.: Research on Automatic Capture Method of Basketball Shooting Trajectory Based on Background Difference Method, Automation and Instrumentation, (7), 2020, 42-45.
[8] Tang, j.; Xia, Q.: Current Situation and Post Training of Coaches in Youth Basketball Training, Sports and Science, (03), 2009, 86-88
[9] Xie, W.: Preliminary Study on New Methods of Basketball Training and Competition in China, Sports Culture Guide, 6, 2011, 63-64.
[10] Yan, Y.; Zhao, J.; Wang, J.: Optimization and Reconstruction of Basketball Training Organization System in Youth Stage in China, China Sports Science and Technology, 042 (001), 2006, 46-49.
[11] Yin, J.: Design and Implementation of Virtual Simulation System Based on Basketball Physical Training, Journal of Inner Mongolia Normal University (Natural Chinese Edition)192 (04), 2018, 36-40.
[12] Zhang, D.; Chen, Y.: Realization of Basketball Training Simulation System, ACTA Graphics, 36 (005), 2015, 789-794.