

# Computer Vision Technology for Constructing a Swing Action Recognition and Feedback System

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## ABSTRACT

This study aims to construct a swing action recognition and feedback system that can be directly applied to table tennis teaching and training to realize real-time evaluation and targeted guidance of athletes' technical actions. Firstly, a dual-view high-speed acquisition scheme was designed. The red-green-blue and depth information were weighted and fused. Combined with dynamic threshold and motion detection, stable background segmentation was completed to ensure the accuracy of skeleton key point extraction. Secondly, a key frame extraction mechanism driven by the combination of speed peak and skeleton posture change rate was introduced before spatiotemporal modeling. Finally, the local joint and whole-body posture features were fused, and trajectory curvature parameters were introduced to describe the racket movement path. Combined with the convolution-attention hybrid network, action classification was realized.

## KEYWORDS

Table Tennis Swing Action Recognition, Multi-Modal Visual Fusion, Trajectory Curvature Characteristics, Personalized Teaching Feedback

## INTRODUCTION

As a sport integrating speed, skills, and strategies, table tennis not only holds an important position on the international competitive stage but also enjoys great popularity in mass fitness and campus sports. The swinging motion is the core of the table tennis technical system, and its quality directly determines the speed, rotation, and landing point of the ball, which in turn affects the athlete's competitive level. In the high-level competition of milliseconds, exquisite swing movements are the key to winning the advantage. Efficient power chain transmission can generate extremely high ball speed to compress the opponent's reaction time. The exquisite control of the wrist and forearm can

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create strong and varied rotations, becoming an important tactical tool for scoring or disrupting the opponent's rhythm. A stable and repeatable swing trajectory is the cornerstone for achieving precise landing point control and executing tactical intentions. Therefore, any subtle flaws in the swinging motion can be magnified in the high-pressure environment of the game, leading to an increase in errors and directly affecting the outcome of the game. However, traditional swing action analysis methods mostly rely on coaches' empirical judgment or video replay, which have problems, such as strong subjectivity in evaluation standards, time-consuming analysis, and inability to provide real-time feedback. These shortcomings make it difficult to meet the needs of modern high-intensity and highly targeted training (Pang, 2022; Wu et al., 2023; Yuan et al., 2025).

In recent years, computer vision technology has developed rapidly in the field of sports teaching and training. With capabilities, such as image recognition, pose estimation, and action analysis, it provides the possibility for automated and objective evaluation of technical actions (He et al., 2025; Liu & Ding, 2022). However, in high-speed small-ball sports, like table tennis, actions occur in an extremely short time and involve complex spatial trajectories. Existing computer vision methods still face challenges in terms of recognition accuracy, real-time performance, and capture of subtle differences (Tang, 2024). To address the above issues, this study aimed to study a table tennis swing action recognition and teaching feedback method based on computer vision to achieve high-precision and low-latency technical evaluation and provide targeted improvement suggestions for athletes. The research objective was to construct a swing action recognition model that can adapt to the characteristics of high-speed small-ball sports, as well as realize accurate capture and classification of different types of swing techniques.

The innovation of this study is mainly reflected in the proposal of a swing action recognition model based on multimodal visual information fusion. By combining dual-view red-green-blue (RGB) and depth information, the model maintains stable performance under complex conditions, such as illumination changes and partial occlusion.

The structure of this study is arranged as follows. The following section reviews the research progress in related fields, including table tennis swing action analysis methods, the application of computer vision in sports action recognition, and intelligent teaching feedback technology. Next is a section that elaborates on the proposed swing action recognition and teaching feedback method based on multimodal vision and spatiotemporal modeling. Then, there is a section that presents the experimental design and result analysis, as well as verifies the performance of each key technical link through comparison. This is followed by a section that conducts in-depth discussions combined with the experimental results. Finally, the last section summarizes the overall work of the study, as well as points out the research limitations and future improvement directions.

## **LITERATURE REVIEW**

W. Li (2024) adopted a method combining high-speed photography and manual video annotation to decompose actions, such as forehand attack, backhand push, and serving. Kinematic parameters, including hitting point position, swing speed, and racket angle, were extracted, and it was found that high-level players exhibited a larger range of wrist angle adjustment at the moment of hitting. Z. Wang et al. (2022) obtained skeleton point data based on a 3D motion capture system. By comparing the center-of-gravity transfer patterns of athletes at different levels, they concluded that skilled players showed more stable center-of-gravity changes during the racket-back and hitting phases (Z. Cai et al., 2025). However, most of these studies rely on manual annotation or specialized sensing equipment, which are high in cost and poor in real-time performance, thus limiting their popularization and application in daily training.

Google's MediaPipe solution performs well in terms of lightweight design and cross-platform deployment, but it suffers from insufficient key point localization accuracy in the context of fast-moving small-ball sports (Garg et al., 2023; Kim et al., 2023). To enhance the modeling of temporal

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