Computer Vision Analysis of Volleyball Serves

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***Abstract*—This capstone project presents a comprehensive computer vision system for analyzing volleyball serves. The work addresses the challenge of automatically tracking and analyzing volleyball ball trajectories during serve execution through a multi-stage pipeline combining video processing, frame extraction, and machine learning annotation. Key contributions include a systematic data collection methodology using standardized camera positioning, an interactive serve segmentation tool, and a comprehensive annotation framework for ball bounding boxes and court geometry. The system enables quantitative analysis of serve performance through automated ball tracking and trajectory analysis. Results demonstrate the effectiveness of the proposed pipeline for creating a structured volleyball serve dataset suitable for machine learning applications.**

Index Terms—computer vision, volleyball analysis, ball tracking, sports analytics, machine learning

***Index Terms*—Computer vision; Volleyball analysis; Ball tracking; Sports analytics; Machine learning; YOLO; DeepSORT; Trajectory analysis**

I. Introduction

A. Motivation and Problem Statement

This capstone project addresses the challenge of automated volleyball serve analysis using computer vision techniques [1]. The motivation stems from the need for objective, quantitative analysis of volleyball serve performance, which traditionally relies on subjective coaching observations. Volleyball serves are critical to match outcomes, yet current analysis methods lack the precision and consistency needed for systematic performance evaluation.

B. Goals and Scope

The primary goal is to develop a comprehensive computer vision system for analyzing volleyball serves through automated ball tracking, trajectory analysis, and landing zone estimation. The scope encompasses data collection methodology, annotation frameworks, machine learning model development, and performance evaluation. The system targets serve analysis for training and coaching applications.

C. Contributions

This work contributes: (1) A systematic data collection methodology using standardized camera positioning, (2) Interactive serve segmentation tools for efficient video processing, (3) Comprehensive annotation framework for ball tracking and court geometry, (4) Machine learning models for ball detection and trajectory analysis, and (5) Open-source implementation of the analysis pipeline.

D. Report Structure

The remainder of this report is organized as follows: Section II provides background on volleyball serve mechanics and computer vision in sports, Section III presents the system overview and pipeline, Section IV describes dataset design and collection methodology, Section V details the annotation framework, Section VI covers model architecture and training, Section VII presents evaluation methodology, Section VIII shows results and visualization, Section IX discusses findings and applications, and Section X concludes with future work.

II. Background and Related Work

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III. Dataset Design and Collection

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IV. Annotation Framework

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V. Model Architecture and Training

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VI. Evaluation

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VII. Results and Visualization

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VIII. Conclusion and Future Work

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Acknowledgment

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