Project Proposal: Fusing Computational Imaging and Computer Vision for Tennis Swing Analysis and Improvement

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Motivation

As an avid tennis and table tennis player, I am constantly seeking ways to improve my technique, particularly my swing mechanics and posture. The best way I learn is by using visual techniques and images to identify subtle inefficiencies in my movements. This project aims to leverage computational imaging techniques such as optical flow and depth estimation with computer vision techniques to analyze my swing by comparing it with professional players who share a similar playstyle and physique. By applying these techniques, I can gain actionable insights to refine my technique and enhance my performance.

Related Work

Recent advancements in computational imaging and computer vision have enabled detailed analysis of athletic movements, including tennis swings. Below are key scientific papers and techniques that provide a foundation for this project:

1. **T. Brox et al., "High Accuracy Optical Flow Estimation Based on a Theory for Warping," European Conference on Computer Vision (ECCV), 2004.**
   Optical flow is a technique for tracking motion between consecutive video frames. It can be used to analyze the trajectory of the tennis racket and ball, providing insights into swing speed and direction.

2. **Z. Cao et al., "OpenPose: Realtime Multi-Person 2D Pose Estimation Using Part Affinity Fields," IEEE Transactions on Pattern Analysis and Machine Intelligence, 2019.**
   OpenPose provides a robust framework for real-time pose estimation, enabling detailed analysis of joint movements in tennis swings.

3. **P. Kelly and N. E. O'Connor, "Visualisation of tennis swings for coaching," 2012 13th International Workshop on Image Analysis for Multimedia Interactive Services, Dublin, Ireland, 2012, pp. 1-4.**
   This paper explores the use of augmented reality and accelerometers to visualize tennis swings, highlighting the importance of tracking joint movements and swing paths.

4. **C. Wang, "Method for Capturing Tennis Training Actions under Machine Vision Images," 2023 International Conference on Computer Science and Automation Technology (CSAT), Shanghai, China, 2023, pp. 409-413.**
   Wang's work focuses on using machine vision and deep learning techniques, such as YOLO and pose estimation, to capture and classify tennis training actions.

5. **T. Xu, Z. Li, M. Yuan, Z. Zheng, J. Zhang, and X. Kuai, "Three-Dimensional Spatiotemporal Reconstruction and Feature Analysis of Table Tennis Movement Enhanced by Multi-view Computer Vision," 2023 3rd International Conference on Information Technology and**

Contemporary Sports (TCS), Guangzhou, China, 2023, pp. 60-68.
This study employs multi-view computer vision to reconstruct 3D spatiotemporal movements in table tennis, providing insights into 3D motion analysis.

Overview and Goals

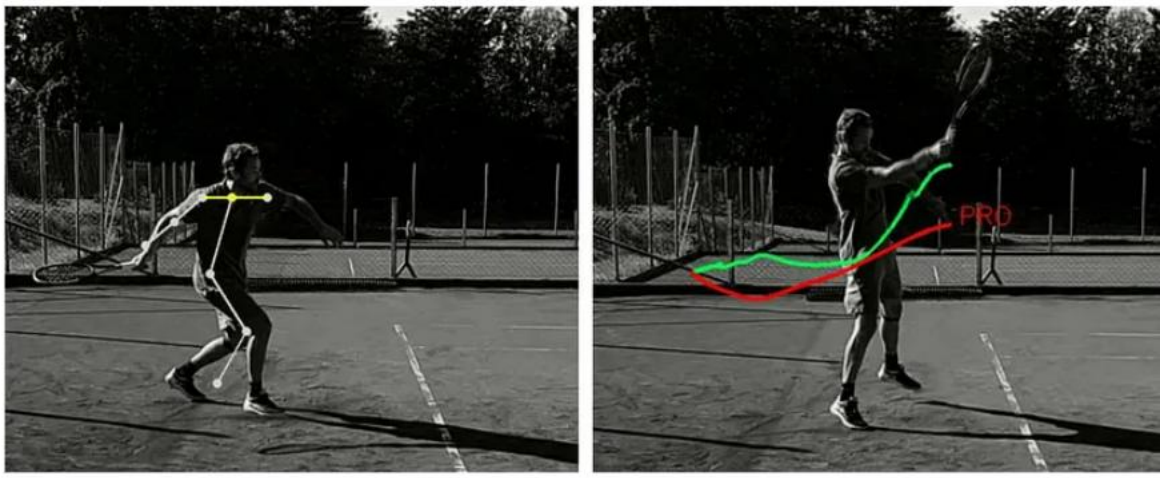
The goal of this project is to develop a system that records and analyzes tennis swings using computational imaging and computer vision techniques. Specifically, I will:

1. Record and Enhance Videos: Capture videos of my tennis swings and apply super-resolution techniques to improve video quality for more accurate analysis.
2. Denoise and Deblur: Use denoising and deconvolution techniques to remove noise and motion blur from the videos and background, ensuring clearer images for analysis.
3. Track Movements: Use optical flow and pose estimation algorithms to track joint movements and swing paths in 2D.
4. Compare with Professionals: Analyze videos of professional players with similar playstyles and physiques to establish a benchmark for optimal swing mechanics.
5. Identify Differences: Highlight discrepancies in body positioning, swing trajectory, and joint angles between my swings and those of professionals.

Milestones and Timeline

Below is a proposed timeline with milestones and intermediate goals:

Date	**Milestone**
3/2	Record videos of my tennis swings and apply super-resolution techniques to enhance video quality.
3/5	Implement denoising and deconvolution techniques to remove noise and motion blur from the background.
3/9	Apply optical flow and pose estimation algorithms to track joint movements and swing paths.
3/11	Perform a comparative analysis of my swings versus professional swings, identifying key differences.
3/12	Submit the video demonstration, showcasing the analysis.
3/14	Submit the final code, report.



This is an example I found in an article that shows the end result similar to what I want to accomplish.