Comparing OpenCap and Marker-Based Motion Capture for Golf Swing Kinematic Assessment

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Summary

This study evaluates OpenCap, a marker-less motion capture system, against a traditional marker-based system in analyzing golf swings. Results show strong agreement in upper-body joint kinematics, while lower-body joints exhibit variability. Physiological factors and camera occlusions influenced outcomes, emphasizing setup optimization. OpenCap demonstrates promise for biomechanical analysis in accessible and real-world contexts.

Introduction

Marker-less motion capture (MoCap) systems are emerging as cost-effective and accessible alternatives to traditional marker-based systems for biomechanical analysis. Among these, OpenCap [1] has shown potential for capturing human movement dynamics using widely available video technology. However, its performance in analyzing complex, high-velocity movements like the golf swing remains unexplored. This study aims to benchmark OpenCap against Vicon, a state-of-the-art marker-based MoCap system, in capturing kinematic trends during a golf swing. By focusing on overall joint angle patterns, this work provides an evaluation of OpenCap's suitability for analyzing a technically demanding motion.

Methods

Eight participants, including one professional golfer and seven with handicaps ranging from 3–10, were recruited for this study. Golf swings were captured simultaneously using Vicon and OpenCap. The Vicon setup included 12 infrared cameras and 39 reflective markers placed on anatomical landmarks following the Plug-in Gait Full Body AI Marker Set [2]. OpenCap was set up using two iPhone 14 Pro cameras positioned at 45° in front of participants. Each participant performed 20 swings (5 half, 15 full). Vicon joint angles were directly obtained, while OpenCap angles were computed using OpenSim's Inverse Kinematics Tool. The OpenCap data was filtered using a Woltring filter (smoothing factor: 10) consistent with Vicon's pipeline. Joint angle time series were aligned via cross-correlation, and Normalized Cross-Correlation (NCC) assessed the similarity of joint angle patterns.

Results and Discussion

The results demonstrate strong overall agreement between Vicon and OpenCap for tracking upper joint kinematics, with mean NCC values for elbow joint angles exceeding 0.84 for all participants. In contrast, lower-body joint kinematics (hip and knee) showed moderate agreement with greater variability. Notably, P02 and P04 displayed lower NCC values, which can be attributed to physiological factors, leading to marker occlusion during their swings. For left shoulder angles, occlusion was observed during the follow-through phase; since cameras were positioned only in front of the participants, the rotated left side of the body was often obscured. Adding cameras behind the participant could address this limitation, but we limited cameras to test the feasibility of this setup in real-world environments.

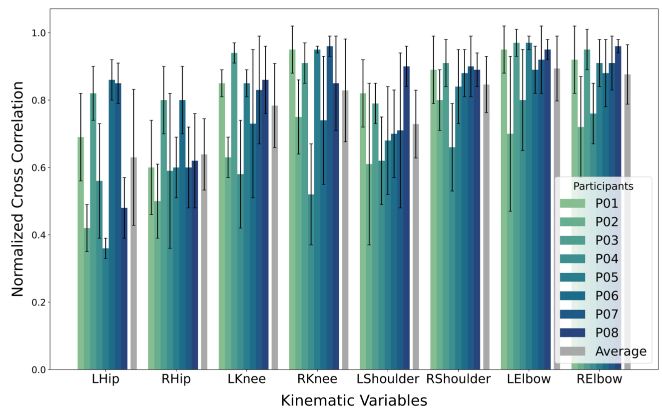

Figure 1: Bar plots showing the normalized cross-correlation (NCC) between the two capture systems for various joint angles (kinematic variables) across participants. Higher NCC values indicate stronger agreement between the systems. Averages across participants for each variable shown in gray.

Conclusions

OpenCap shows promise as a marker-less motion capture tool for golf swing analysis, with strong alignment to traditional marker based MoCap in upper-body joint kinematics but variability in lower-body joints due to occlusion and setup constraints. Its simplicity makes it suitable for real-world applications, though setup optimization remains crucial.

References

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