Impact of video resolution on center of mass estimation: A cross-models analysis (preliminary study)

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Summary

Recent advances in markerless motion capture (MC) have made biomechanical analysis more accessible. However, video parameters might affect pose estimation accuracy. This study investigates how video quality (540p and 1080p at 16:9) influences 3D center of mass (CoM) accuracy across different triangulated 2D pose estimation algorithms (RTMpose, OpenPose, OpenPose with marker augmentation and Theia3D). A healthy participant (age: 52) performed 60 statics standings trials. CoM estimations from each algorithm were compared against Theia3D. Results indicate that video quality significantly affects estimation accuracy, with varying impacts across algorithms. Our findings suggest considering video settings in markerless MC.

Introduction

CoM estimation is crucial for balance and postural analysis, for both healthy and pathological participants. The commercial software Theia3D has given similar CoM results to marker-based systems **[1]**. Nowadays, many open-source markerless solutions such as OpenPose, RTMPose, are available, allowing researchers to use any type of cameras, for a wide range of activities **[2]**. However, effects of video parameters need further investigation, especially in static tasks. The aim of this study was to quantify effects of video quality on CoM estimation, in a static standing task.

Methods

One healthy male participant volunteered for this study. He stood for 25 seconds in a standardized bipodal position with arms alongside the body and fixed gaze on a visual anchor point, positioned at eye-level, 6 meters ahead. 30 trials were conducted, each under a different recording condition: 540p and 1080p resolution. Video recordings (60Hz) were captured in a 16:9 aspect ratio, using 10 Miqus video cameras, assuring full participant coverage. Cameras were calibrated and synchronized with the Qualisys system, and lighting conditions were consistent across both conditions.

Data processing

All videos were proceeded using Theia3D (v2022.2.0.2777). Then, RTMpose, OpenPose BODY_25B and Augmented Openpose model, following Pose2Sim's workflow recommendations [3]. CoM positions were exported using Visual3D (v2023.12.1) for Theia3D. For the other models, OpenSim 4.5 was used. The data was filtered by a 4th order Butterworth low-pass filter at 6 Hz. The trajectory was calculated for 15s between 7 to 22s to avoid postural adjustments. Root means square errors (RMSE) of CoM displacement, when compared with Theia3D at each frame was calculated using MATLAB (R2023a), followed by a repeated measure ANOVA.

Results and Discussion

Table 1: COM RMSE (Mean ±SD)

	OpenPose Aug.	RTMPose	OpenPose
1080p (mm)	50.6 ± 2 *****	41.2 ± 4 *****	17.0 ± 1*****
540p (mm)	49.1 ± 3 *****	42.1 ± 0.7*****	9.42 ± 1*****

***** Indicates statistical significance $p < 0.05$

Table 2: Mean total CoM trajectory displacement (mm)

	OP Aug.	RTMPose	OpenPose	Theia3d
1080p (mm)	209.6	177.7	135.7	312.8
540p (mm)	291.8	204.4	184.4	726.6

Despite using the same participant's videos and calibration files, the algorithms produced varying CoM displacements for both resolutions (cf Table1 and Table2). These differences likely stem from factors such as model architecture and training data **[2]**.

Conclusions

Open-source models have enhanced MC, but video resolution must be considered for precise CoM's estimation. Further research is required, particularly for static tasks.

References

[1] A. Chaumeil et al., Agreement between a markerless and a marker-based motion capture systems for balance related quantities, J Biomech 165 (2024)
[2] A. Yacine Lardjane et al., Agreement of Gait Events Detection by Inertial Measurement Units and an open source Markerless End-to-End Workflow?, (2024).
[3] D. Pagnon et al. , Pose2Sim: An open-source Python package for multiviewmarkerless kinematics, JOSS 7 (2022)