Comprehensive database for benchmarking markerless motion capture methodologies: example results

Antoine Muller[1], **Raphaël Dumas**[1], Alexandre Naaïm[1], Mohamed Adjel[2], Sandrine Bousigues[1], Anaïs Chaumeil[3], Marien Couvertier[4], David Pagnon[5], Diana Pardo Ramos[1], Alexandre Schortgen[6], Thomas Robert[1]
[1]Univ Eiffel, Univ Lyon 1, LBMC UMR_T 9406, F-69622 Lyon, France
[2]LAAS-CNRS, Université de Paul Sabatier, Toulouse, France
[3]Univ Polytechnique Hauts-de-France, LAMIH CNRS UMR 8201, Valenciennes France
[4]Université de Poitiers, Institut PPrime (UPR3346 CNRS Univ. Poitiers ISAE-ENSMA)
[5]University of Bath, Bath, United Kingdom
[6]INRIA Grenoble Rhone-Alpes, LJK, UMR 5224, Grenoble, France
Email: antoine.muller@univ-lyon1.fr

Summary

A comprehensive database is introduced including markerless, marker-based, and biomechanical estimations derived from various markerless processing methods. This database can be useful for benchmarking markerless method to estimated biomechanical variables. As an example, this abstract provides a comparison of 10 markerless methodologies available on this database.

Introduction

The rapid development of markerless motion capture is having a significant impact on biomechanics, providing an alternative to more traditional marker-based systems. By eliminating the need for subject instrumentation, markerless methods could facilitate various applications.

Several commercial and open-source solutions, such as Theia3D (Theia Markerless Inc, Kingston, Ontario, Canada), OpenCap [1], and Pose2Sim [2], estimate biomechanical variables like joint angles from video data. Each software uses different methodologies, and their accuracy is classically assessed through independent studies on their own data, resulting in a lack of benchmarking against other methods.

To address this issue, we aimed to develop and provide a database that includes video data, marker-based data, and biomechanical estimations derived from multiple markerless processing methods. This database enables systematic comparisons across different approaches, allowing for a more standardized and objective evaluation of markerless motion capture techniques. This abstract describes the database and presents an example of a comparison of 10 markerless methodologies, blindly performed by 7 independent teams as part of a markerless national workshop.

Methods

The database contains motion data from two participants (a young male and female) performing five tasks: walking, sit-to-stand, and a handling task (individually). Each also performed a challenging pose detection task - a handstand hold for one and a Y-pose for the other. The final task was a dance performed together. The tasks were simultaneously recorded by 10 opto-electronic and 9 video cameras (Qualisys Miqus Video, 60 Hz, resolution 1920×1088 pixels). The video cameras were calibrated using the Qualisys process. Several videos of a checkerboard were also captured to allow for camera calibration.

Ten markerless methodologies were applied to video data to estimate 10 joint coordinates for each task. Each was compared to a marker-based estimation. The results present a subset of this comparison.

Results and Discussion

For the flexion/extension degrees of freedom, all correlations were higher than 0.8 (Figure 1). Bias of up to 15° was observed for some methods, likely due to differences in the definition of biomechanical models. For the abduction/adduction degree of freedom, the correlations varied between 0.1 and 0.9, indicating a large impact of the methodology used.

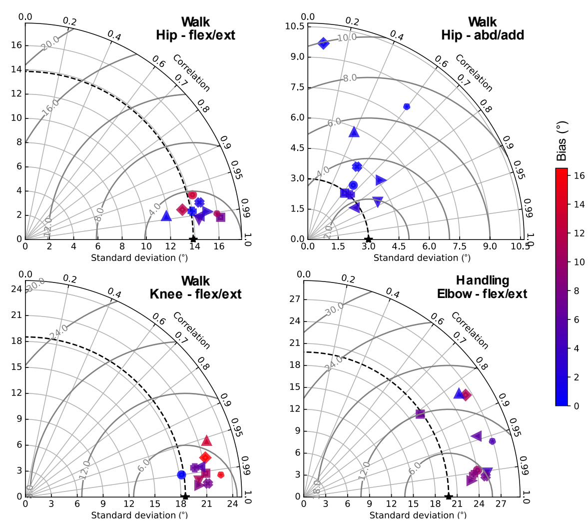

Figure 1: Taylor diagrams of the 10 markerless methods' estimate compared to marker-based estimate. Each symbol is associated to one markerless methodology.

Conclusions

The introduced database, soon to be released as open-source, will serve as a benchmarking platform for assessing markerless methods in estimating biomechanical variables.

References

[1] Uhlrich SD et al. (2023). *PLoS Comput. Biol.*, 19(10), e1011462.

[2] Pagnon D. (2022). *J. Open Source Softw.*, 7(77), 4362.