Evaluating Markerless Motion Capture Accuracy for Humerus Tracking Using Biplanar Videoradiography

Kayla D.L. Lee[1], Erin C.S. Lee[1], Michael J. Rainbow[1]
[1]Queen's University, Kingston, Canada
Email: lee.kayla@queensu.ca

Summary

Markerless motion capture (mocap) is becoming popular for tracking high-speed upper extremity motions, but its accuracy in estimating bone motion remains uncertain. This study assessed markerless mocap accuracy for the humerus using biplanar videoradiography (BVR) as the ground truth. Errors were comparable to marker-based mocap, indicating that markerless mocap provides a promising, less cumbersome alternative to marker-based methods for tracking humerus motion.

INTRODUCTION

Markerless motion capture is gaining popularity for capturing high-speed upper extremity motions. It typically uses standard video recording paired with machine learning-based algorithms to track the 3D pose of body segments [1]. Markerless mocap is advantageous because it is less time-consuming and may allow participants to move more naturally without instrumentation [2]. Despite these advantages, it is unknown how well markerless mocap estimates the underlying bone motion. The purpose of this study was to determine markerless motion capture accuracy for the humerus bone using biplanar videoradiography (BVR) as our ground truth measure.

METHODS

Ten participants (5F/FM, age = 24 ±2 y) performed a seated, loaded (15kg) pulldown motion while spatially-registered and phase-locked markerless mocap and BVR systems were simultaneously captured at 60 Hz. Seven Miqus cameras (Qualisys) coupled with Theia3D were used to record full-body motion and estimated the humerus pose from video. We used the BVR system coupled with a CT scan to directly track humerus bone pose (accuracy 0.3 mm and 1.2 deg[3].

The position and orientation of the Theia-tracked humerus was directly compared with the BVR-tracked humerusanatomical coordinate system (ACS) as the reference. We quantified translational error as the distance between the center of the humeral head tracked with BVR and Theia. We quantified rotational error using a YXZ Euler sequence describing axial rotation about the long axis of the BVR humerus, followed by rotation about a roughly ab/adduction floating axis, and finally rotation about a flexion axis in the Theia humerus. We quantified error with Root Mean Square (RMS) differences.

RESULTS AND DISCUSSION

The median translational RMSE of the Theia-tracked humeral head was 8.3 mm, 9.7 mm, and 7.0 mm for the anterior/posterior, superior/inferior, and medial/lateral directions, respectively. The median rotational RMSE of the Theia-tracked humerus was 4.7°, 10.1°, and 1.7° in adduction/abduction, axial rotation, and flexion/extension, respectively (Figure 1).

The magnitude of the translation error likely reflected Theia's estimation of the humeral head from external landmarks. In future work, we plan to isolate the differences between motion tracking and coordinate system definitions. This data can also be used to re-train the markerless algorithms because landmarks that indicate internal bone locations such as the humeral head, epicondyles, and points of interest on the scapula can be directly located on the training images.

CONCLUSIONS

Markerless motion capture can estimate the position of the humerus with accuracies on par with marker-based motion capture, without the need for marker placement. The nature of the training data for markerless invites the potential to improve accuracy further with augmentation from ground truth BVR-based bone poses.

REFERENCES

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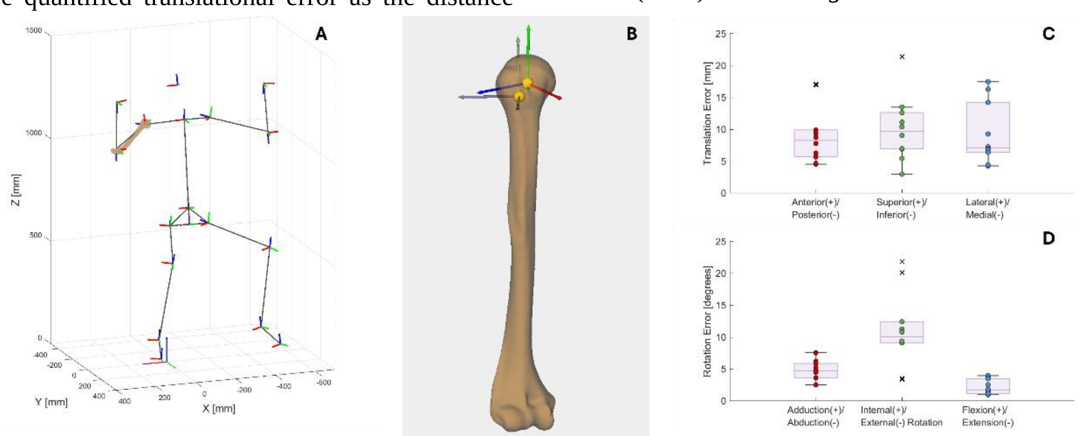

Figure 1: (A) Theia link model and overlayed BVR humerus. (B) Theia and BVR coordinate systems. (C,D) RMS translation and rotation error.