Combining Inertial Motion Capture with Ultimate Inside-Out Trackers for Drift-Free and Enhanced Motion Tracking

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Summary

This study evaluates the integration of HTC Vive Ultimate trackers with the Xsens MVN system for drift-free, improved positional accuracy and enhanced motion tracking. Inertial Motion Capture (IMC) systems are widely used for motion analysis but are hindered by positional drift. We demonstrate that combining IMC with Ultimate inside-out trackers eliminates drift and enhances accuracy and consistency. Specifically, upper-body motion was highly correlated with optical markers ($R^2 > 0.97$ vs. $R^2 > 0.92$ without aiding), and inter-hand and object-hand distances were more accurate during clapping and object-reaching tasks. Similarly, in a 10-minute walking trial, the integration of the Ultimate trackers improved motion accuracy ($R^2 > 0.99$ vs. $R^2 = 0.83 \pm 0.02$) and eliminated a 2.27 m drift observed without aiding. These results support the use of Ultimate trackers for precise, dynamic and portable motion tracking applications where accuracy and portability are essential, such as in ergonomics.

Introduction

Inertial Motion Capture (IMC) systems are widely used in occupational health for objective ergonomic assessments, as well as in sports, clinical gait analysis, and human-robot training [1,2]. However, IMC accuracy is hindered by positional drift, as IMUs measure acceleration and angular velocity but not absolute position. Although techniques exist to reduce drift [3], achieving drift-free motion remains challenging. Integrating IMC with positional tracking technologies could solve this [4,5], but existing systems often rely on stationary camera-based solutions. The HTC Vive inside-out Ultimate trackers offers a portable, high-accuracy solution [6], which this study explores in combination with the Xsens MVN system to enhance motion tracking and positional accuracy for ergonomic applications

Methods

Motion capture was performed with the Xsens MVN Awinda system (17 sensors, 60 Hz), 5 HTC Vive Ultimate trackers (120 Hz), and a Qualisys optical system (120 Hz). Participant-specific anthropometrics were used to scale the MVN biomechanical model 2.0 [7]. Ultimate trackers were calibrated and integrated into MVN via its positional aiding framework. MVN calibration followed the N-Pose+Walk protocol, and synchronization with Qualisys was achieved via vendor integration. Trials were HD reprocessed in MVN (smoothing estimate over a large time window) with and without positional aiding, and compared with optical data. Upper-body analyses assessed inter-hand and object-hand distances during clapping and object-reaching tasks, while lower-body analysis focused on gait kinematics. Accuracy and drift were quantified using RMSE and R^2 correlations between all 43 optical markers and their corresponding MVN counterparts, as well as inter-hand and hand-object distances.

Results and Discussion

Integrating Ultimate trackers significantly enhanced motion tracking. Upper-body motion correlations increased ($R^2 > 0.97$ with aiding vs. $R^2 > 0.92$ without aiding), and inter-hand and object-hand distances were significantly more accurate and consistent during clapping and object-reaching tasks (Figure 1). A 10-minute walking trial in straight line demonstrated improved accuracy (RMSE: 8.8 ± 6.0 cm, $R^2 > 0.99$), compared to no aiding (RMSE: 82.7 ± 58.0 cm, $R^2 = 0.83 \pm 0.02$), effectively eliminating a 2.27 m drift. While preliminary, these findings support previous findings on the precision of the Ultimate trackers [6] and demonstrates its capabilities as positional aiding system for IMC.

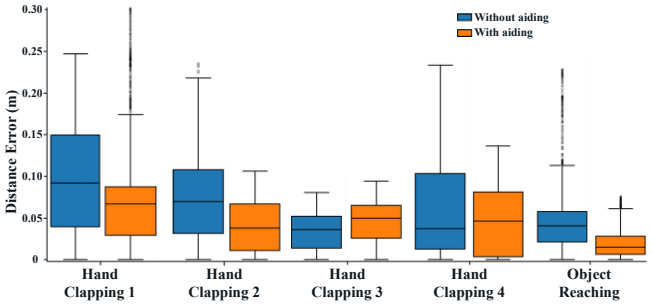

Figure 1: Absolute error (m) in inter-hand and object-hand distances across multiple trials with positional aiding from Ultimate trackers (orange) and without (blue).

Conclusions

Integrating HTC Vive Ultimate trackers with the Xsens MVN system enhances motion accuracy and consistency while eliminates drift, addressing a critical need when using IMC systems. This integration benefits ergonomic assessments and pave the way for broader adoption in dynamic and portable environments where positional accuracy is essential.

References

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