HoloMoCap: A Low-Cost Augmented Reality Motion Capture Application for HoloLens 2

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Summary

Low-cost, portable motion capture (MoCap) systems often lack the accuracy and real-time capabilities needed for clinical applications. To address these challenges, we present HoloMoCap [1], the first standalone MoCap application for HoloLens 2, enabling physiotherapists to receive real-time Augmented Reality (AR) feedback on patients' movements. Leveraging Deep Learning (DL) and marker-based MoCap, HoloMoCap accurately estimates hip and knee angles, offering a practical solution for clinical motion analysis.

Introduction

Gold-standard marker-based MoCap systems like Vicon are costly and lack portability, limiting their clinical adoption. Recent advancements in low-cost depth sensors and DL technology have enabled the development of affordable and portable marker-based MoCap solutions [2]. In this context, we propose the use of HoloLens 2 for low-cost MoCap.

Methods

The HoloMoCap application runs on HoloLens 2, worn by the physiotherapist while observing the patient (Figure 1). At each frame: **a)** IR and depth images are captured using the HoloLens 2 depth sensor to retrieve 3D marker coordinates. **b)** These coordinates are processed by an on-device DL model to automatically label each marker. **c)** Hip and knee joint angles are calculated using a modified Plug-in Gait model. Since HoloMoCap tracks only frontal markers, the sternum marker is used to estimate pelvic tilt. **d)** The system overlays virtual spheres and labels on the corresponding markers, providing real-time visual feedback to the physiotherapist.

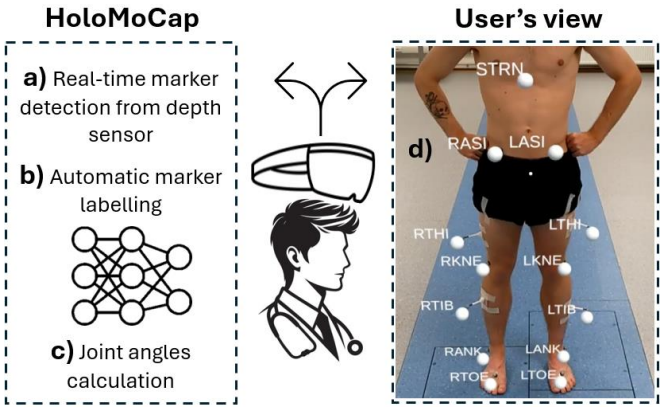

Figure 1: System overview.

HoloMoCap's joint angle accuracy was evaluated against concurrent Vicon measurements from 5 healthy test subjects performing squat and hip abduction exercises. Evaluation metrics included Pearson correlation, Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and MAE of the Range of Motion (ROM).

Results and Discussion

During testing, HoloMoCap operated consistently at 5 fps, and the model demonstrated a labeling accuracy of 100%. High accuracy was achieved across all joint angles (knee and hip flexion, abduction, and rotation) with RMSE and MAE values below 2° for most measurements. Table 1 reports the evaluation metrics for knee and hip flexion angles during squats, and hip abduction angle during hip abduction exercises. The higher errors in hip flexion estimation (RMSE > 5° and MAE of ROM >10°) stem from differences in pelvic orientation definitions: HoloMoCap relies solely on frontal markers, while Vicon uses both frontal and posterior (sacral) landmarks.

Table 1: Comparison of HoloMoCap's joint angles against Vicon.

Angle	Pearson	RMSE (°)	MAE (°)	MAE of ROM (°)
Knee Flex	1.0 ± 0.0	1.1 ± 0.6	0.9 ± 0.5	1.2 ± 0.7
Hip Flex	1.0 ± 0.0	6.0 ± 3.5	5.0 ± 2.9	13.4 ± 7.3
Hip Abd	1.0 ± 0.0	0.9 ± 0.7	0.7 ± 0.6	0.4 ± 0.2

Conclusions

HoloMoCap provides accurate, real-time joint angle estimations with a portable AR setup. However, to introduce the system into clinical settings, the low frame rate (5fps) remains a challenge.

Acknowledgments

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References

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