6dof EMob: Occlusion-Free 3D Position and Orientation Measurement Under Clothing

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Abstract

Measuring 3D human bodies under clothing remains a challenging problem due to occlusion. Yet, this is an ultimate goal of many human body measurement systems. In a recent breakthrough (Bolanos et al. 2024), we introduced a novel system called EMob for measuring under clothing using electromagnetic (EM) tracking. EMob utilizes remarkably small (as small as 1.8mm diameter) electromagnetic sensors that can be attached to the skin or hidden layers of clothing. A sensor (EMu, ElectroMagnetic unit) can be tracked at high rates (up to 960 fps, though we use 240 fps in our experiments) using a Polhemus electromagnetic tracking system.

However, the previous work only utilized the positions of these sensors. The electromagnetic sensors are capable of measuring orientations as well, enabling full 6 degree-of-freedom (6dof) tracking. In this work, we extend the EMob system to leverage both position and orientation data. This 6dof tracking significantly complicates the calibration process, as the electromagnetic sensors are subject to spatially varying distortions caused by environmental factors, which can lead to inaccuracies in both position and orientation measurements. We address this challenge by implementing a neural network that learns spatially varying corrections on SE(3), the group of rigid body transformations, to improve the accuracy of the EM tracking system. With our novel data-driven calibration, the EMob system can be effectively used in challenging environments, such as inside a 3D body scanner.

The 6dof EMob system offers numerous practical applications. Anthropometric landmarks can be accurately located under clothing during 3D body scanning and consistently tracked across different body poses. We have also successfully demonstrated the system's effectiveness in a real-world application, measuring and quantifying the relative motion between skin and clothing during dynamic activities.

Bolanos, L., Wyder-Hodge, P., Lin, X., & Pai, D. K. (2024). Measuring Human Motion Under Clothing. In SIGGRAPH Asia 2024 Conference Papers, Dec 3 (pp. 1-10).

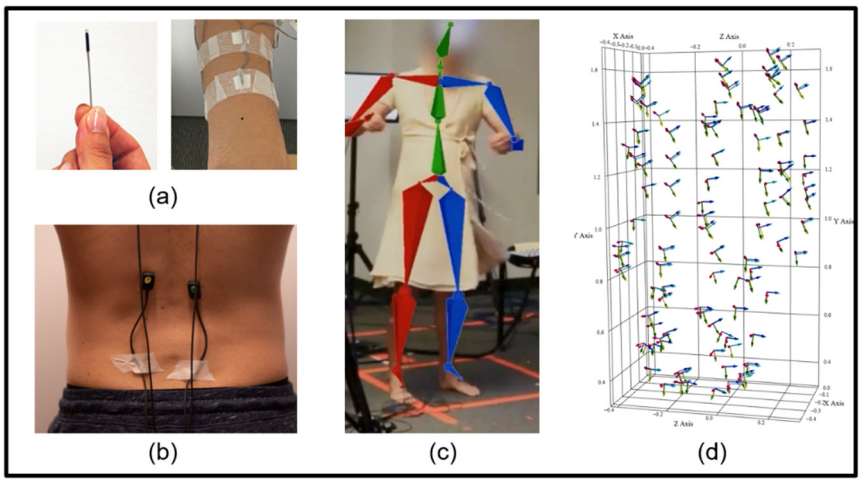

Figure 1: 6dof EMob system for measuring under clothing. (a) 1.8mm microsensor, shown taped on arm; (b) Larger sensors attached to the back; (c) Body skeleton/armature reconstructed using EMob; (d) A sequence of coordinate frames on an EMu captured within a Humanetics Vitus 3D body scanner in our lab, after calibration. Ground truth (RGB colored) frames were captured using a Vicon system; the EMu measured frame is shown in CMY colors and is very close the ground truth.