Magnetic Inertial 6-DoF Tracking

Hardware and Firmware Design for a Magnetic–Inertial Motion Tracking System

Student

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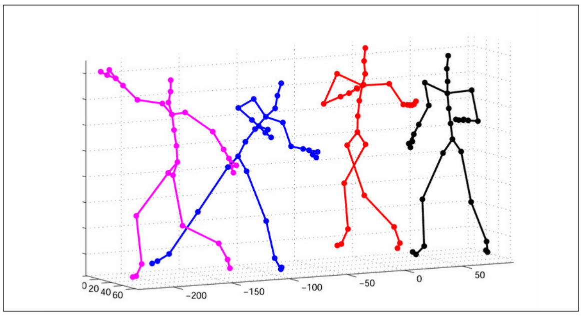
Introduction: This thesis presents the design and implementation of a magnetic–inertial six-degrees-of-freedom (6-DoF) motion tracking system. Potential application areas include medical fields such as physiotherapy and sports science, as well as robotics and virtual reality. To handle diverse motion behaviors, the system needs a high dynamic range while maintaining a compact, standalone, and wireless form factor. The objective of this work is to further investigate an existing magnetic positioning system developed in a previous bachelor's thesis at the Eastern Switzerland University of Applied Sciences (OST). The proposed approach combines low-frequency magnetic coupling with inertial measurements to enable robust motion tracking without line-of-sight requirements.

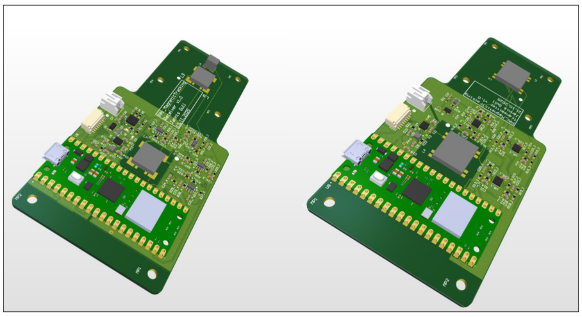
Approach / Technology: A compact transmitter–receiver hardware architecture based on triaxial coils and lock-in signal demodulation is employed. An application-specific integrated circuit (ASIC) enables direct extraction of in-phase and quadrature (IQ) components from sigma–delta modulated signals. An inertial measurement unit (IMU) complements the stable but noisy magnetic measurements by providing high-bandwidth acceleration and rotation data. Particular emphasis is placed on timing, synchronization, and phase stability. Experiments show that wireless time synchronization using wireless local area networks (WLAN) is insufficient for precise phase alignment. Consequently, an alternative phase measurement approach based on IQ signal extraction combined with pre-operational calibration is implemented.

Conclusion: The developed system enables stable signal extraction and reliable data transmission. A phase difference measurement with a standard deviation of 0.5° is achieved. The IMU is sampled at rates of up to 400 Hz, while magnetic measurements are performed at 10 Hz. Although full six-degrees-of-freedom position reconstruction is beyond the scope of this thesis, the presented results establish a robust basis for future research on real-time magnetic tracking and sensor fusion in wearable and indoor applications.

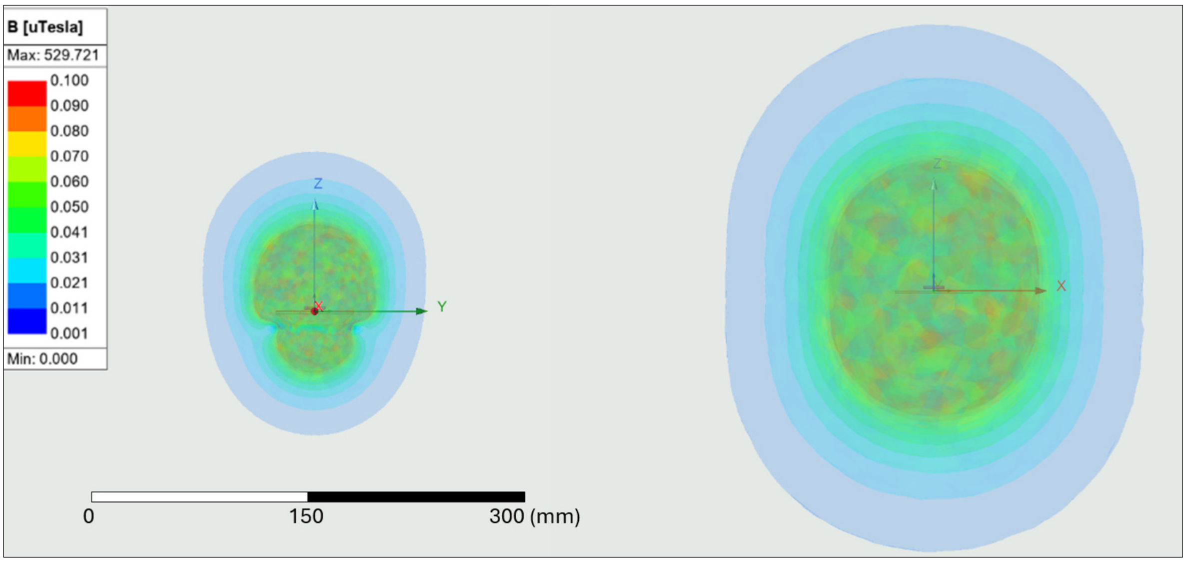
Example of human motion tracking without line-of-sight requirements.
https://viso.ai



Receiver (left) and Transmitter (right) PCBs.
Own presentment



Simulated magnetic field before (left) and after (right) layout modifications.
Own presentment



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Subject Area
Electrical Engineering