Positioning and Orientation using Three-Axis Magnetic Coils

Accurate Motion Tracking via Lock-In Amplifiers and Physical Model-Based Optimization

Graduate

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Introduction: The Institute of Communication Systems (ICOM) is developing a solution for accurately tracking body motion using wearable sensors that measure electromagnetic fields. As illustrated in Fig. 1, three orthogonally arranged transmitter coils generate alternating magnetic fields at different frequencies. These fields are detected at a distance by three identically arranged receiver coils, resulting in nine coupling signals. A dedicated algorithm then computes the receiver's position and orientation relative to the transmitter coils from these signals.

Approach / Technology: Each transmitter coil couples to all three receiver coils. After multiplexing, the received signals are processed by three lock-in amplifiers, each tuned to one transmitter frequencies, before being digitized. These lock-in amplifiers, designed by the Institute for Microelectronics, Embedded Systems, and Sensorics (IMES), provide amplitude and phase data, representing the nine coupling signals. An optimization algorithm then computes the relative position and orientation of the receiver coils using a physical model of the magnetic fields. A preceding calibration algorithm compensates for non-idealities such as filter frequency response, coil core properties, and asymmetry. Finally, a live visualization displays the position and angle of the receiver, as shown Fig. 2.

Conclusion: The system determines position with an accuracy of 2 mm over a distance of 4-10 cm between the transmitter and receiver coils, as observed in Fig. 3. Under optimal conditions, both accuracy and range can be improved. Furthermore, averaging measurements over 0.1 seconds results in a precision of 1mm while still maintaining sufficient dynamics for the desired applications.

Fig. 1: Illustration of three-axis coils generating and detecting magnetic fields for position and orientation tracking.
Own presentment

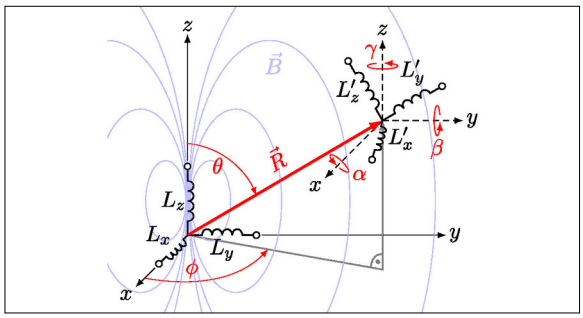


Fig. 2: Graphical visualisation of the position and orientation of the three-axis coils on the desktop computer.
Own presentment

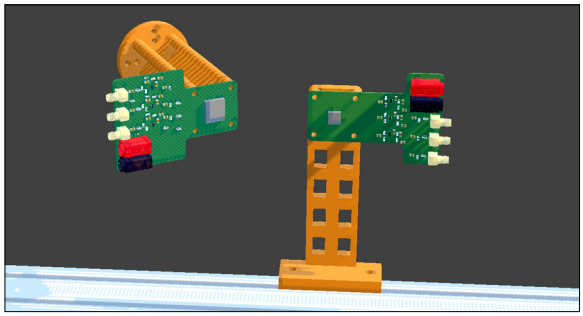
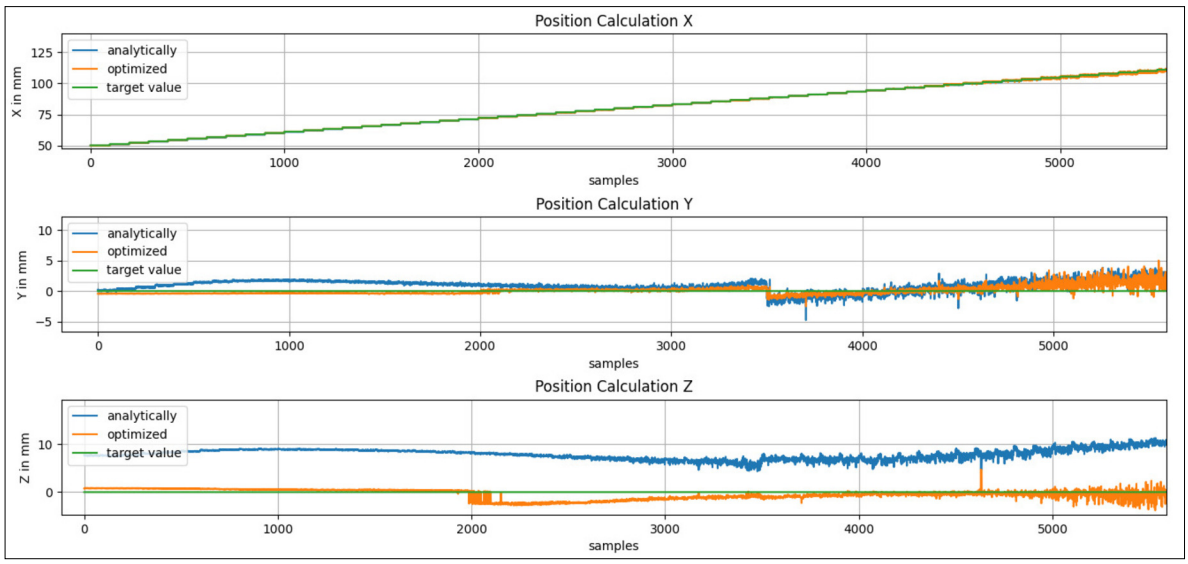


Fig. 3: Calculated (blue, orange) and expected position (green) at distances up to 10 cm.
Own presentment



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