PhD position

Versatile magnetic localization device for assisted surgery

Supervision:
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Host unit:
- ICube laboratory (EM3 research team) of the University of Strasbourg / CNRS
  https://icube.unistra.fr

Collaboration:
- University of Applied Sciences of Müttenz (Switzerland) – Institute for Medical Engineering and Medical Informatics
  https://www.fhnw.ch/plattformen/im2_projects/home/

Salary: 2,300 € gross salary (about 1800 € net salary) for 36 month

Starting date: 1st October, 2026

Context: Electromagnetic tracking (EMT) is a preferred technology used in many applications to determine, in real time, the precise position and orientation of objects—particularly in cases where optical methods are ineffective (due to lack of line of sight or low illumination), as is often the case in computer-assisted surgery. It is based on the principle of triangulation, which makes it possible to determine the object's position from the distance between a sensor embedded in the object and several external magnetic field generators (FGs). Although, in theory, three sources and one sensor are sufficient, it is often necessary to increase the number of sources in order to improve accuracy or expand the operational area. Since magnetic fields are spatially oriented, the use of a 3-axis sensor also makes it possible to determine the object's orientation. Furthermore, multiple sensors can be integrated into a single instrument to enhance precision and, more importantly, to facilitate orientation estimation.

The EM3 team of the ICube laboratory, in collaboration with FHNW (Fachhochschule Nordwestschweiz), has recently developed a new tracking system called ManaDBS, dedicated to deep brain stimulation (DBS) surgery. This technology relies on 3-axis anisotropic magnetoresistance (AMR) magnetic sensors and a field generator (FG) composed of four PCB coils generating quasi-static magnetic fields. The ManaDBS system can detect the position of a DBS electrode with 1 mm accuracy and its orientation with 1° accuracy within a 20×20×20 cm³ volume [1].

The main objective of this PhD is to pursue this line of research by developing, this time, a versatile system that can be applied to different types of surgical procedures.

Project description: The PhD project involved three main work packages.

Integrated System Design

The Integrated System Design work package focuses on the development and optimization of the magnetic localization device. The first main task involves designing a **system composed of an external magnetic field generator and magnetic sensors integrated directly into the surgical instrument**. The second task explores an alternative configuration in which the **field generator is embedded in the instrument while using external sensors**. Together, these tasks aim to identify the most effective and versatile system architecture, ensuring accurate localization while facilitating integration into different surgical tools and procedures.

Data Processing

The Data Processing work package aims to develop the computational methods required for accurate magnetic localization in the applicative context. The first task involves designing algorithms capable of **localizing either the sensors or the magnetic sources based on measured magnetic fields**. In parallel, a setup and protocol will be defined to perform **registration**, ensuring that the device's coordinates can be accurately mapped within the patient reference frame. A **registration algorithm** will then be applied to compute the device's position relative to the patient, enabling precise guidance during surgery. Techniques for spatial registration in medical imaging provide a relevant methodological foundation for this work [2].

Experimental Validation

The Experimental Validation work package will focus on the practical validation and performance assessment of the magnetic localization system. The first task involves the detailed **characterization of the measurement devices, including sensors and field generators, to quantify their accuracy, sensitivity, and stability under conditions relevant to surgical applications**. The second task will consist of **proof-of-concept** demonstrations using application-oriented phantoms, simulating relevant surgical environments to validate the complete localization workflow, from magnetic signal acquisition to spatial registration within the phantom reference frame [3].

References :

[1] Vergne, C., et al. (2022). Low-field electromagnetic tracking using 3-D magnetometer for assisted surgery. IEEE Transactions on Magnetics, 59(2), 1-5.
[2] Maintz, J.B.A., & Viergever, M.A. (1998). A survey of medical image registration. Medical Image Analysis, 2(1), 1–36.
[3] Vergne C., et al. , (2025). Electromagnetic tracking system for position and orientation detection of deep brain stimulation electrodes during surgery. IEEE Transaction on Biomedical Engineering, 72(6), 1973-1982.

Skills required
- Electronics (PCB design)
- Signal and data processing (python, machine learning)
- Prior experience in magnetic sensors / systems would be an asset.