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Challenges of Electromagnetic Tracking in Biomedical Navigation

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Electromagnetic technology is used in minimally invasive medicine for biomedical tracking and navigation. It finds applications in bronchoscopy, colonoscopy, orthopaedics, cardiovascular interventions, and in general in endoscopic procedures with flexible tools when a line of sight is not available. The main advantages of electromagnetic tracking (EMT) over other tracking solutions are the possibility of accurate and continuous tracking, the inherent safety, the absence of ionizing radiation, the small dimension of EMT systems and their affordable cost. However, magnetic field interference can cause a reduced tracking accuracy, making the system unstable and unreliable.

In general, conductive and ferromagnetic materials have an opposite effect on the tracking error, in that the former act like lenses that make the tracked target appear further, while the latter make it appear nearer. In this presentation, the working principle of EMT is exposed and the reason why different materials cause opposite tracking errors is explained. The effects of magnetic distorters that can be commonly found in the operating theatre are demonstrated and visualized, as results of real EMT experiments.

Many solutions for the magnetic distortion problem have been proposed over the last years. Some techniques, such as passive magnetic shielding or non-AC field excitation, are aimed to avoid or reduce the cause of distortion. Other methods perform an active distortion compensation, based on additional information, such as an undisturbed tracking system or redundant sensors. Some examples include the use of sensor arrays, simultaneous localization and tracking, corrections based on artificial neural networks, sensor fusion of inertial and magnetic sensors. The solutions employed by state-of-the-art EMT systems are reviewed, and the recent advances found in the scientific literature are reported. Finally, two new techniques are proposed, which make use of external medical patches and a handheld calibration tool respectively, to achieve intraoperative compensation of magnetic distortions.