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Abstract

Low-Frequency Magnetic Localization of Capsule Endoscopes with an Integrated Coil †

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Abstract: Wireless capsule endoscopy is a promising and less invasive alternative to conventional endoscopy. A patient swallows a small capsule with an integrated camera to capture a video of the gastrointestinal tract. For accurate diagnosis and therapy, the capsule position in terms of the travelled distance must be known for each video frame. However, up to now, there is no reliable localization method for endoscopy capsules. In this paper, a novel magnetic localization method is proposed. A coil as a magnetic field source is integrated into a capsule and fed with a low-frequency alternating current to prevent static geomagnetic field interference. This alternating magnetic field is measured by twelve magnetic sensors arranged in rings around the abdomen. The coil and the capsule batteries were designed based on the geometry and power supply of a commercially available endoscopy capsule and simulated by COMSOL Multiphysics software. In this way, the coil position and orientation were determined with an accuracy below 1 mm and 1 °, respectively. As an analytic model for the magnetic flux density of the coil in that setup, a modified dipole model was derived. It was used to show that the batteries help to increase the amplitude of the magnetic flux density. The model is valid when signals below 100 Hz are applied, and no eddy currents are generated within the batteries. It is concluded that the magnetic flux density generated by the developed coil would be measurable with state-of-the-art magnetic sensors.

Keywords: wireless capsule endoscopy; magnetic localization; coil design; low-frequency