Wireless Capsule Endoscopy technique: a numerical analysis of a telemetry system

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This work focuses attention on wireless capsule endoscopy (WCE), an innovative technology that uses a miniaturized capsule to explore the gastrointestinal tract without the need for traditional endoscopic instruments[1]. Inside the capsule are present several types of sensors, to detect important biological parameters (e.g., pH, pressure, temperature, intestinal gases). Typically, it is also equipped with one or more cameras, a data transmission system (i.e., a transmitter-TX antenna), and a battery. The capsule presented in this study is a model of a real prototype of 12 mm ×6 mm dimension. In this analysis step, the authors focused on the capsule featuring only the TX loop antenna, with outer and inner diameters of 6.2 mm and 5.7 mm, respectively. which sends the collected data with an external receiving antenna (RX) on the patient's hips[2]. The data collected by the RX antenna are subsequently processed for clinical purposes. The authors propose a TX-RX system configuration (see Figure 1) with an array of loop RX antennas mirroring the dimensions of the TX loop.

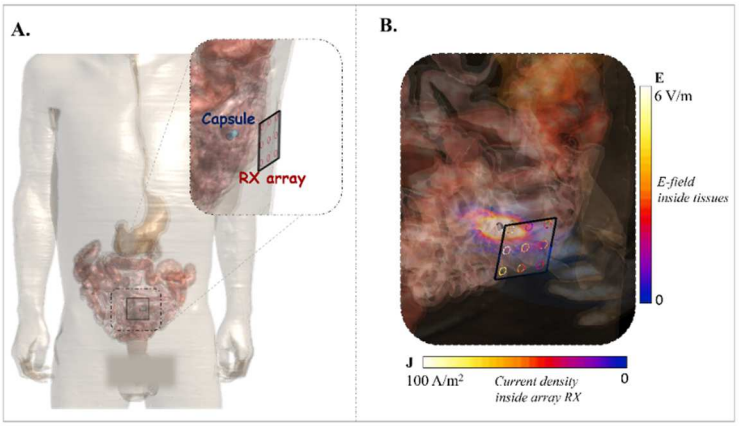

Figure 1. Capsule with TX antenna in the small intestine and a 10x10 mm array of RX antennas on the patient's body surface (A); Electric field (E) and current density (J) maps induced by the TX antenna in human tissues and RX array, respectively.

Figure 1 displays the capsule positioned in the small intestine, precisely centered and at the same height as the RX array. TX operates at 3.45 mW (maximum allowed power to compliance with the human safety reccomandentions[3]). As it can be seen, all RX loops receive a signal from the TX, showing a 99th percentile of induced current density (J) up to 250 A/m² in the loop located exactly at the TX. This preliminary analysis raises a crucial issue about the potential development of an on-body localization system by improving the displayed RX array. This system to date is one of the most studied aspects[4] within WCE.

Reference

1. Muhammad, K., Khan, S., Kumar, N., Del Ser, J. & Mirjalili, S. Vision-based personalized Wireless Capsule Endoscopy for smart healthcare: Taxonomy, literature review, opportunities and challenges. *Futur. Gener. Comput. Syst.* **113**, 266–280 (2020).
2. Neebha, T. M., Andrushia, A. D. & Durga, S. A state-of-art review on antenna designs for ingestible application. *https://doi.org/10.1080/15368378.2020.1821707* **39**, 387–402 (2020).
3. Std C95.1-2005. IEEE standard for safety levels with respect to human exposure to radio frequency electromagnetic fields, 3kHz to 300 GHz. 238 (2005) doi:0.1109/IEEESTD.1992.101091.
4. Castro, I. *et al.* Magnetic Localization of Wireless Ingestible Capsules Using a Belt-Shaped Array Transmitter. *Electron.* **12**, (2023).