DIFFERENTIAL MAGNETOMETRY TO DETECT SENTINEL LYMPH NODES IN LAPAROSCOPIC PROCEDURES

STATIC RESULTS

Melissa M. van de Loosdrecht [a,*], Sebastiaan Waanders [a], Erik Krooshoop [a], and Bennie ten Haken [a]
a Magnetic Detection and Imaging group, Faculty of Science and Technology, University of Twente, Enschede, the Netherlands
Correspondence to: m.m.vandeloosdrecht@utwente.nl

BACKGROUND

When a patient is diagnosed with cancer, it is important to know if the tumor has spread through the body. Sentinel node biopsies are used to determine if the tumor has spread via the lymphatic system [1]. Consequently, patient care will be personalized.

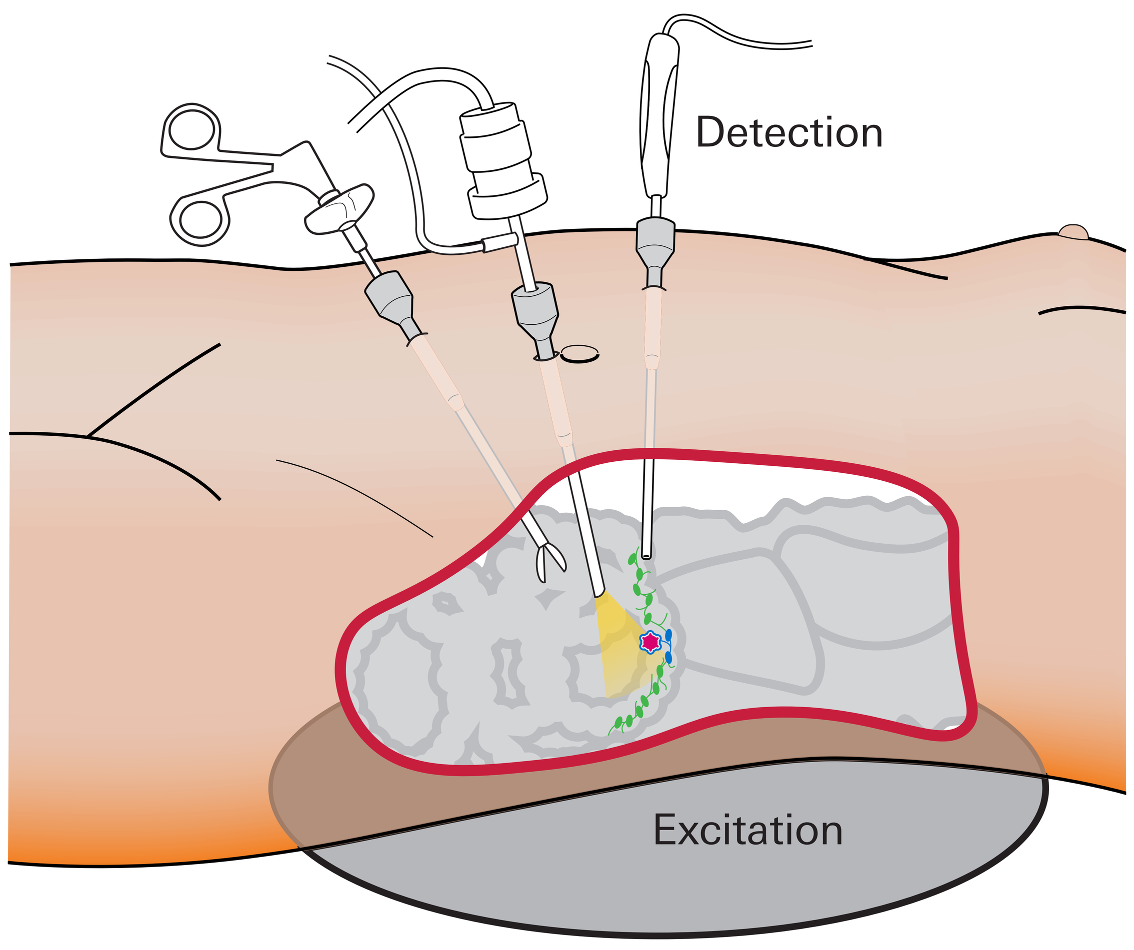

FIGURE 1 A novel laparoscopic probe for sentinel node biopsies. SPIONs are used as a tracer agent. Excitation and detection coils are mechanically separated to increase depth sensitivity.

PURPOSE

Our purpose is to locate superparamagnetic iron oxide nanoparticles (SPIONs) *in vivo* during laparoscopic surgery (**Figure 1**), using Differential Magnetometry (DiffMag) [2]. To achieve this, SPIONs are excited at a frequency between 1 and 10 kHz. To enable laparoscopic (minimally invasive) surgery, the diameter of the inserted instrument needs to be 12 mm or less. Therefore, the excitation and detection coils are mechanically seperated.

DIFFERENTIAL MAGNETOMETRY

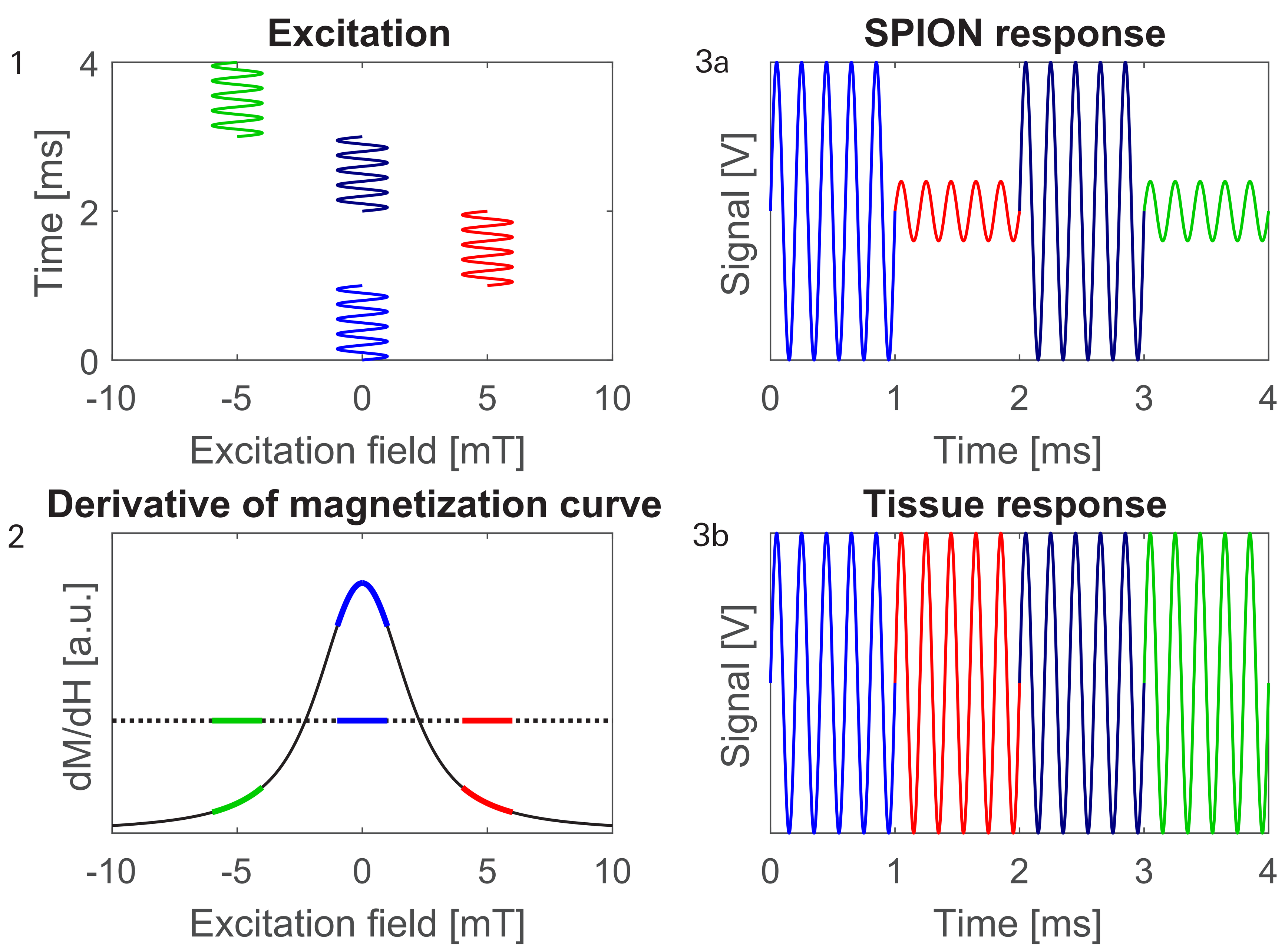

FIGURE 2 In DiffMag the nonlinear magnetization characteristics of superparamagnetic iron oxide nanoparticles (SPIONs) are exploited. The derivative of this nonlinear magnetization curve is shown in step 2, together with the linear diamagnetic magnetization of the human body. The first step in DiffMag is the excitation, which is achieved by applying a constant amplitude AC magnetic field and alternating DC blocks generated by a set of induction coils. The SPION signal is detected by a pair of detection coils in gradiometer configuration. Due to the nonlinearity, the amplitude changes between the different DC offsets (3a). Since the difference of the amplitudes is taken, the linear magnetization of tissue (3b) is discarded in the final DiffMag value. The amplitude of the AC field is approximately 1 mT, which is 1000x smaller compared to Magnetic Resonance Imaging and 10x smaller compared to Magnetic Particle Spectroscopy.

ACTIVE BALANCING

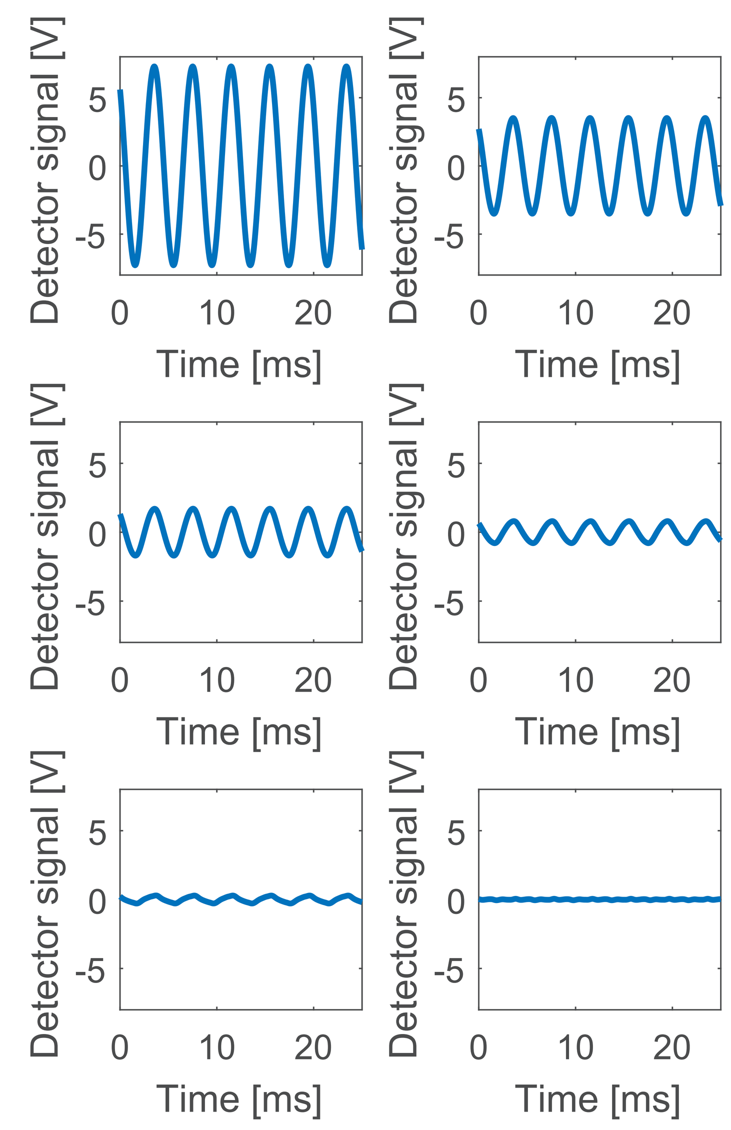

FIGURE 3 The main challenge of separating excitation and detection coils is a varying mutual inductance between these coils. Therefore, the detector signal is hindered by the excitation field. To avoid this, we use active balancing with compensation coils. This iterative process is demonstrated in this figure.

RESULTS

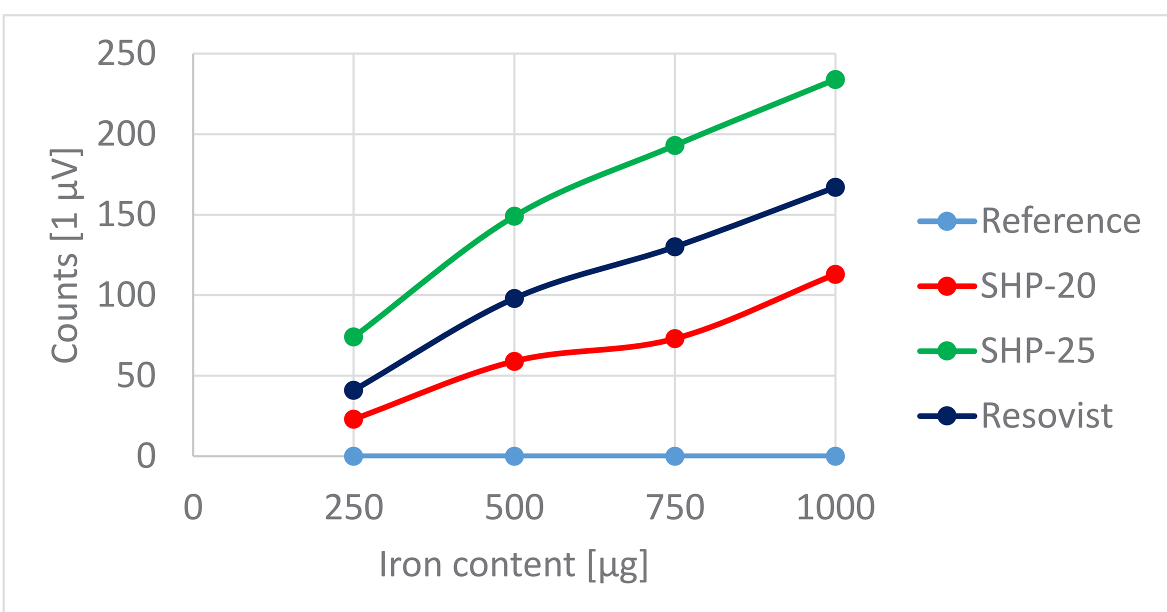

FIGURE 4 DiffMag measurements using our separate coil setup on three types of particles containing various amounts of iron. 20 DiffMag cycles were acquired with an AC amplitude of 0.5 mT, an AC frequency of 2.5 kHz, and a DC offset of 49.8 mT. The distance between the excitation and detection coils in this static setup was 5 cm and the sample was placed directly in front of the detection coils. This figure replaces results presented in the abstact, which have become obsolete.

DISCUSSION

Our next challenge is to enable movement of the detection coils. To achieve this, the active balancing algorithm will be implemented in the DiffMag protocol, allowing adjustments of the compensation signal during measurements.

CONCLUSION

These first results are promising for sentinel node biopsies, since it is possible to compensate for the excitation field and to measure small amounts of particles.

Acknowledgements
Financial support by the Netherlands Organization for Scientific Research (NWO), under the research program Magnetic Sensing for Laparoscopy (MagLap) with project number 14322, is gratefully acknowledged.

References
[1] A. E. Giuliano and A. Gangi, Breast J., vol. 21, no. 1, 2015.
[2] S. Waanders et al. Phys. Med. Biol., vol. 61, no. 22, pp. 8120–8134, Nov. 2016.

MD&I UNIVERSITY OF TWENTE.