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Emerging Technology

Wireless Electromagnetic Tracking with Sub-millimetre Accuracy for Image Guided Laparoscopic Procedures

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Introduction

Electromagnetic tracking (EMT) is beneficial in laparoscopic and endoscopic procedures for locating medical instruments inside the body without line-of-sight or ionizing-radiation based imaging.

Clinical need:
The wires required for conventional EMT can hinder surgical workflow and cause additional clutter in the OR.

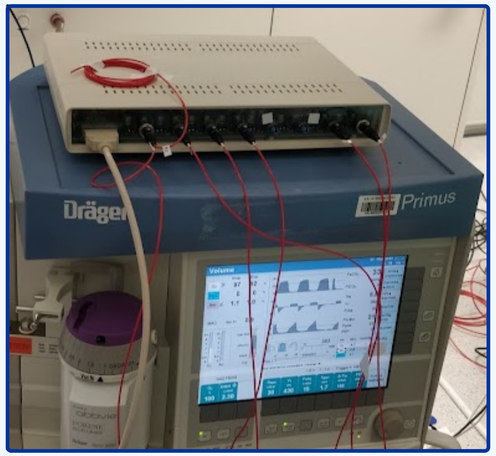


Figure 1: Sensor wires obstructing equipment while using the standard wired Anser EMT system.

A wireless sensor solution for EMT has been developed based on the open-source Anser EMT System (*UCC, Ireland*) [1].

References

[1] H. A. Jaeger et al., 'Anser EMT: the first open-source electromagnetic tracking platform for image-guided interventions', Int J CARS, vol. 12, pp. 1059–1067, Jun. 2017, doi: 10.1007/s11548-017-1568-7.
[2] M. Srivastava et al., "3D Position Tracking using On-chip Magnetic Sensing in Image-guided Navigation Bronchoscopy," in IEEE Transactions on Biomedical Circuits and Systems, Apr. 2024, doi: 10.1109/TBCAS.2024.3384016.

Methods

Design requirements:
1. Battery power with integrated charging and protection.
2. Precision analog circuitry.
3. Digital processing and Bluetooth optimization.
4. Small form factor.

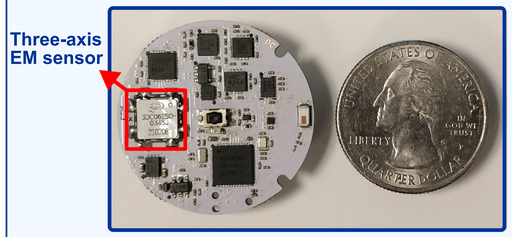


Figure 2: Wireless EMT sensor designed for use as CT-patient registration patch.

Testing
1. Static grid test with optical tracker as gold standard.
2. Compare with standard wired Anser sensor.
3. Breathing lung model dynamic evaluation.

Clinical Applications

Current version integrated in wireless patient-registration reference patch with reusable electronics enclosure and disposable adhesive backing.

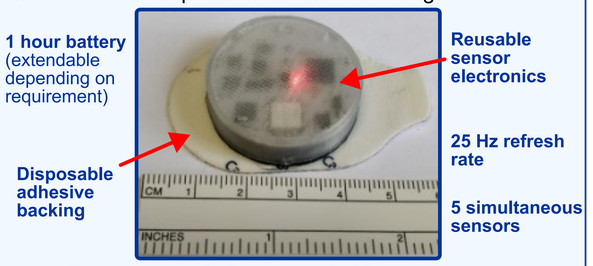


Figure 3: Wireless EMT sensor node for CT-patient registration.

Wireless sensor technology has immediate applications in wireless instrument tracking including:
- Flexible laparoscopic ultrasound
- Colonoscope tip tracking
- Laparoscope camera tracking

Future Work

Combining the wireless method introduced in this work with recent advances in on-silicon EMT sensors [2] will enable the design of capsule endoscopy cameras with integrated tracking.

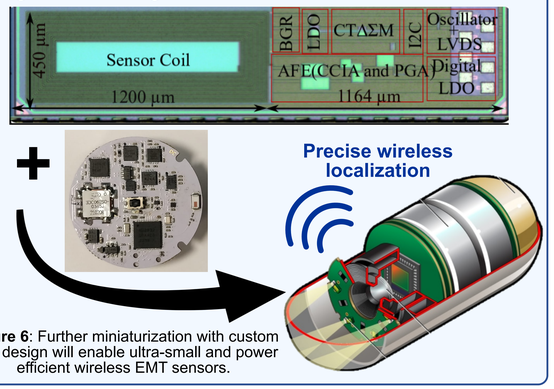


Figure 6: Further miniaturization with custom chip design will enable ultra-small and power efficient wireless EMT sensors.

Results

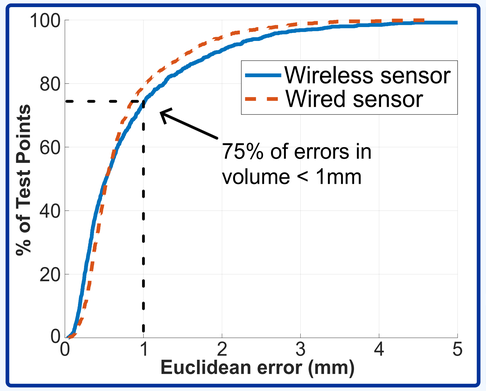
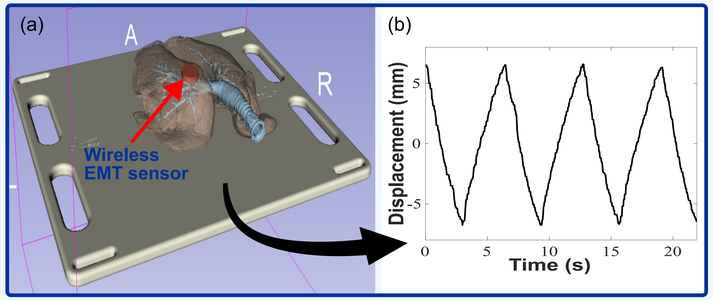


Figure 4: Static tracking volume test results.



Mean accuracy = **0.84 mm**
Precision = **0.29 mm**
Tracking volume = **40 x 40 x 35 cm**

Figure 5: Dynamic tracking results with breathing lung model showing (a) 3D Slicer scene view and (b) recorded respiratory motion from wireless sensor.

Conclusion

Wireless EMT will enhance the usability and practicality of tracking in applications such as endoscopy and laparoscopy. The sub-millimetre accuracy wireless sensor presented here will serve as the basis for future integration in wireless surgical navigation systems.

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