Distortion-free Magnetic Tracking of Metal Instruments in Image-guided Surgery

Eoin Higgins[1,2], Daragh Crowley[1,2], Christian van den Bosch[1,2], Pádraig Cantillon-Murphy[1,2]

[1]Tyndall National Institute, Cork, Ireland; [2]University College Cork, Ireland.

Email: eoin.higgins@tyndall.ie

Motivation

Laparoscopic instrument tracking offers significant potential in real-world training assessment (see Figure 1, [1]) and image fusion (Figure 2, [2]). The magnetic sensors used for instrument tracking are distorted by the metal of the instruments which, to date, has required complex mechanical solutions (see Figure 3, [1]) to separate the sensor from the metal.



Figure **1**: Imaging an abdominal phantom using fusion of magnetic tracking and ultrasound [1].

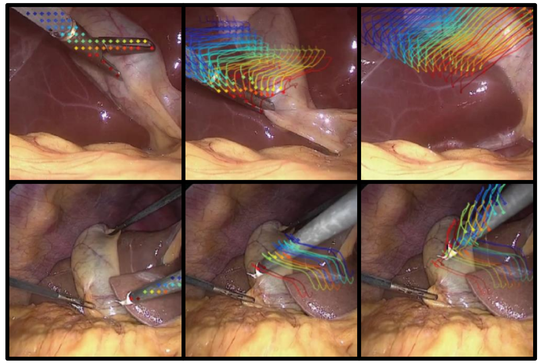


Figure **2**: Trajectories of tracked surgical instruments [2].

Methods

Our approach combined careful analytical calculations and electrical frequency selection of the transmitted signal to demonstrate accurate instrument tracking with a sensor inside the metal shaft.

Results

Mean tracking error of 1 mm is achievable for sensors inside stainless steel instruments with careful frequency selection. The achieved accuracy for different electrical frequencies and instrument diameters can be seen in Table 1.

Next Steps

Virtual visualisation (Figure 4), tool tracking and image fusion is now feasible with sensors inside metal instruments using magnetic tracking.

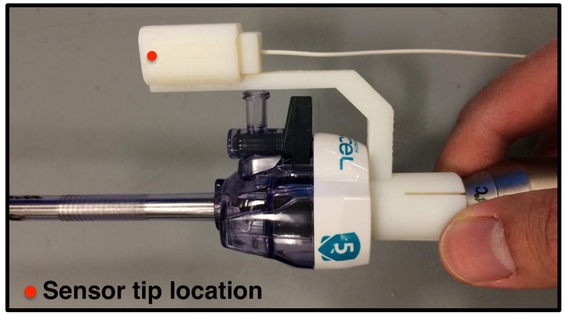


Figure **3**: A laparoscopic ultrasound probe with added structure to separate the magnetic sensor from the metal. Adapted from [1].

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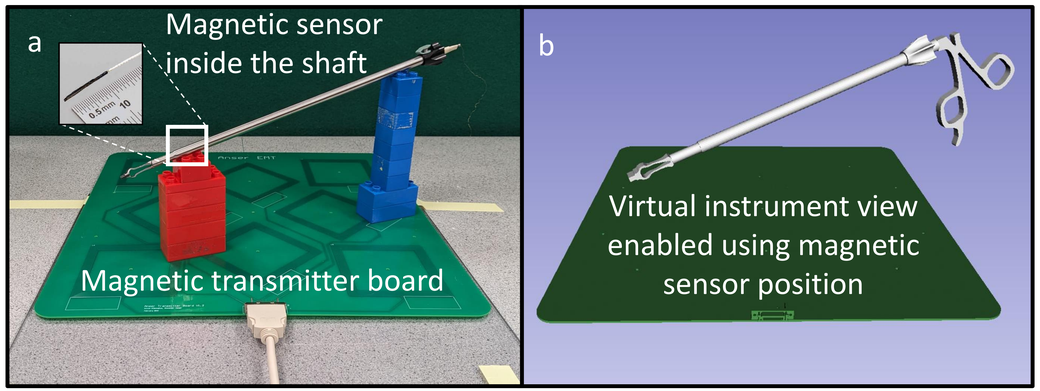


Figure **4**: The tracked laparoscopic graspers in (a) the real scene and (b) the virtual scene of 3D Slicer.

Table **1**: Accuracy for tracked surgical instruments.

Frequency [kHz]	Accuracy (8 mm outer diameter) [mm]	Accuracy (12 mm outer diameter) [mm]
1	1.1 ± 0.2	1.1 ± 0.3
5	1.0 ± 0.3	1.3 ± 0.3
10	1.4 ± 0.4	4 ± 1
15	2.3 ± 0.8	9 ± 2
20	11 ± 3.0	22 ± 5

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References

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