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The ARMM System: Demonstrating Clinical Feasibility in Steering Magnetically Actuated Catheters in Endovascular Applications

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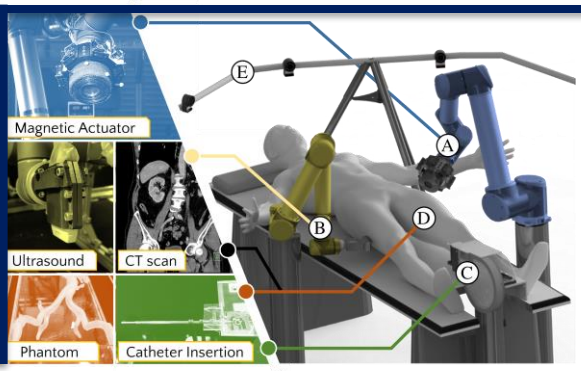
Introduction

- We introduce a fully-automated tracking and control algorithm of the Advanced Robotics for Magnetic Manipulation (ARMM) system. The aim is to demonstrate how such a system can be used to assist clinicians with the **magnetic actuation** of endovascular catheters.
- We plan to demonstrate **intra-operative collaborative control** of surgical robots using a clinically relevant phantom.

ARMM ADVANCED ROBOTICS FOR MAGNETIC MANIPULATION

The ARMM system



System integration

- The two surgical robots of the Advanced Robotics for Magnetic Manipulation (ARMM) system. The UR10 manipulator carries an electromagnet, (A) which actuates a magnetic endovascular catheter.
- The UR5 maneuvers an ultrasound (US) transducer (B) for intra-operative US imaging. Insertion is done autonomously by a catheter insertion device (CID) (C) into a clinically-relevant gelatinous phantom (D).
- An infrared tracking system (E) reconstructs the pose and tracks the motions of obstacles.

Clinically-relevant experiments

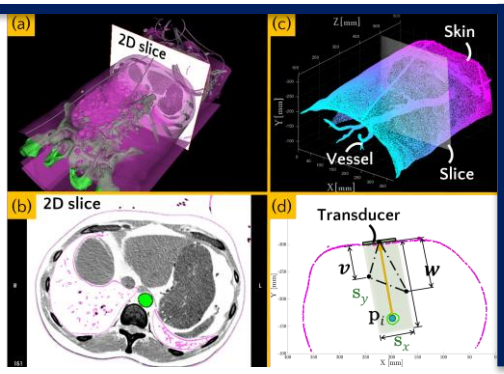
The experiments are approximate imitations of surgical interventions related to **targeted drug delivery** - a method to guide a magnetic, flexible catheter to a target region using a US-based template matching algorithm:

(a) Once a 3D target for the catheter tip is known, a DICOM slice is extracted.

(b) The 2D view of the extracted slice, with the artery masked in green, and the surrounding soft tissue in pink.

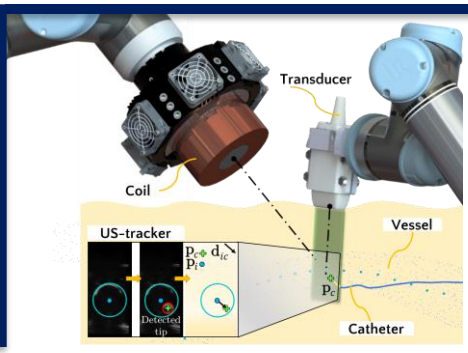
(c) The anatomical parts of interest are converted to a 3D point cloud set.

(d) The corresponding 2D point cloud representation is a result from combining XYZ data points at each target in a 2D slice.



Materials & Methods

Ongoing & Future Work



Expected results

- Autonomous magnetic steering of catheter tip ($\mathbf{p}_c$) to multiple user-defined 3D targets ($\mathbf{p}_i$) inside a realistic gelatin phantom is planned.
- The main contribution of the control strategy employed in the ARMM system is the ability to accurately account for the dynamics of both robotic arms, during endovascular surgery.
- This may be useful during **endovascular interventions** that require high accuracy target localization, smooth handling of surgical instruments, or making small incisions using robotic arms.
- Potential applications include: Targeted drug delivery, multiple surgical robots, advanced catheter ablation therapies, real-time motion tissue compensation.

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