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

Christoff M. Heunis, Jakub Sikorski, Guiherme Phillips Furtado, and Sarthak Misra

**Affiliations**

- All authors are affiliated with Surgical Robotics Laboratory, Department of Biomechanical Engineering, University of Twente, 7500 AE Enschede, The Netherlands.
- Sarthak Misra is also affiliated with the Department of Biomedical Engineering, University of Groningen and University Medical Centre Groningen, 9713 CZ Groningen, The Netherlands.

**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.

**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 URS 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 gelatious 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. The 2D view of the extracted slice, with the artery masked in green, and the surrounding soft tissue in pink.
- **(b)** The anatomical parts of interest are converted to a 3D point cloud set.
- **(c)** The corresponding 2D point cloud representation is a result from combining XYZ data points at each target in a 2D slice.
- **(d)**

**Materials & Methods**

**Expected results**

- Autonomous magnetic steering of catheter tip (p_t) to multiple user-defined 3D targets (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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