



Checkpoint Presentation

Team 9: Electromagnetic Tracking of Endovascular Catheters

Department of Computer Science | Johns Hopkins University | Baltimore, MD

Project Overview



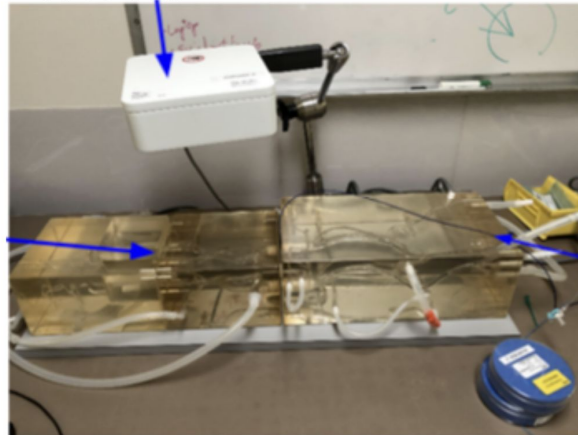
Motivation:

Endovascular navigation requires intraoperative fluoroscopy to real-time track the position of the catheter. We wish to eliminate the need of fluoroscopy through the use of electromagnetic tracking.



Aurora
Field Generator

Phantom



Catheter

Figure 1: current setup

Major Milestones

- ❑ **Catheter Prototype:**
 - ❑ Iteration 1 is ready
 - for data collection and algorithm verification
 - ❑ Design of Iteration 2 is approved. In the process of manufacturing
 - more suitable for clinical use
- ❑ **Registration Between EM and CT Frame**
 - ❑ Out of body fiducial point registration is complete
 - ❑ Nailed down method for in body path registration

Catheter Prototype – Iteration 1

Directly stick the EM 5-DOF sensor inside the catheter

- ❑ Pros: Easy to implement, provides enough functionality for data collection and algorithm verification
- ❑ Cons: The sensor is not highly securely attached to the catheter, leaves no space for other tools inside the catheter

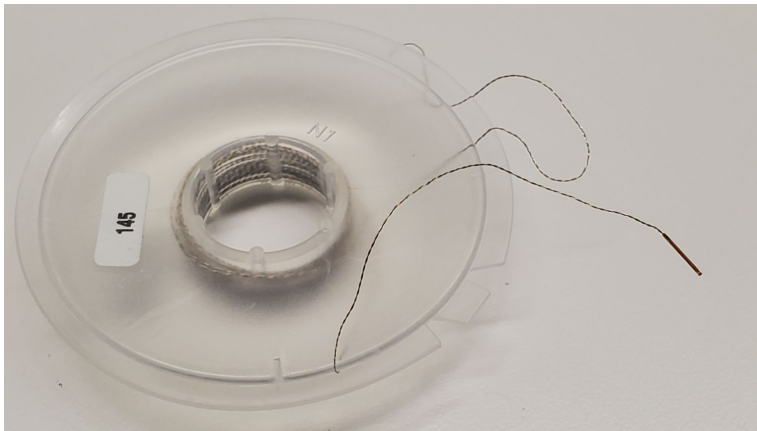


Figure 2: 5-DOF Sensor

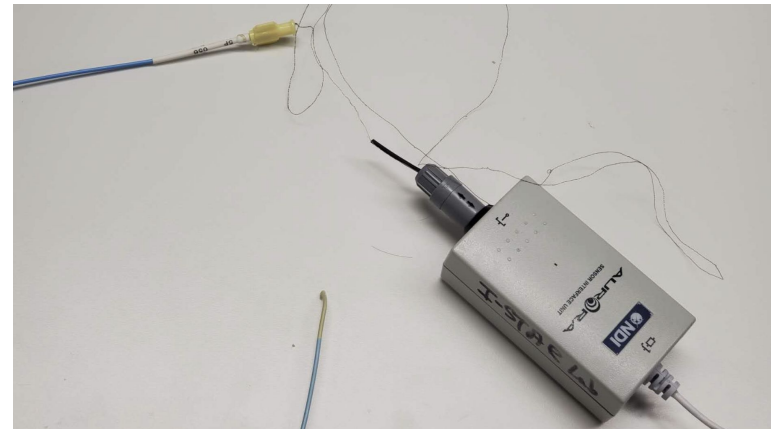
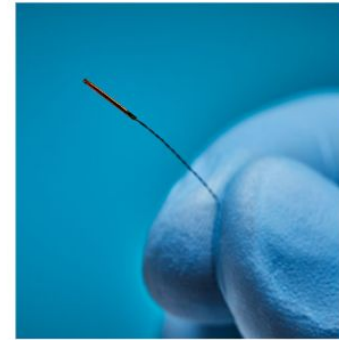
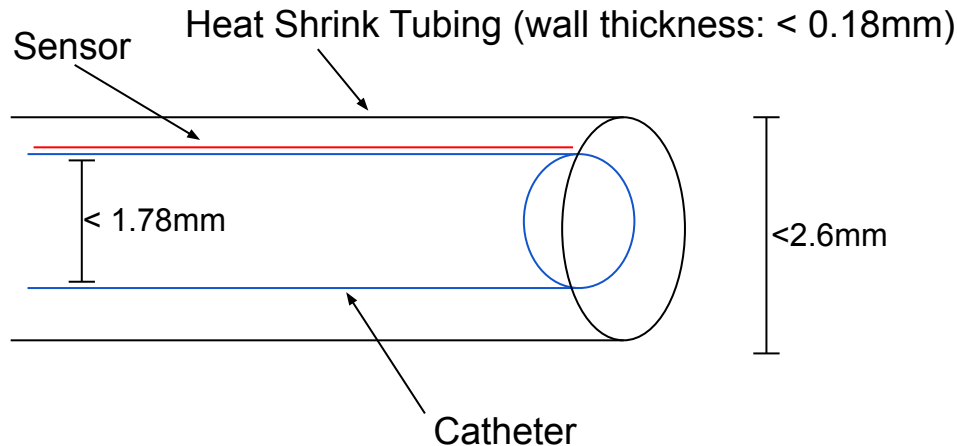


Figure 3: Catheter Prototype Iteration 1

Catheter Prototype – Iteration 2

Put the EM 5-DOF sensor outside the catheter and use heat shrink tubing to secure the whole system

- ❑ Pros: More suitable for clinical use, more robust compared to iteration 1
- ❑ Cons: Added extra thickness to the catheter



5-DOF Sensor
($\varnothing 0.45\text{mm}$)

Figure 4: Design of catheter prototype iteration 2

Registration – Fiducial Points

- ❑ Mark a series of points on the CT image using 3DSlicer Markup
- ❑ Place EM tracker at locations on the phantom corresponding to these points and record location
- ❑ Use Arun's method to compute a rigid transformation

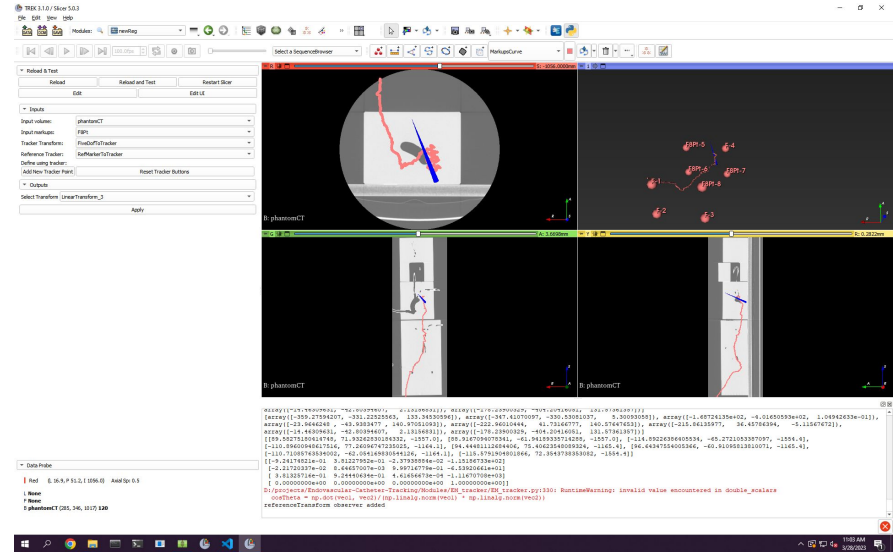


Figure 5: Fiducial registration workflow

Registration – Path Registration

- ❑ Use vtkm to find the vessel centerline of the region we are interested in in CT frame
- ❑ Treat the tracked path as the vessel centerline in EM frame
- ❑ Perform registration using CPD
- ❑ **Note:** The start and end points of the vessel center lines have agree

Deliverable Update

Minimum Deliverable	<p>Hardware prototype: A catheter prototype integrated with an EM sensor on tip, which can be used in phantom surgical studies.</p> <p>Evaluation Protocol: For evaluating the accuracy and robustness of EM catheter tracking.</p>
Expected Deliverable	<p>Software:</p> <ul style="list-style-type: none">- Path tracking based on EM data of the catheter tip- Registration between EM Tracker frame and CT frame (before catheter enters the body)- Curvature detection for going the wrong path- Visualization of the Path on a rough model of the primary catheter path fitted to the patient's physique.
Maximum Deliverable	<p>Software:</p> <ul style="list-style-type: none">- Registered tracking of the catheter path on cerebral CT angiography (after catheter enters the body)

Deliverable Update

- ❑ Pure path visualization is enough for surgeons to identify if the catheter is on the right path before catheter enters the chest
 - Navigating the catheter from the femoral artery to the aortic arch takes 2 seconds
 - If there is a 90 degree turn in the path, the catheter is in the wrong place

- ❑ Registration between EM and CT frame is more meaningful after catheter enters the chest
 - Scenario 1: Perform registration outside the body by placing the catheter at reference points. (Expected Deliverable)
 - Scenario 2: Perform registration inside the body using path based registration between catheter path and vascular shape. (Maximum Deliverable)

Timeline Update

		March	April	May	Completed
Catheter Prototype	Design				Completed
	Manufacturing Prototype: Iteration 1				Delayed
	Design Documentation: Iteration 1				As planned
	Manufacturing Prototype: Iteration 2				
	Design Documentation: Iteration 2				
Tracking Algorithm within Model	Setup Existing Path Tracking System				
	Evaluation Existing Path Tracking Result, Identify Room for Improvement				
	Path Visualization Documentation for Modification of Path Visualization and Coarse Model Registration				
	Path Visualization Algorithm Improvement				
	Evaluation of the improved path tracking Algorithm				
	Coarse Model Identification and Acquiring (Generic CT or single X-ray)				
	Path-to-Coarse-Model Registration Algorithm (Point Cloud)				
Registered Tracking on Brain CT	Evaluation of the Registration + Tracking Model				
	CTA data Identification and Acquiring				
	Non-rigid Path Registration Algorithm Documentation				
	Non-rigid Path Registration Algorithm for Brain CT (Coherent Point Drift)				
	Acquiring Cerebral Artery Phantom				
Evaluation of the CTA Registration Model					
UI Interface Design					
Project Report and Presentation					

Timeline Update

Major Delay in Path Visualization Algorithm

- May need to show precise orientation of catheter to improve user experience, not achievable with single 5-dof sensor
- Will discuss this Thursday with clinical mentor on precise requirement

