Advanced Computer-Integrated Surgery

Kick-Off: Design and Evaluation of a Bioelectric Guidewire

Erin Sutton

Feb 9, 2017

Computer Aided Medical Procedures

LIMBS LABORATORY

Technische Universität München

+

JOHNS HOPKINS WHITING SCHOOL of ENGINEERING

Advanced Computer-Integrated Surgery

Bioelectric Navigation

Computer Aided Medical Procedures

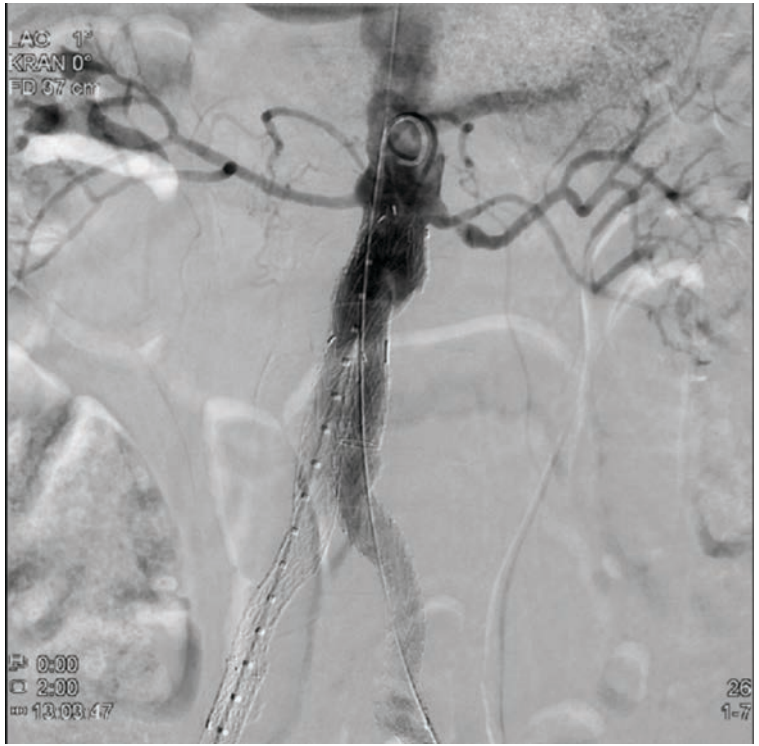
LIMBS LABORATORY

Technische Universität München

+

JOHNS HOPKINS
WHITING SCHOOL of ENGINEERING

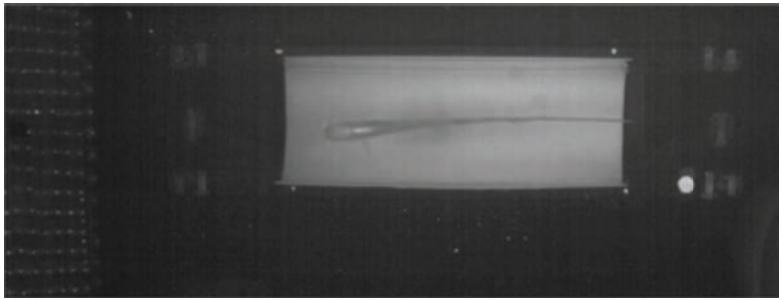
Clinical Need

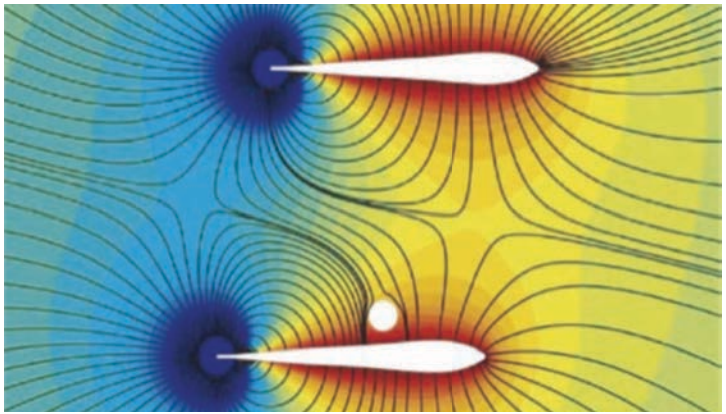


- 8 million intravascular procedures performed under fluoroscopy each year Schauer 2009
- Radiation dose equivalent to 250-3500 chest x-rays CDRH 2010
- Pediatric, pregnant patients especially vulnerable
- Technically challenging

Can we meet the technical challenges without radiation?

Inspiration

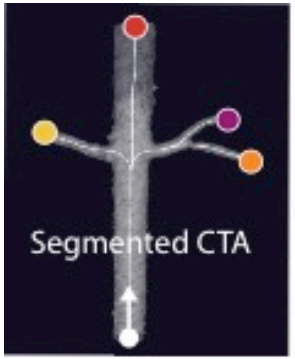


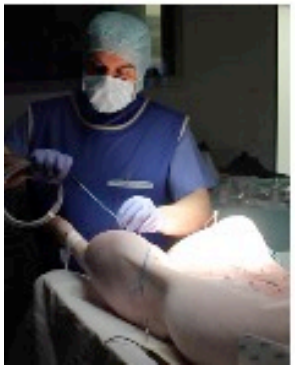


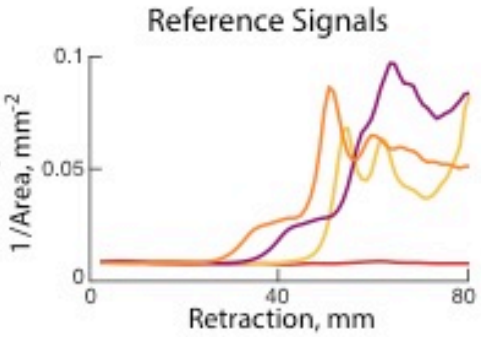
Stamper 2009

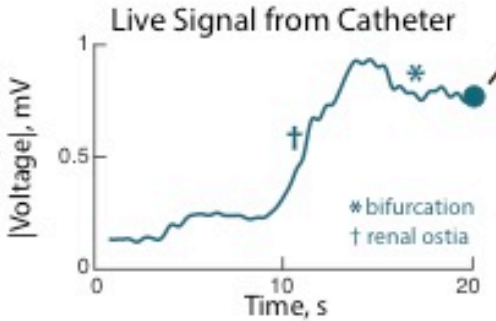
- electric fish use vision and electrosense to characterize and localize objects
- EOD creates electric field
- measure changes to electric field caused by objects of different impedance

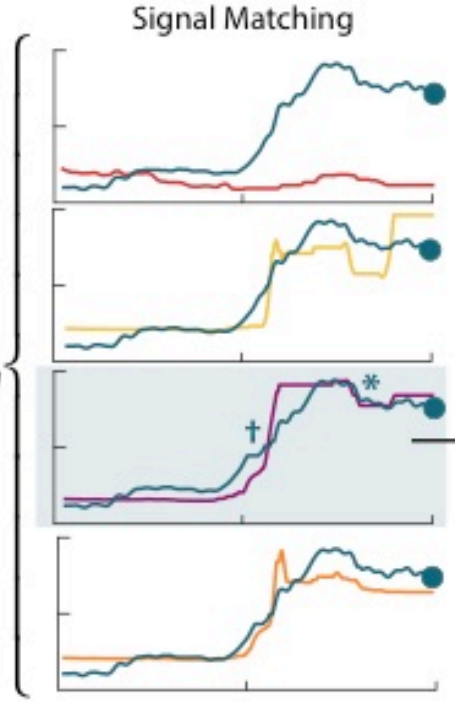
Bioelectric Navigation

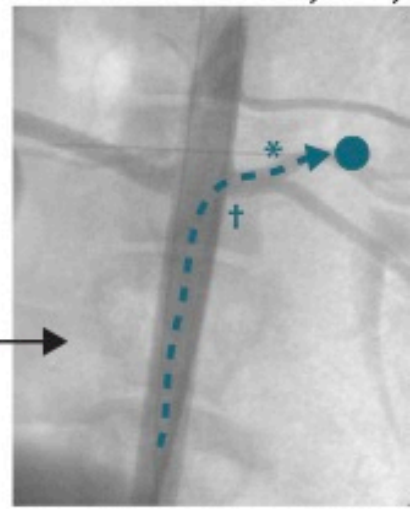




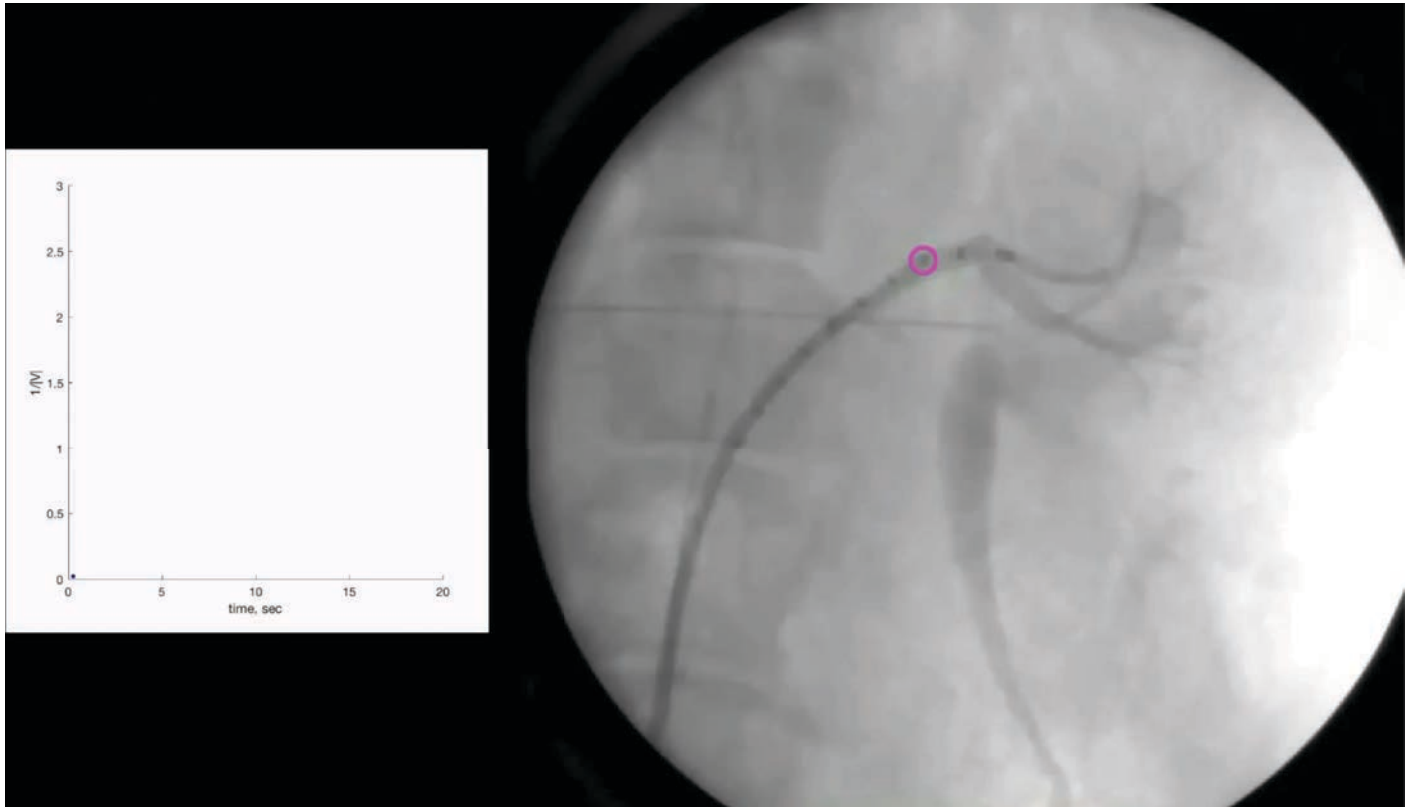








In Vivo Catheter Test



Advanced Computer-Integrated Surgery

Project and Team

Computer Aided Medical Procedures

LIMBS LABORATORY

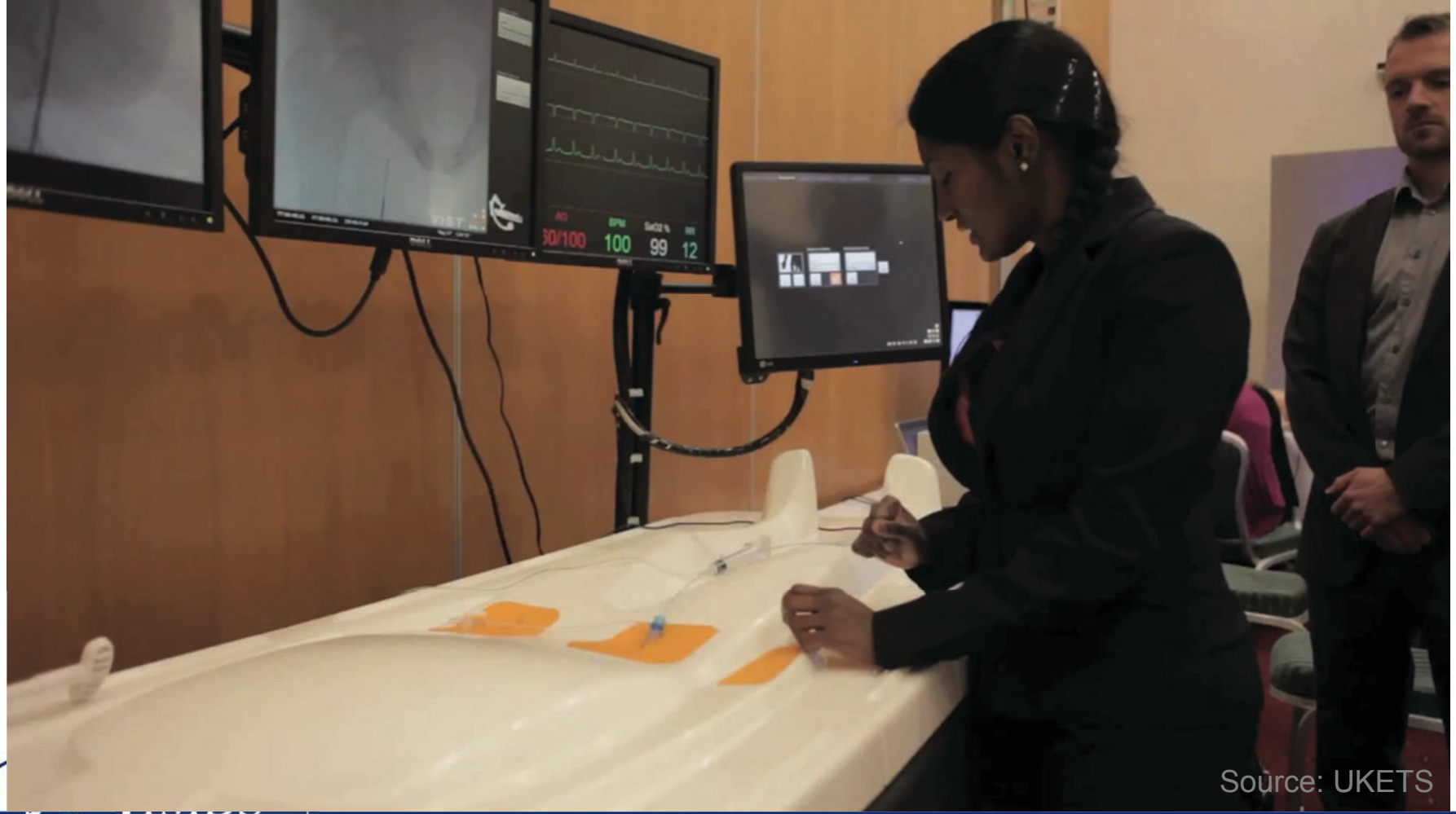
Technische Universität München

+

Johns Hopkins Whiting School of Engineering

Project Goal

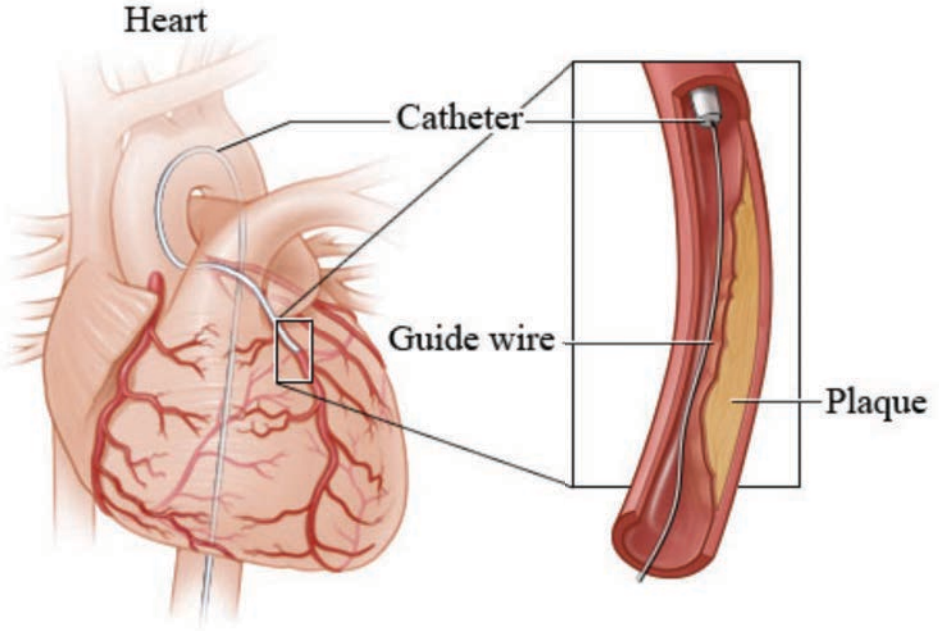
The state of the art for intravascular navigation is to first navigate a guide wire under fluoroscopy to the area of interest then advance a catheter over the guide wire. The current BN prototype uses a commercially available, non-irrigated 6F catheter, too large to be used as a guide wire. The goal of this project is to create a guide wire based on the BN technology.



Source: UKETS

Relevance

- Navigation is done with a guidewire, not a catheter
- Clinical collaborator specifically asked for guidewire to test navigation
- Integral to eventual adoption of technology for navigation



Team

- Erin Sutton

- Bernhard Fuerst
- Nassir Navab
- Noah Cowan

Source: Miller-Stephenson Medical

Advanced Computer-Integrated Surgery

Approach

Computer Aided Medical Procedures

LIMBS LABORATORY

Technische Universität München

+

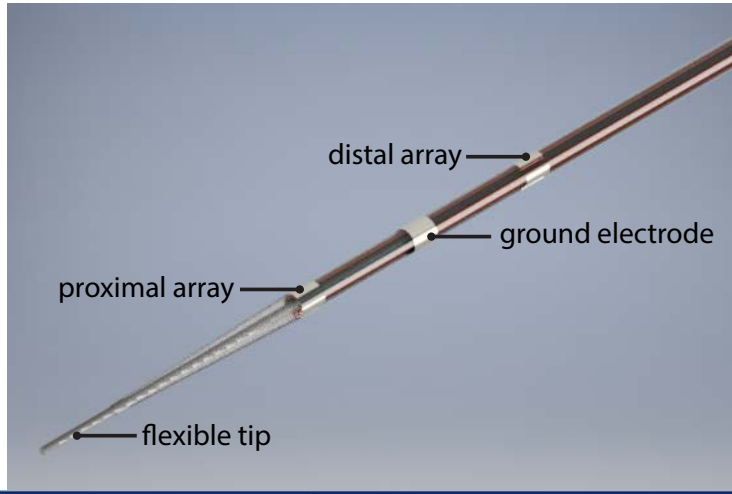
Johns Hopkins Whiting School of Engineering

Approach

- Research guidewire construction
- Simulate 3-electrode guidewire in COMSOL
- Design guidewire
  - Define design constraints
  - Fully develop at least 3 designs
  - Perform decision analysis with mentors to pick design
  - Improve embodiment design
  - BOM
- Build guidewire
- Test guidewire in acrylic phantom
  - Measure voltage as guidewire passes through all paths
  - Use video as ground truth
  - Compare results with catheter's performance
  - Detect branches as small as 2 mm

Deliverables

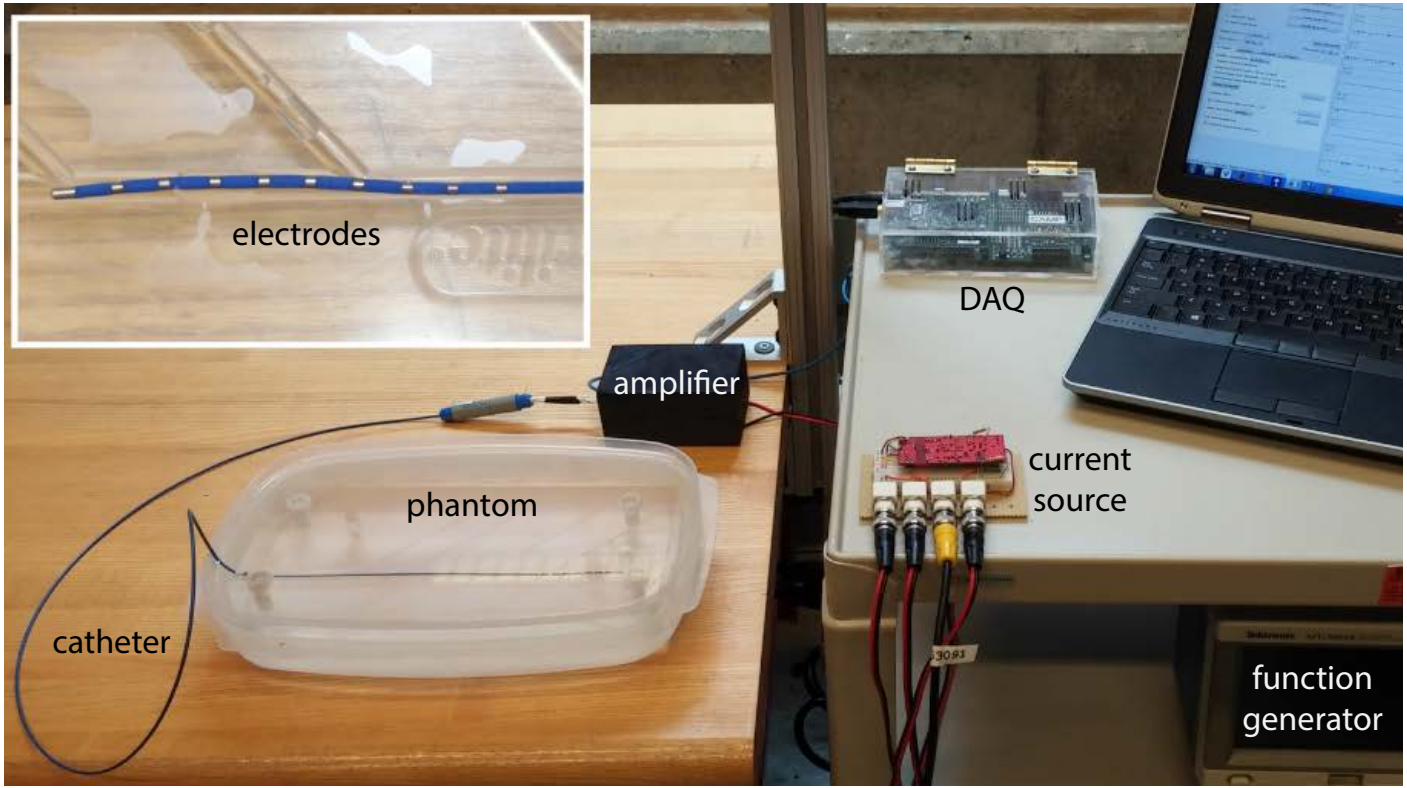
- Weekly meeting with other CAMP CIS II projects
- Project Plan report and presentation ← Feb 9
- Simulation (COMSOL) of 3-electrode guide wire
- Seminar presentation and critical review ← Mar 7
- Replacement of current sources
- CAD design of guide wire, including BOM
- Checkpoint presentation ← Mar 30
- Working guide wire prototype
- Experiment design report ← Apr 5
- Experimental validation
- Final report and presentation ← May 16



Dependencies

- Not sure how to solder stainless steel to platinum – ask Iulian and Noah
- May have trouble sourcing small enough heat shrink tubing – either don't coat wire for this experiment or look into specialty polymer manufacturers
- Many other responsibilities this semester (grant, paper, thesis) – delay construction until grant and paper are out, guidewire important part of thesis

Experimental Setup



Reading List

- University of Wisconsin-Madison. [UW Health]. (2015, Feb 17). *Endovascular Repair for Aortic Aneurysms*. [video]. Retrieved from https://youtu.be/Y2a_cYvpf_U.
- Fazel, R., Krumholz, H., Wang, Y., Ross, J., Chen, J., Ting, H., Shah, N., Nasir, K., Einstein, A., and Nallamothu, B. (2009). Exposure to low-dose ionizing radiation from medical imaging procedures. *N Engl J Med*, 361(9):849-857. PMC3707303.
- Von der Emde, G., Schwarz, S., Gomez, L., Budelli, R., and Grant, K. (1998). Electric fish measure distance in the dark. *Nature*, 395(6705):890{894.
- Svendsen, M. C., Choy, J. S., Ebner, A., Bigelow, B., Sinha, A., Moussa, I., Akingba, A. G., and Kassab, G.S. (2014b). A lumen sizing workhorse guidewire for peripheral vasculature: Two functions in one device. *Cathet Cardiovasc Intervent*, 83(1):E85E93.
- Condino, S., Ferrari, V., Freschi, C., Alberti, A., Berchiolli, R., Mosca, F., and Ferrari, M. (2012). Electromagnetic navigation platform for endovascular surgery: how to develop sensorized catheters and guidewires. *J Med Robotics Comput Assist Surg*, 49(2):344-356.

References

- D.A. Schauer and O.W. Linton. NCRP Report No. 160, Ionizing radiation exposure of the population of the United States, medical exposure–are we doing less with more, and is there a role for health physicists? *Health Phys*, 97(1):1–5, 2009.
- Center for Devices and Radiological Health. Initiative to reduce unnecessary radiation exposure from medical imaging. *US Food and Drug Administration*, Feb 2010.
- Stamper, S., Roth, E., Cowan, N., and Fortune, E. (2012). Active sensing via movement shapes spatiotemporal patterns of sensory feedback. *J Exp Biol*, 215(9):1567-1574.
- UK Endovascular Trainees. [UKETS]. (2013, June 26). *Cardiac Catheterisation Part 1 – Left Coronary*. [video]. Retrieved from https://youtu.be/zF8jk_F9Beo.