Advanced Computer-Integrated Surgery

Checkpoint: Bioelectric Guidewire

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Computer Aided Medical Procedures
LIMBS LABORATORY
Technische Universität München
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JOHNS HOPKINS WHITING SCHOOL of ENGINEERING

Team

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- Noah Cowan

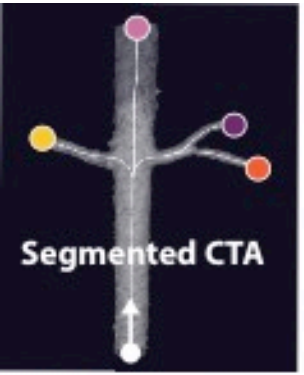
Source: Miller-Stephenson Medical

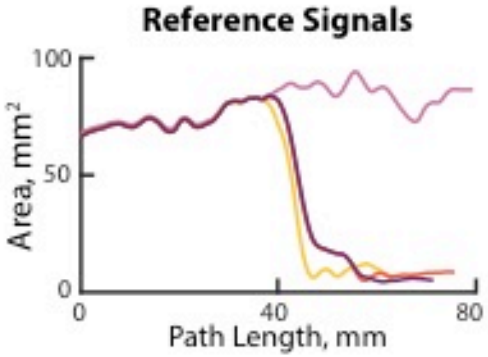
Clinical Need

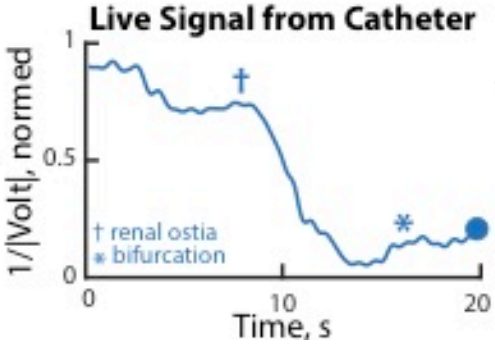
- 8 million intravascular procedures performed under fluoroscopy each year Schauer 2009
- Radiation dose equivalent to 250-3500 chest x-rays CDRH 2010
- Pediatric, pregnant patients especially vulnerable
- Technically challenging

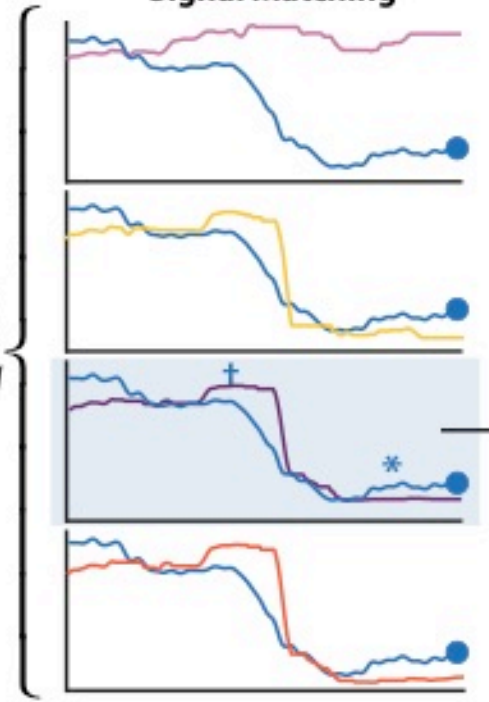
Can we meet the technical challenges without radiation?

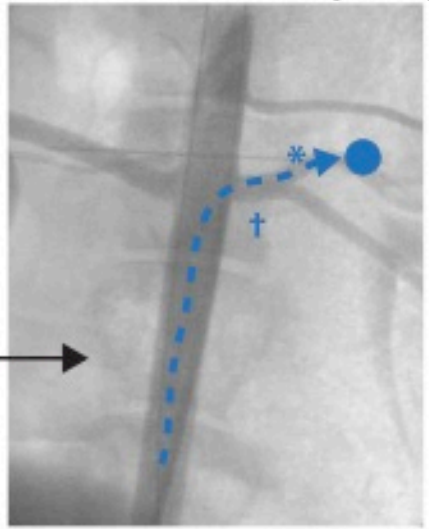
Bioelectric Navigation









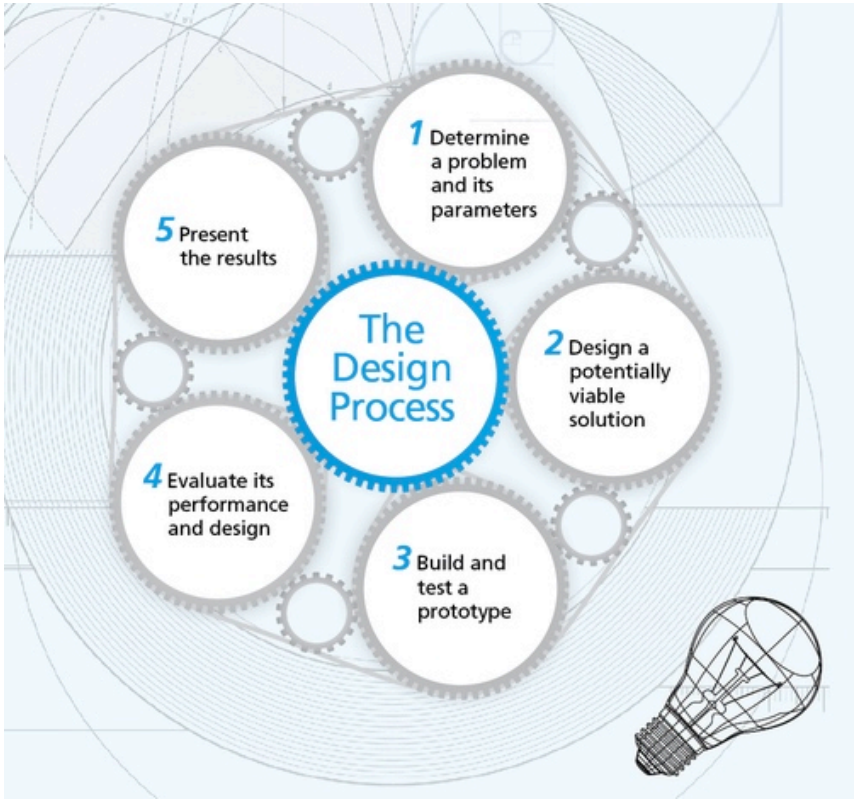


Project Goal

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

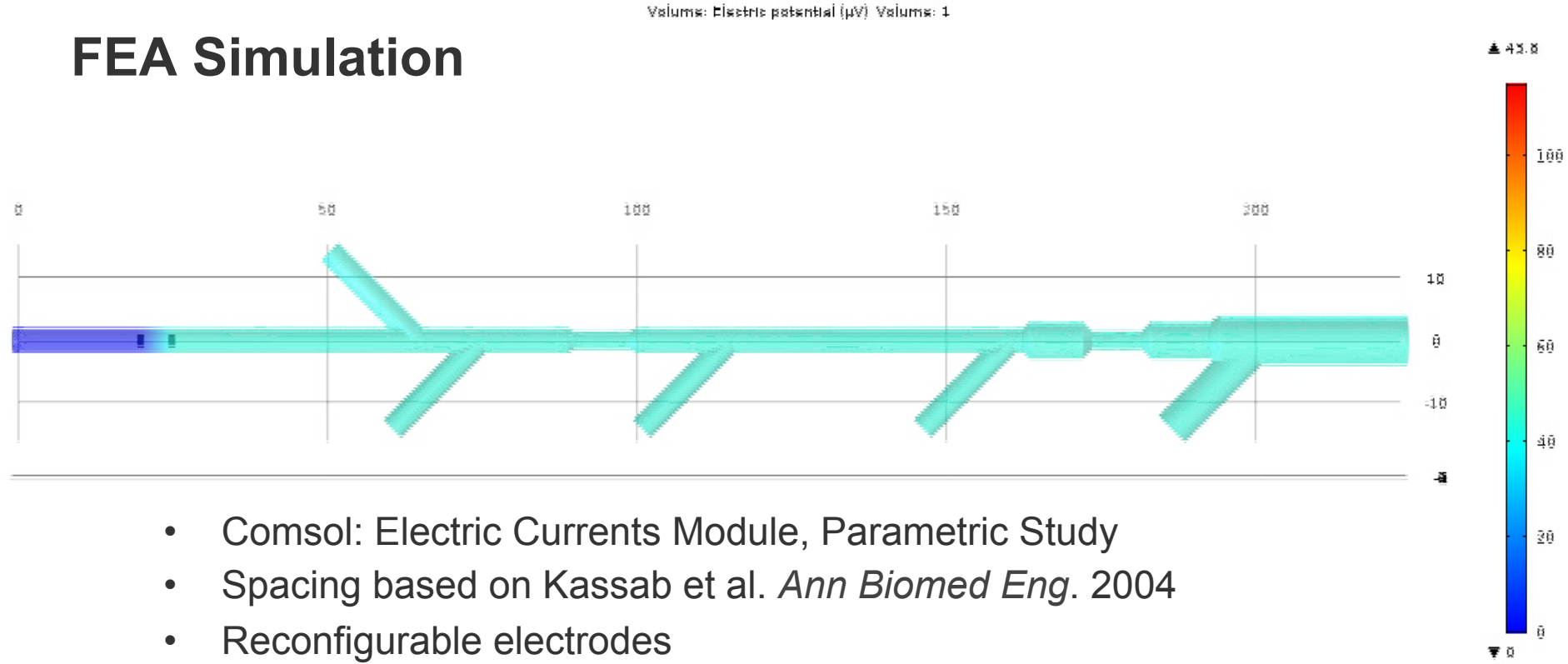
Work Plan

- Research guidewire construction
- Simulate 3-electrode guidewire
- 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



Source: Assist Development

FEA Simulation



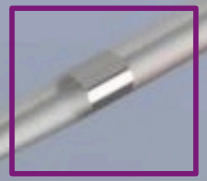
- Comsol: Electric Currents Module, Parametric Study
- Spacing based on Kassab et al. *Ann Biomed Eng*. 2004
- Reconfigurable electrodes

Guidewire Designs

"Spring"
- Spring soldered to copper wire

Polyethlene tubing

"Cylinder"
- Copper wire soldered to Pt cylinders



"Braid"
- Copper braid wound around core
- Selectively exposed wire

0.014" guidewire core

Decision Analysis

Patents, literature

Custom vs off-the-shelf, my skills, available tools

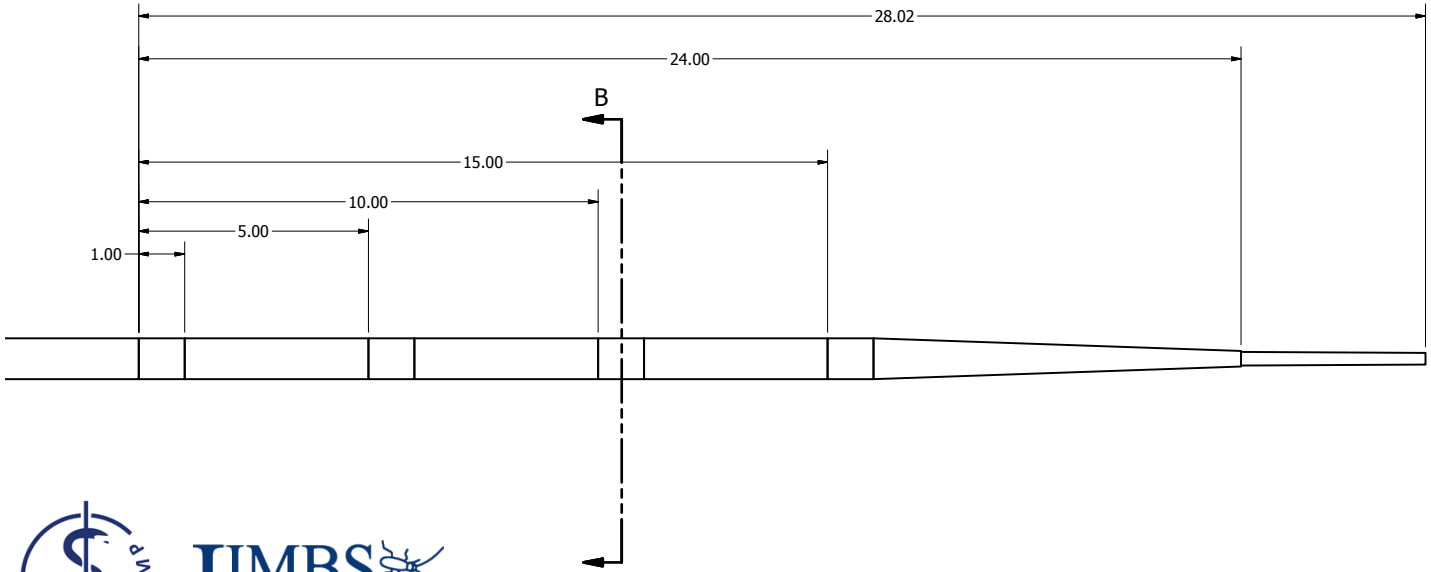
Electrode/wire connection, corrosion

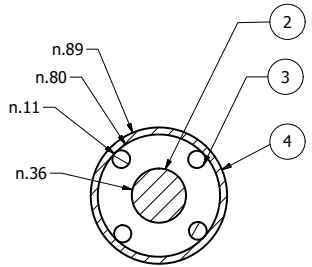
Repeated bends in tortuous paths

	Weight	Cylinder		Spring		Braid	
		Raw	**Weighted**	Raw	**Weighted**	Raw	**Weighted**
Evidence	5	10	**50**	7	**35**	3	**15**
Ease of Manufacture	4	5	**20**	8	**32**	6	**24**
Durability	4	8	**32**	4	**16**	3	**12**
Flexibility	3	5	**15**	7	**21**	7	**21**
Electrode Surface Area	5	10	**50**	6	**30**	3	**15**
Total			**167**		134		87

Embodiment Design

- 0.014” guidewire core
- 0.035” Pt cylinders
- 34 AWG coated stainless steel wire





SECTION B-B
SCALE 40 : 1

Dependencies

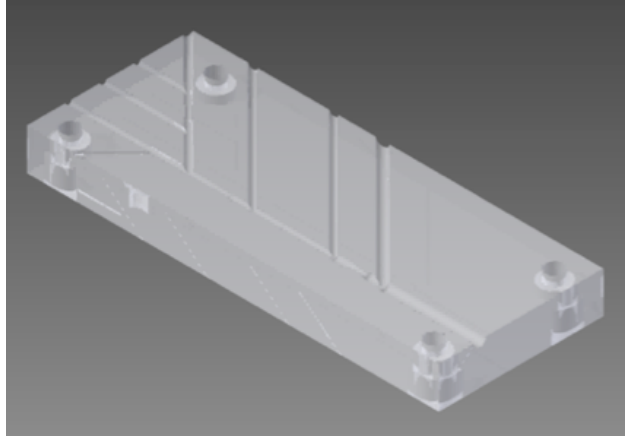
Dependency	Status
How to solder steel to Pt?	Resolved – not difficult
Difficult to source small diameter heat shrink	Resolved – 0.5 mm sufficient
I'm not supposed to operate x-ray machine	Resolved – canceled gelatin experiment

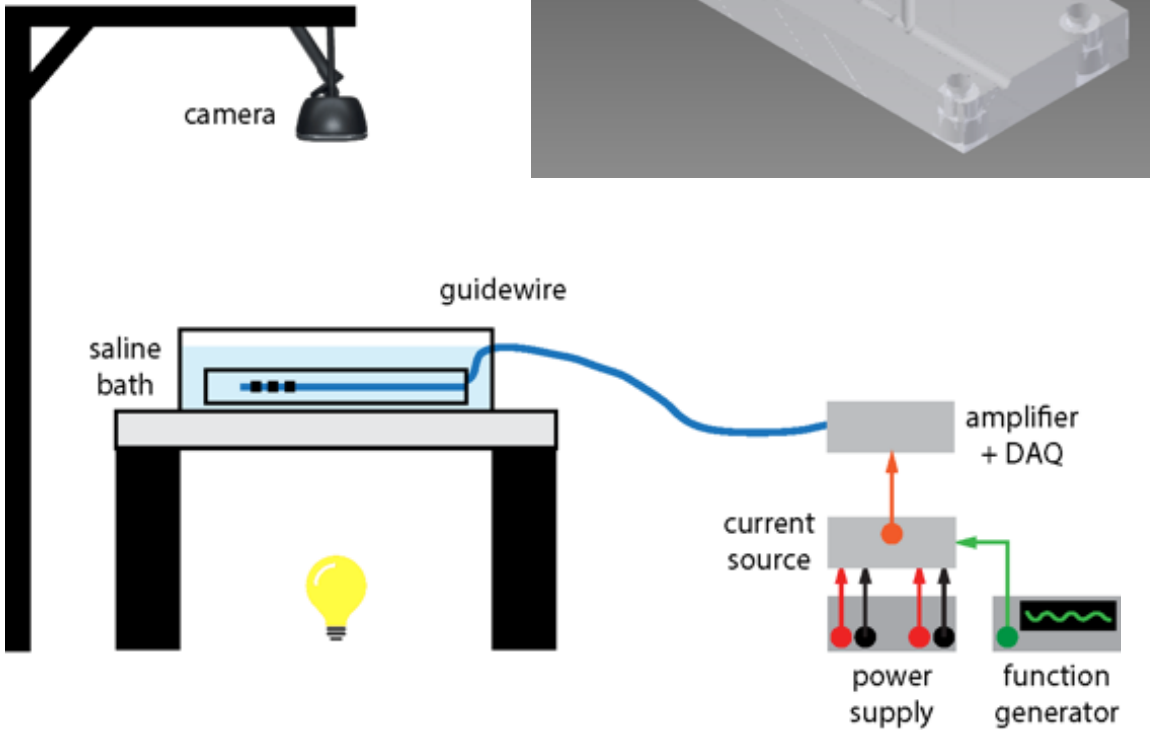
Other challenges:

- Constant current sources delayed at manufacturer, so I made a breadboard version
- Only 10 Pt cylinders, so I will make a 2-electrode guidewire to enable more prototypes

Experimental Plan

- phantom in 0.9% NaCl bath
- camera records guidewire trajectory as it is drawn through 6 paths at 1-2 mm/s
- signal to input electrode is ±5 mV at 730 Hz at constant 18 μA
- voltage between electrodes amplified and filtered
- DFT and matching in Matlab





Minimum	Expected	Maximum
Project Plan report and presentation		
simulation with single stenosis	simulation in phantom's main path	simulation with several electrode configurations
repaired current sources	replacement current sources	design for new current source
CAD design of a single guidewire	several CAD designs for guidewire	
Checkpoint presentation		
working guidewire prototype		
experiment design report		ACUC submission for i*n vivo* test
experimental results from acrylic phantom study		~~results from experiment in gelatin phantom~~
Final report		

Schedule

	17-Feb	24-Feb	3-Mar	10-Mar	17-Mar	24-Mar	31-Mar	7-Apr	14-Apr	21-Apr	28-Apr	5-May	12-May	19-May
write Project Plan	21-Feb													
read articles														
simulate guidewire														
make seminar presentation			2-Mar											
create 3 design alternatives														
write critical review														
source materials														
repair current sources														
build prototype														
write experiment design report								5-Apr						
write checkpoint presentation									11-Apr					
experiment, acrylic phantom														
analyze data														
~~make gelatin phantom~~														
~~experiment, gelatin phantom~~														
~~analyze data~~														
design in vivo test														
write final report														18-May
make poster														18-May

original plan

new plan

completed

References

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Thanks!

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