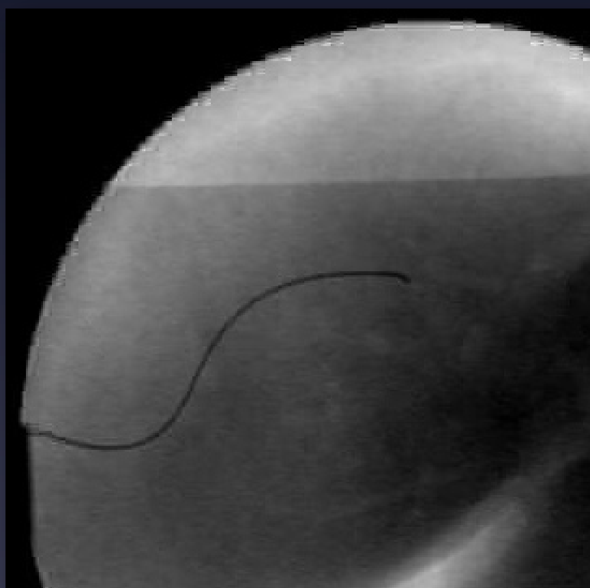
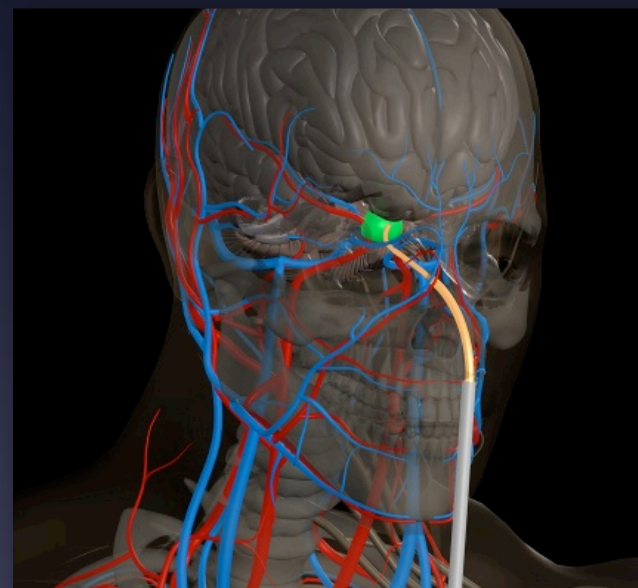
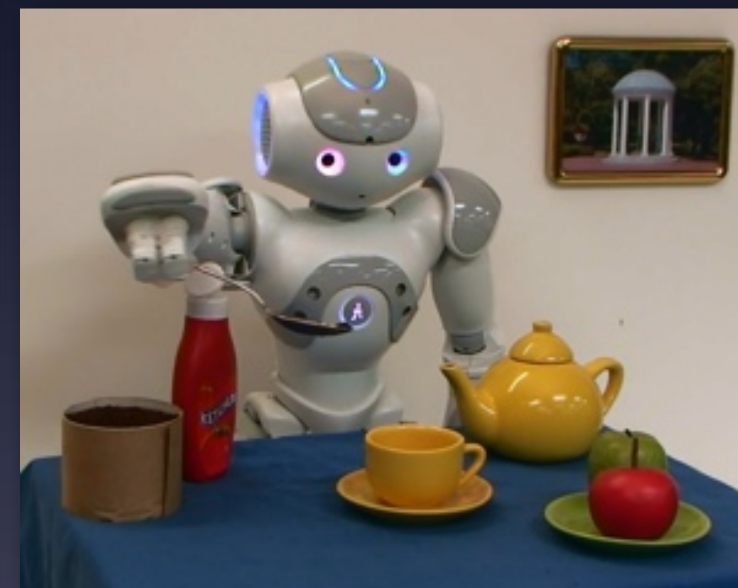
Motion Planning for Medical and Assistive Robots







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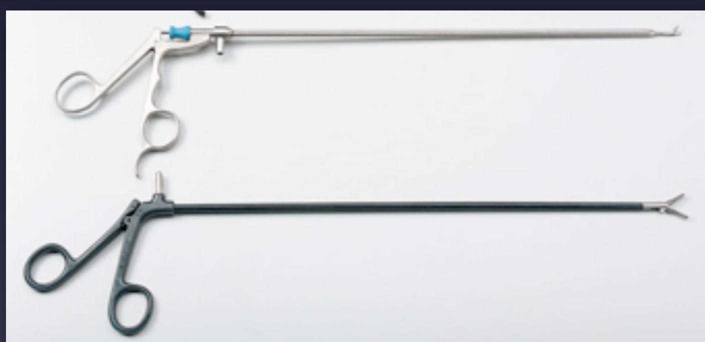
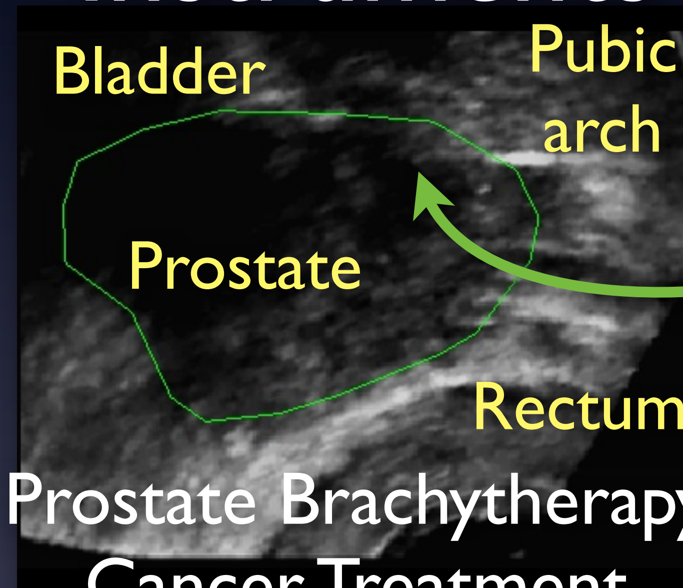
http://robotics.cs.unc.edu

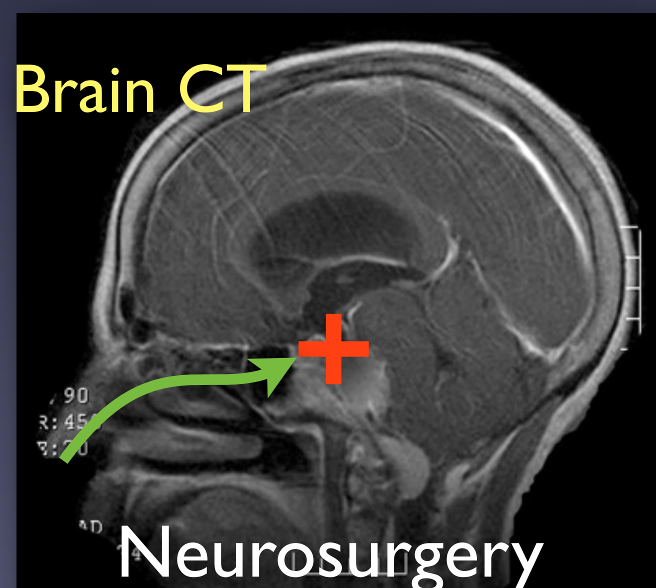
Typical Current Instruments



Steerable Instruments



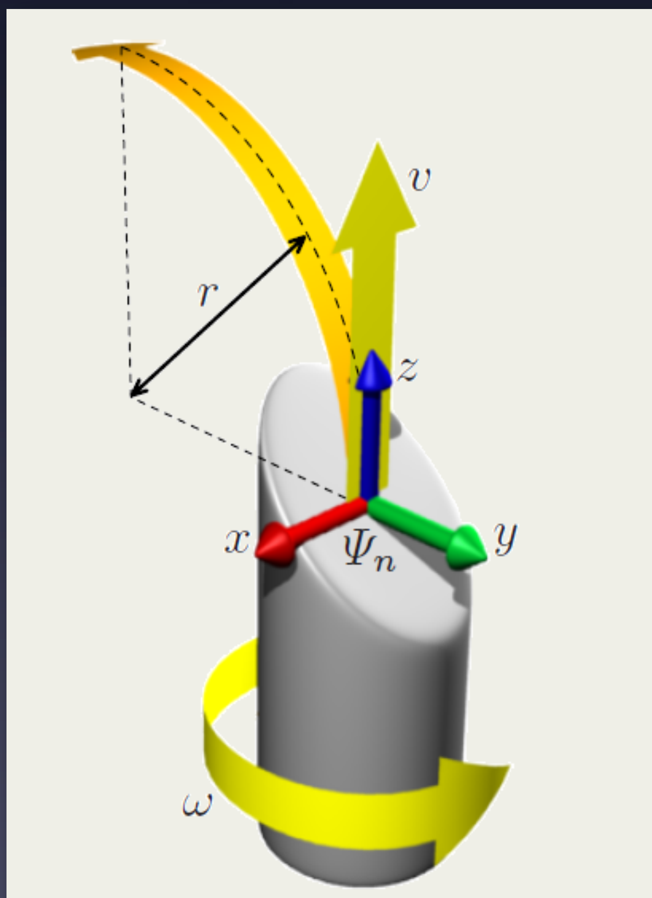
Prostate Brachytherapy
Cancer Treatment



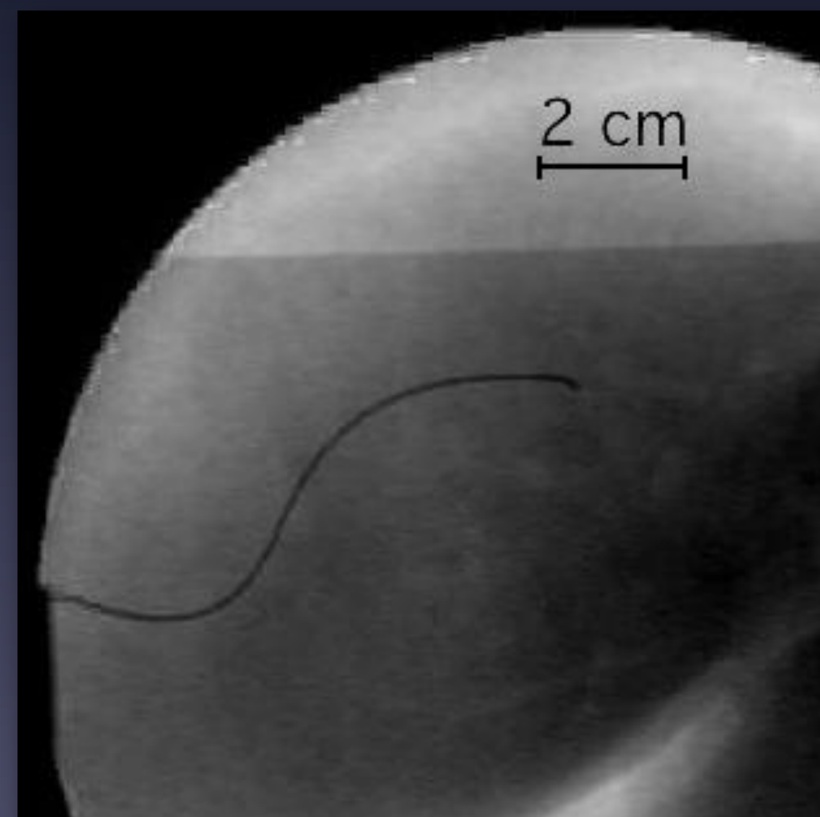
Neurosurgery

Steerable Needles

Bevel-tip &
Highly flexible

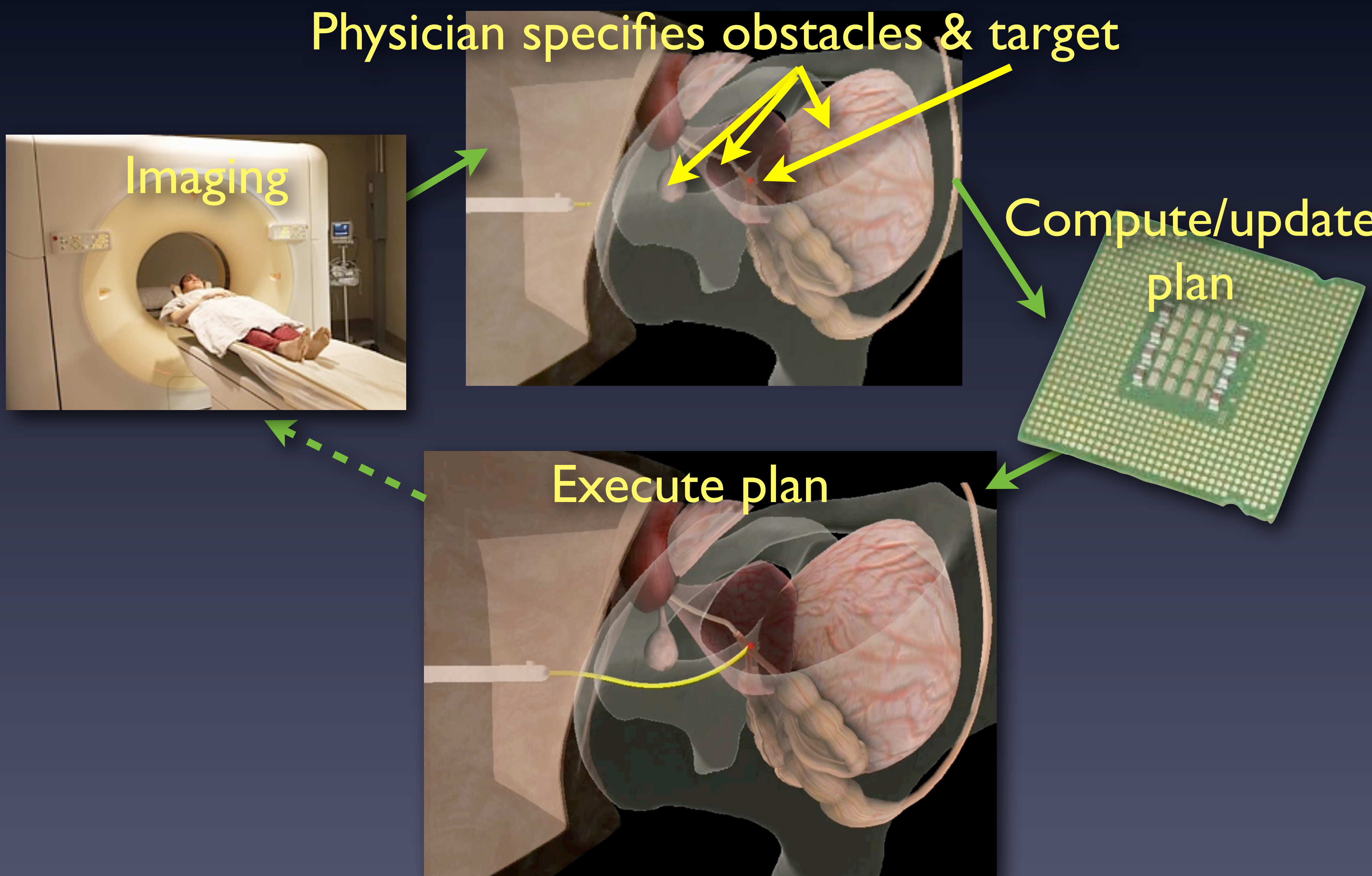


Capable of following
steering through tissue
(shown in ex vivo liver)



[Webster, Okamura, Cowan, Chirikjian, Goldberg, Alterovitz,
United States Patent 7,822,458, 2010]

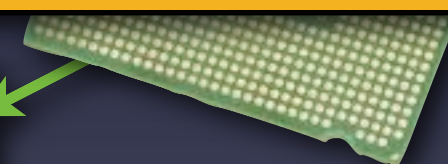
Motion Planning as a User Interface

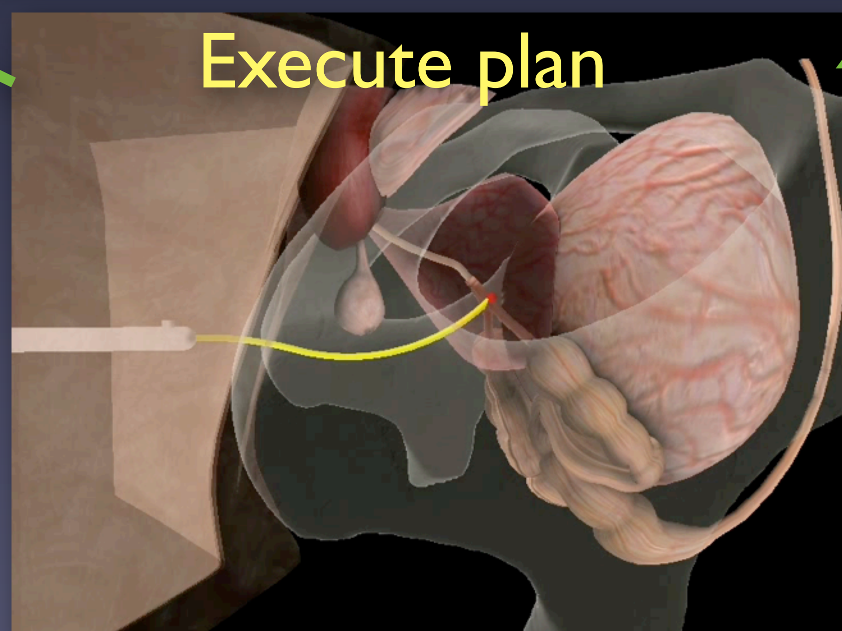


Motion Planning as a User Interface

Key challenges for real-world deployment:

- Must consider uncertainty in motion and sensing
- Tissue deformations
- Guarantee safety

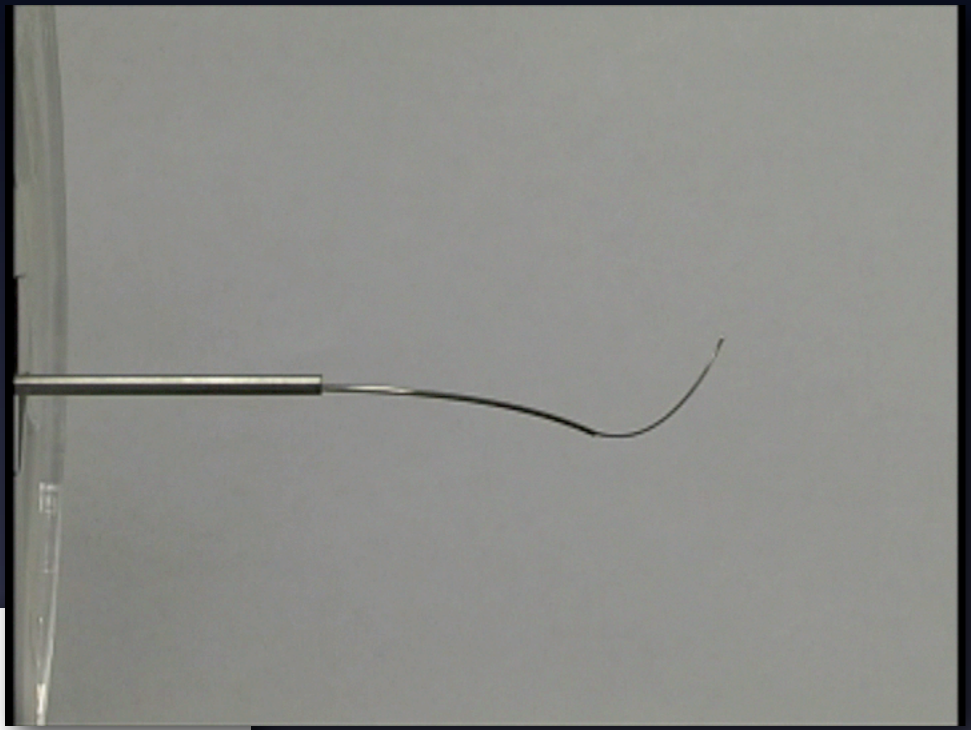


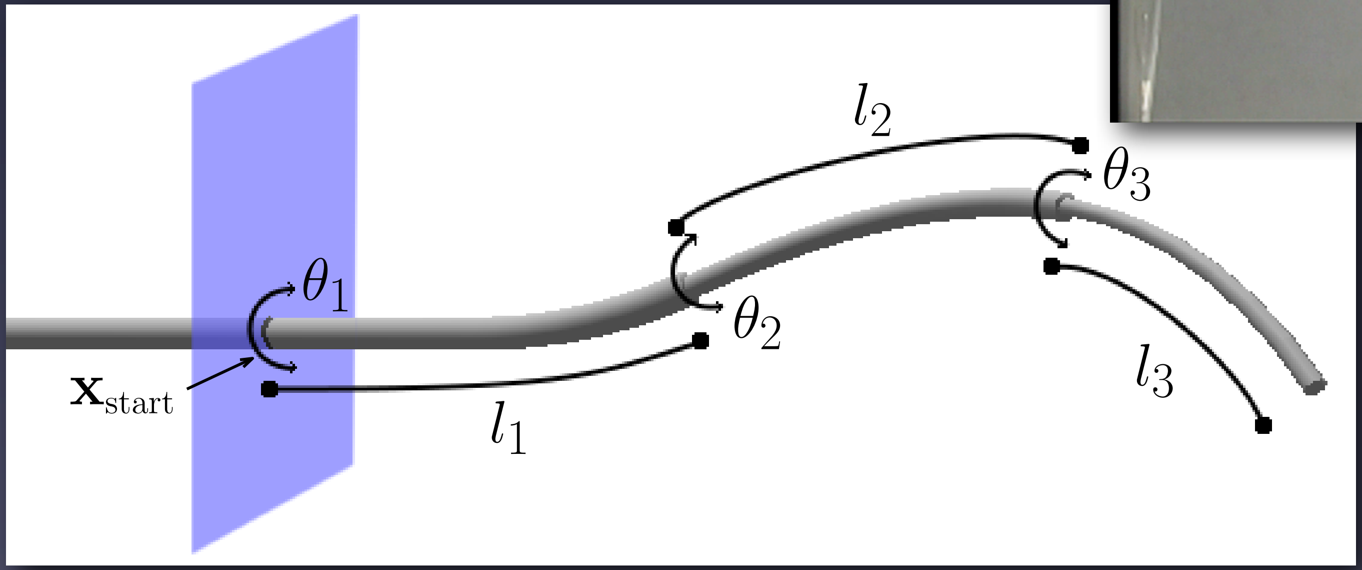


Concentric Tube Robots

Capable of controllable, curved trajectories in air and tissue

Thin, pre-curved, concentric, telescoping tubes





2 DOF per tube:

- insert (l_i)
- rotate (θ_i)

[NIH R21 & R01, Collaboration with Robert J. Webster III]

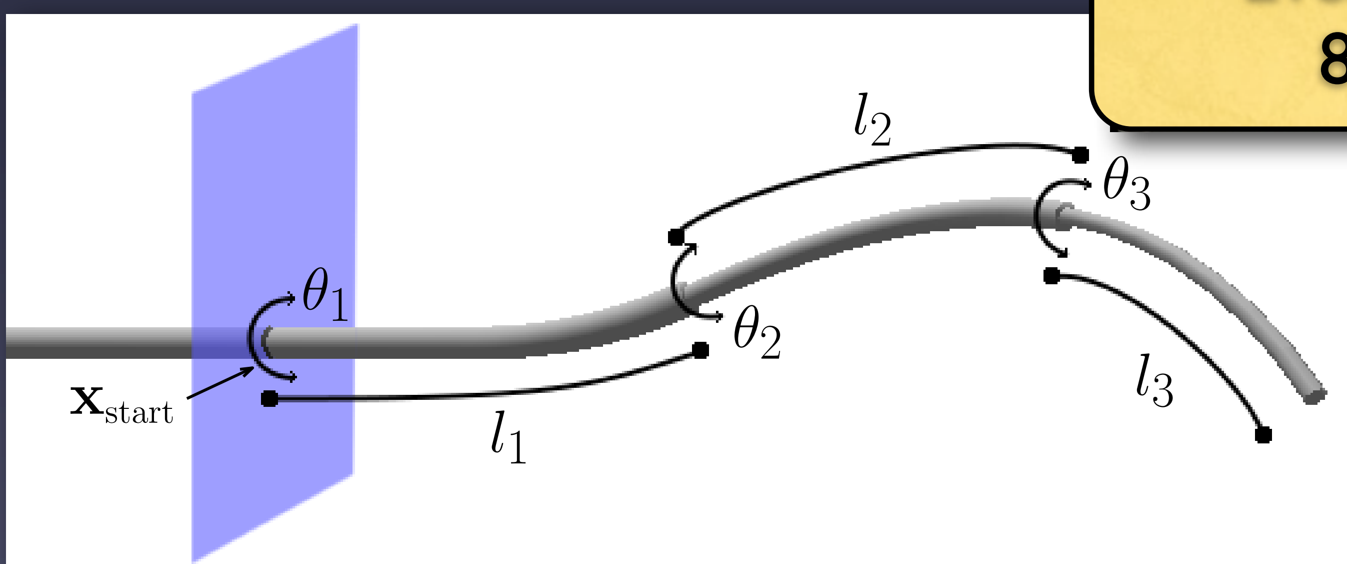
Concentric Tube Robots

Capable of controllable, curved trajectories in air and tissue

Thin, pre-curved, concentric, telescoping tubes

Planning problem:
Reach a clinically relevant site while avoiding anatomical obstacles

Challenge:
Even with only 4 tubes: 8 knobs to adjust!



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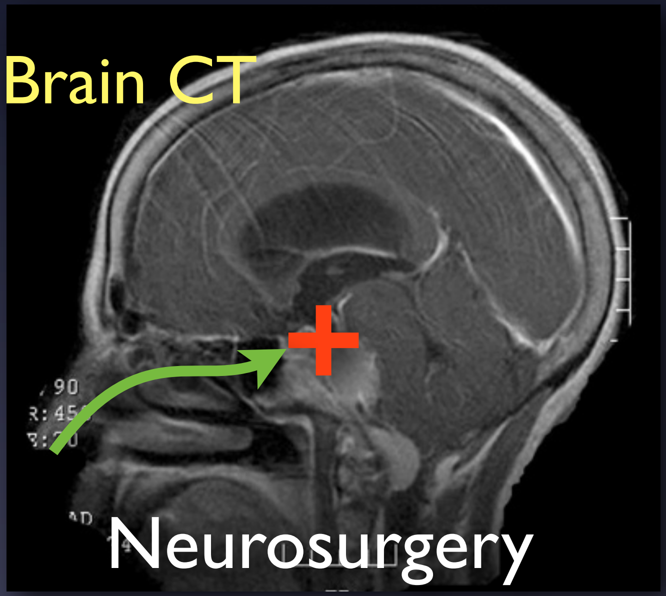
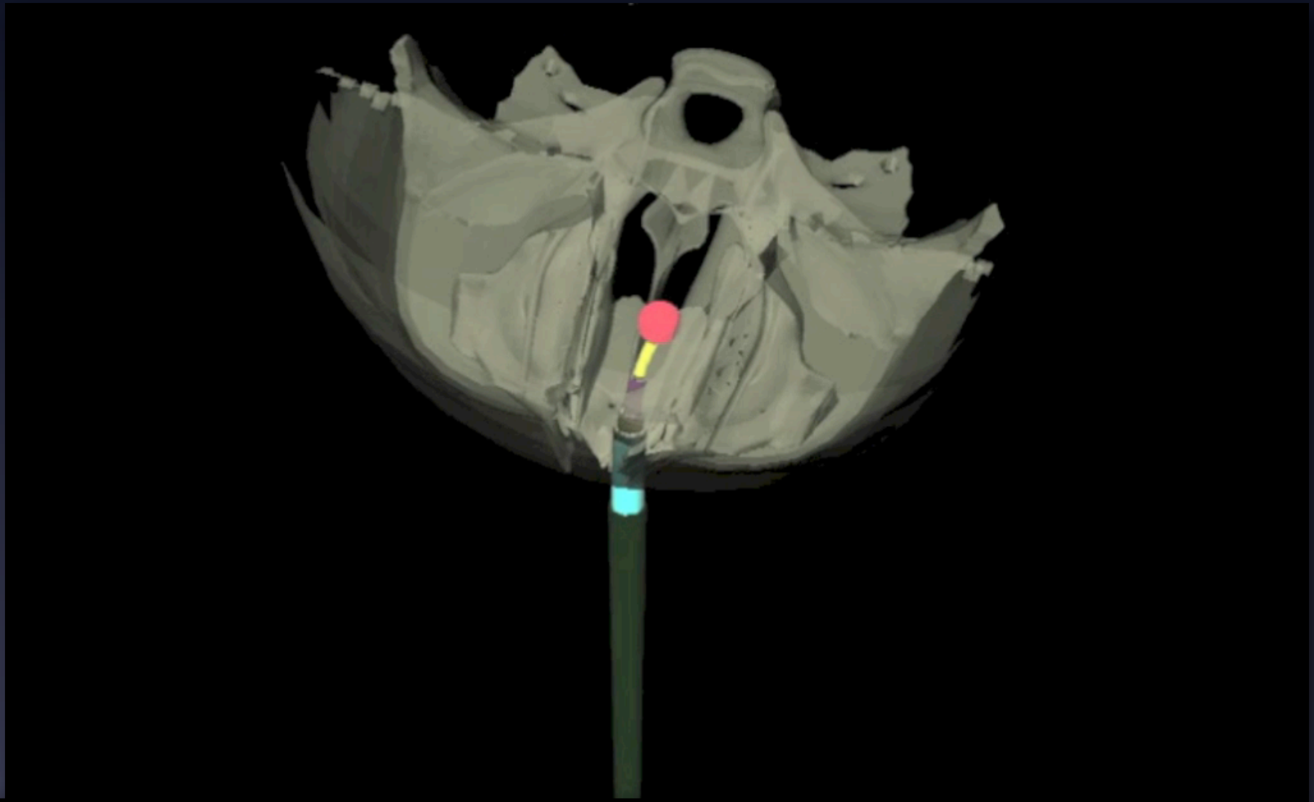
Motion Planning as a User Interface





Key challenges for real-world deployment:

- Must consider uncertainty in motion & sensing
- Guarantee safety
- Interactive, real-time performance

Personal Assistance

[Ye and Alterovitz, International Symposium on Robotics Research, 2011]

Objectives

- Guarantee safety
- Facilitate intuitive operation
- Enable successful performance of complex tasks

Challenges

- Compensating for uncertainty
- Real-time, near-optimal planning
- Integrating human expertise into planning