Active Catheter Tracking: Tracking Micro-Coils in Cardiac Ablation Catheters

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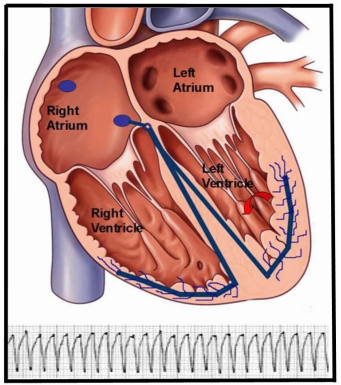
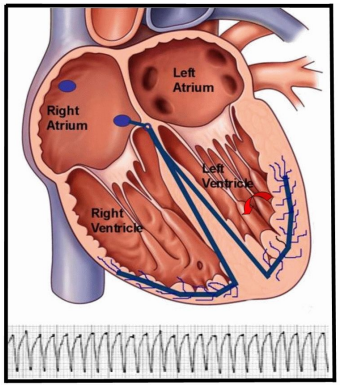
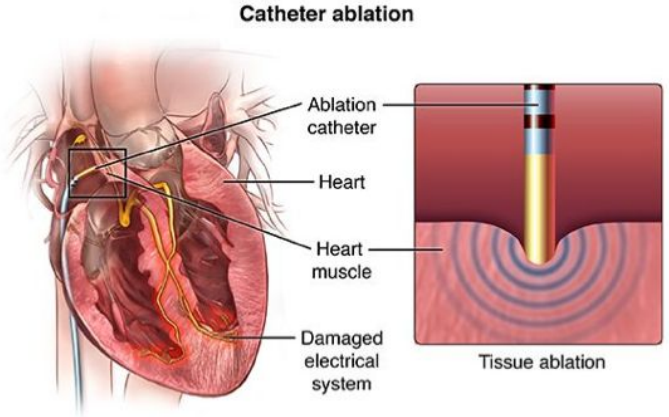
Sunnybrook Research Institute
Toronto, Canada

Cardiac arrhythmia



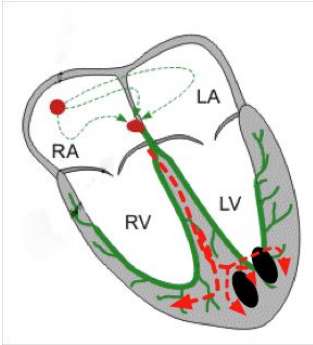
Cardiac arrhythmia

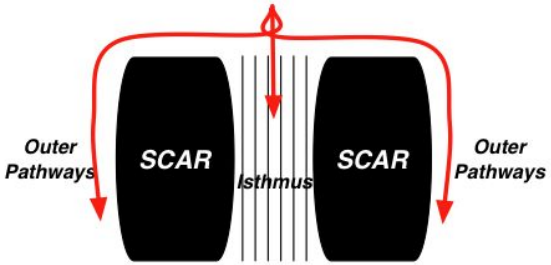


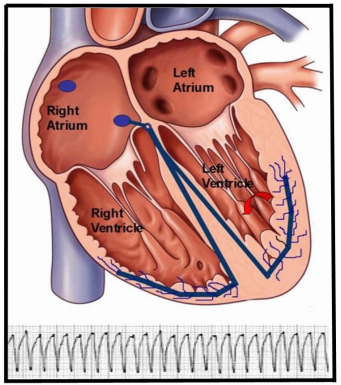


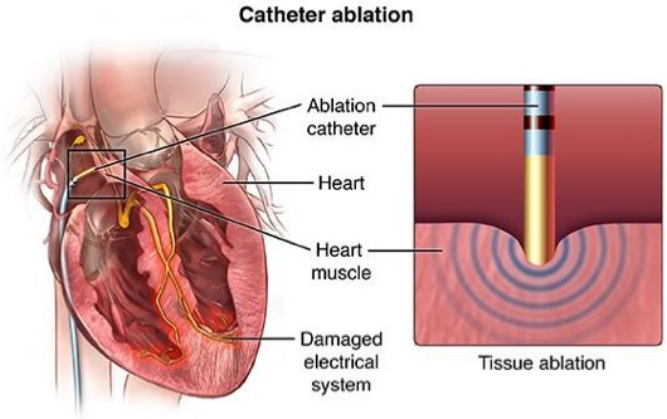
http://www.washingtonhra.com

Cardiac arrhythmia



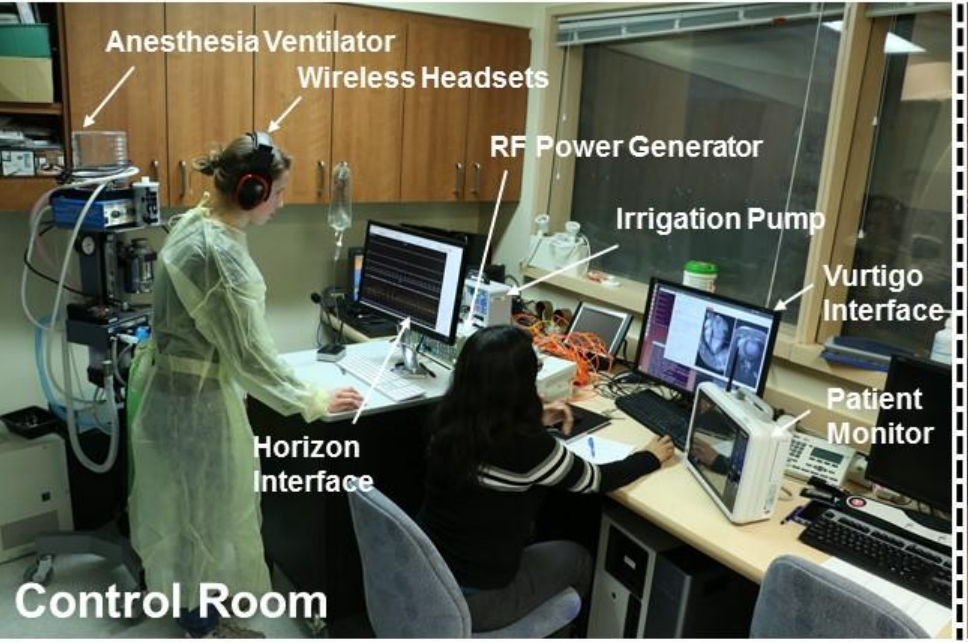


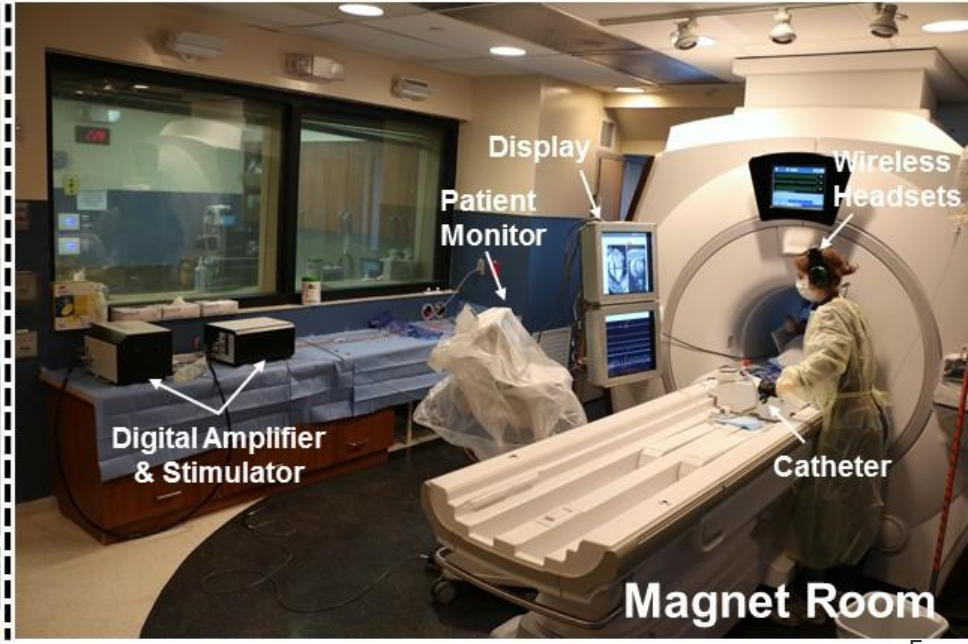




http://www.washingtonhra.com

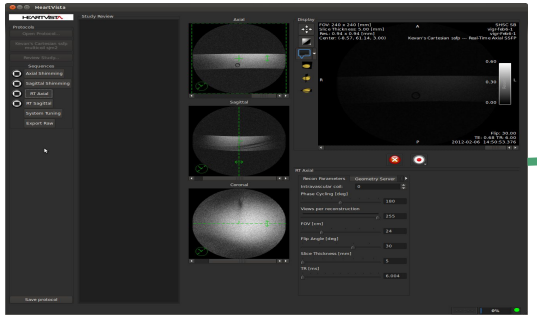
MR Image-guided Interventional Setup



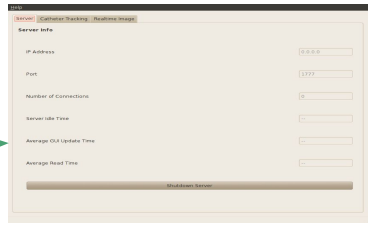


MR Image-guided Interventional Pipeline

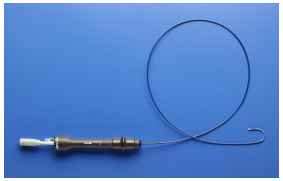
GE 1.5T MR Scanner



RTHawk Research™ real-time MRI package by Heartvista, Inc

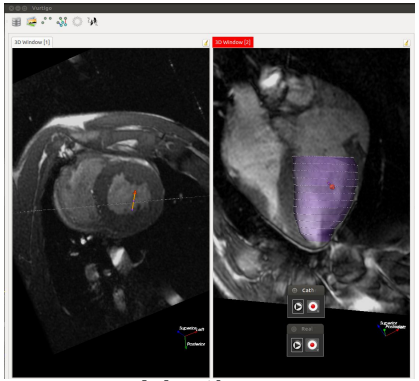


Geometry Server



Vision-MR™ Ablation Catheter by Imricor Medical Systems, Inc

Imricor Advantage Workstation

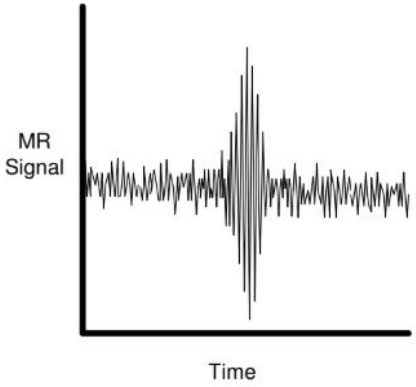


Vurtigo

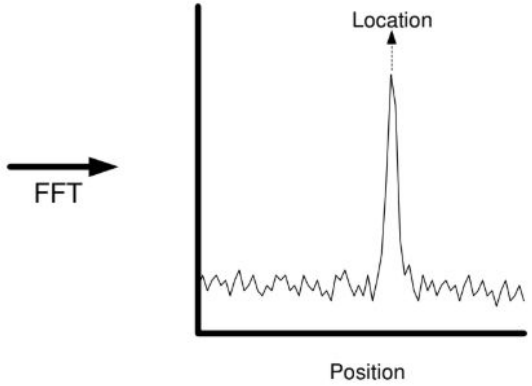
Active Tracking Background

Micro-Coil:

Time Signal:



Frequency Signal:

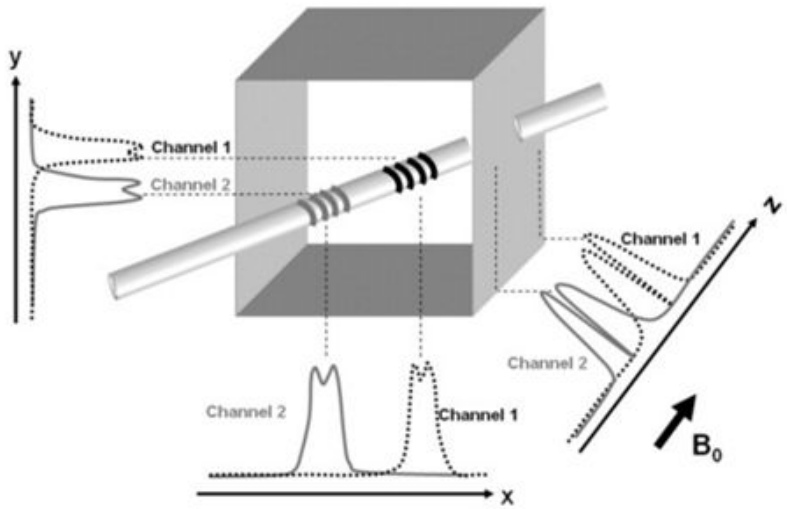


Localization Algorithms

Dumoulin MRM (2010)

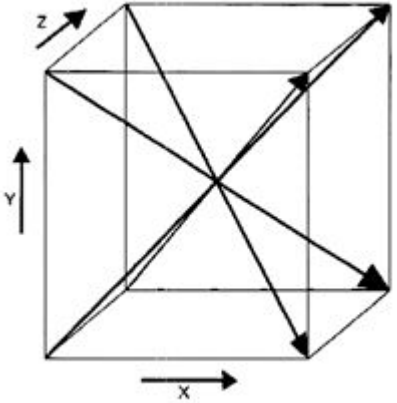
Active Tracking Sequences

Basic Sequence



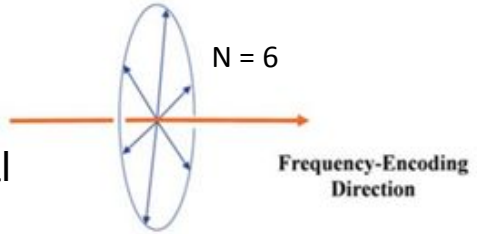
- 3 orthogonal projections

Hadamard Multiplexed with Phase Dithering



- 4 excitation pulses
- Linear recombination
- ↓ Offset error

- N dephasing gradients
- Picks best signal profile

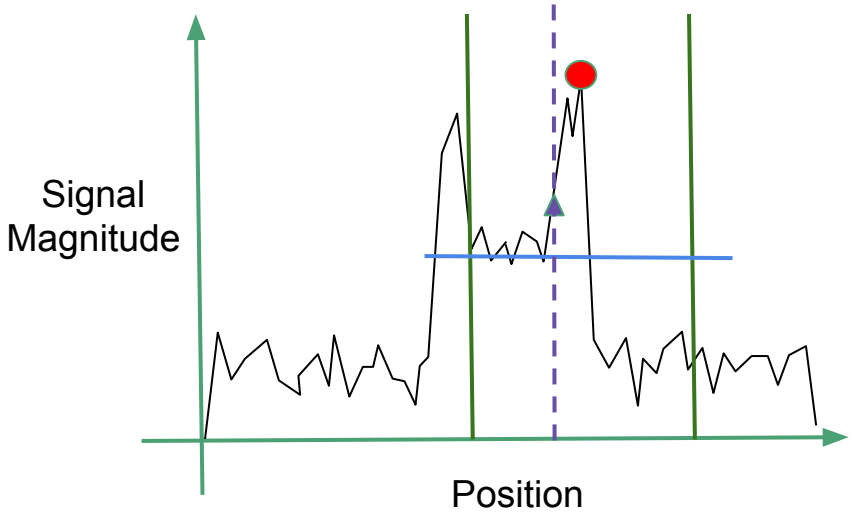


Dumoulin MRM (2010)

Localization Algorithm:

Fixed Width Half Max (FWHM)[6]:

- Find peak
- Apply window
- Apply cutoff
- Calculate centroid

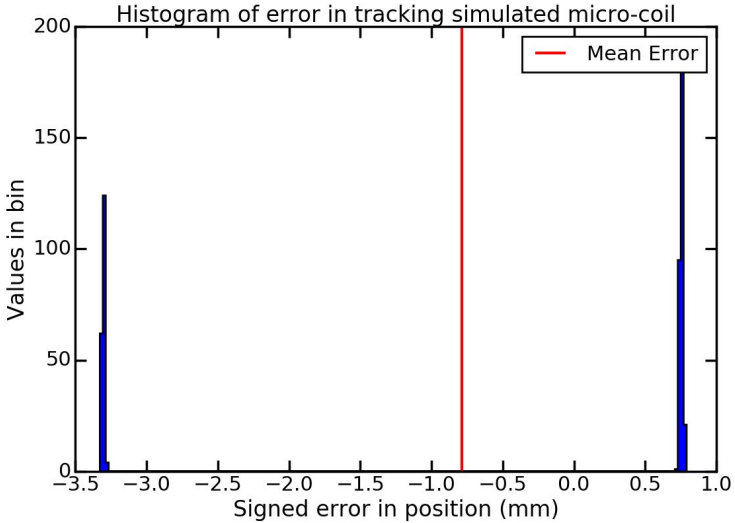


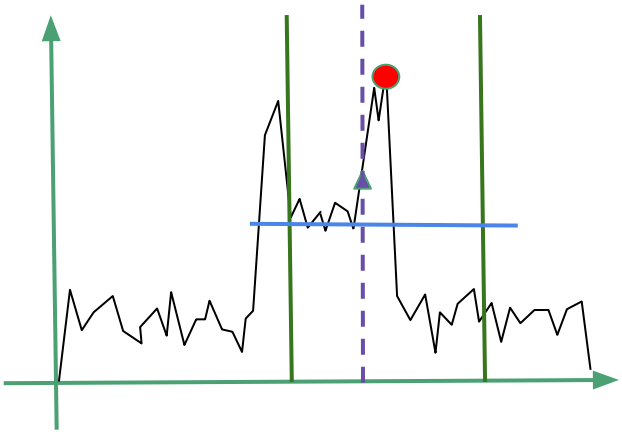
[6]: GE, Tracking Manual 3.5: 2007

Localization Algorithm:

Limitations:

- Magnifying the effects of noise on the signal
- Results in discretized groups of possible positions
- Larger variance with minimal probability of obtaining mean in a real-time environment

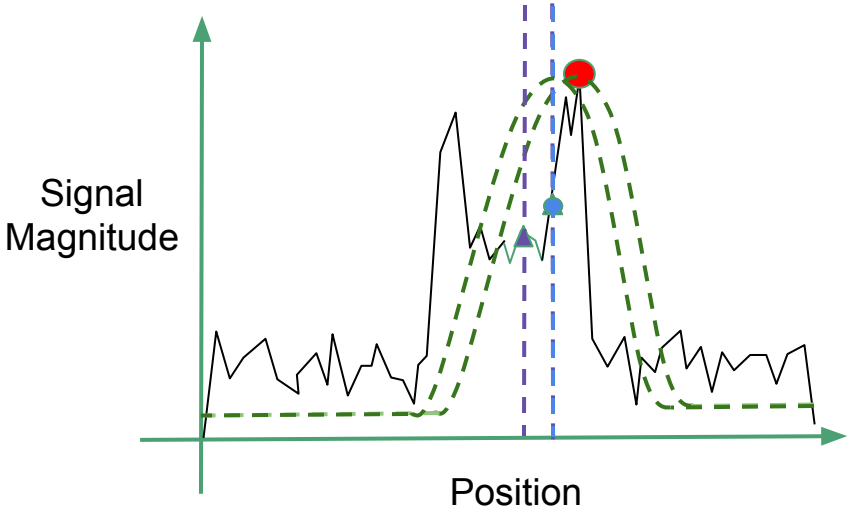




Localization Algorithm:

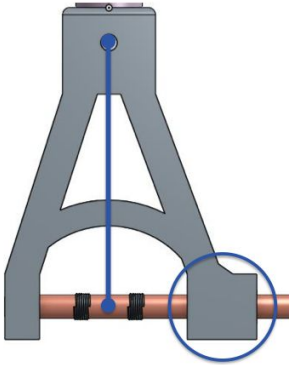
Peak Normed Gaussian (PNG):

- Find peak
- Apply weight function
- Calculate centroid
- Iterate over centroid

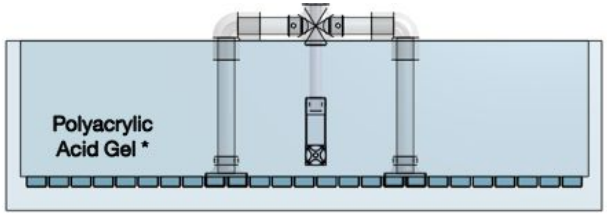


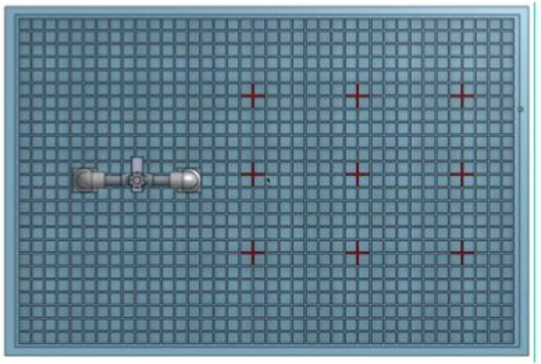
Experiment Setup

Fixture:



Polyacrylic Acid (PAA) Gel Phantom :





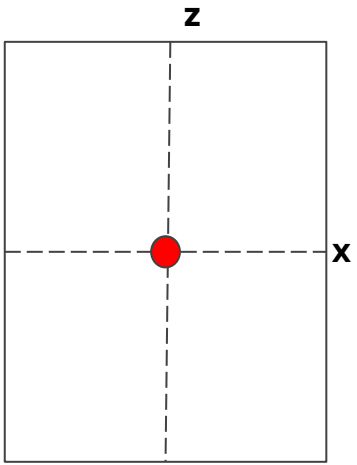
Tracking Sequences

Tracking Parameters	**Basic (SRI) sequence**	**Hadamard sequence**
Flip angle	5°	5°
Readout	512	512
Field of view (cm)	60	60
Repetition Time (ms)	14.27	8.27
Tracking rate (fps)	23.4	10.1
Spatial resolution (mm)	1.17	1.17

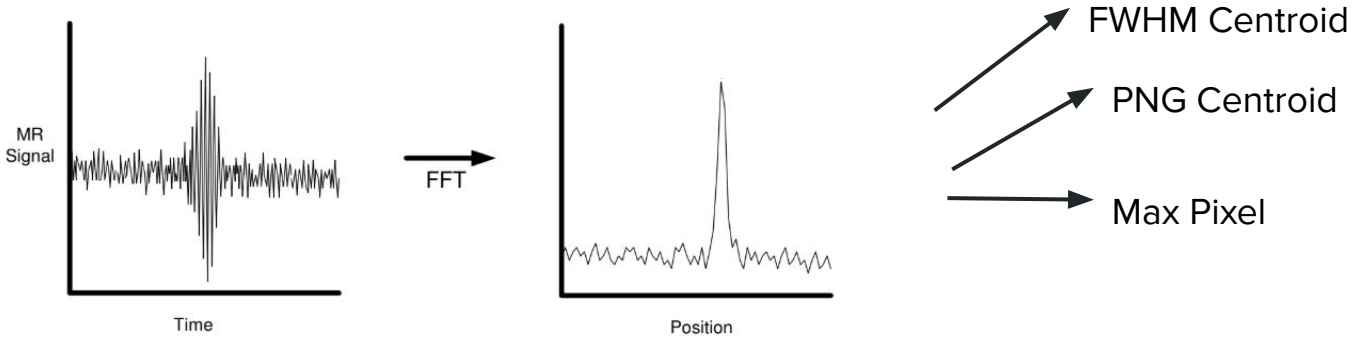
Experiment Setup

- Experimentally determine tracking variability between catheters of the same batch
- Compare accuracy of localization algorithms
- Tracked 3 catheters:
  - Cath284, Cath299, Cath285
- Measured at two positions:
  - Near Isocenter, 1D Offset (-150mm)
- Catheter aligned with magnetic field

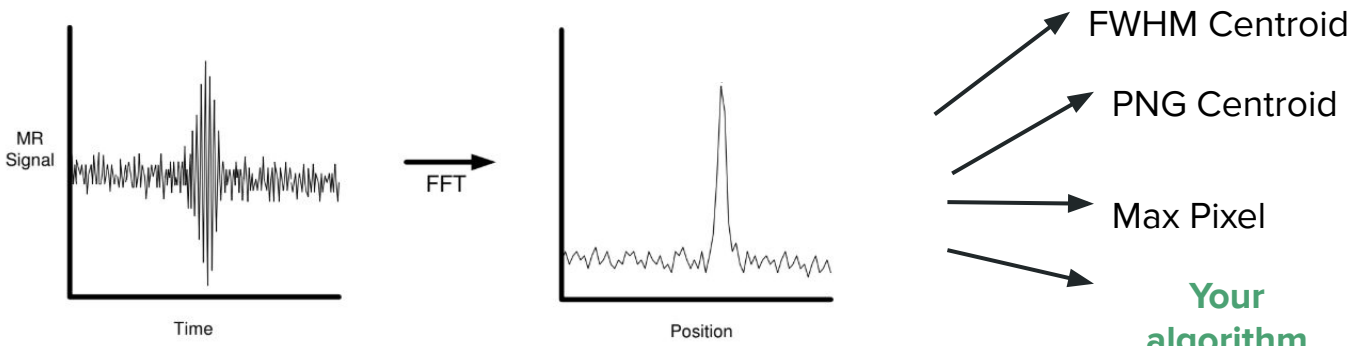
Near Isocenter



Contribution ideas



Contribution ideas



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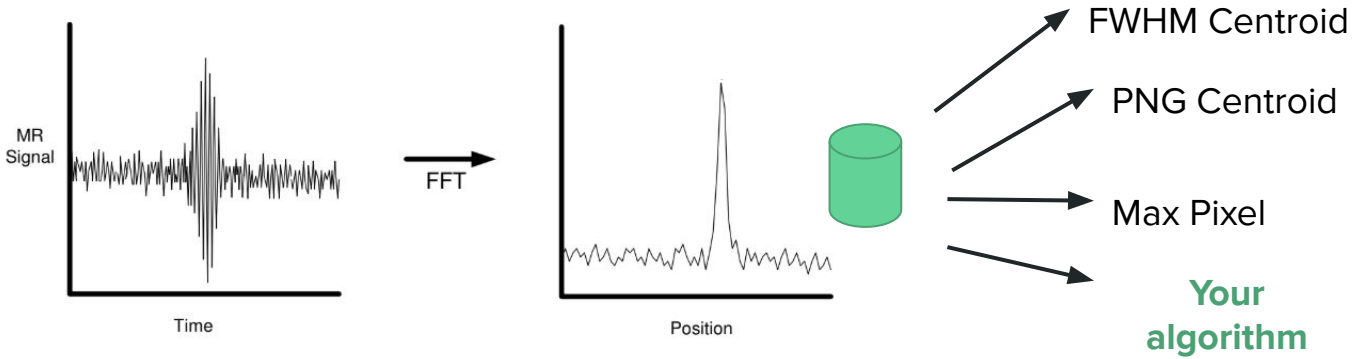

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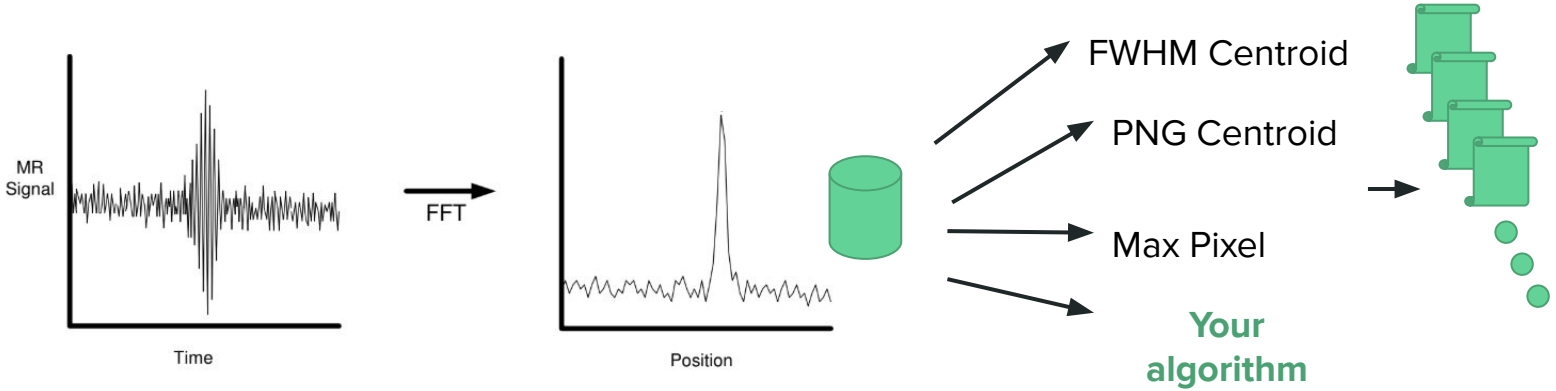

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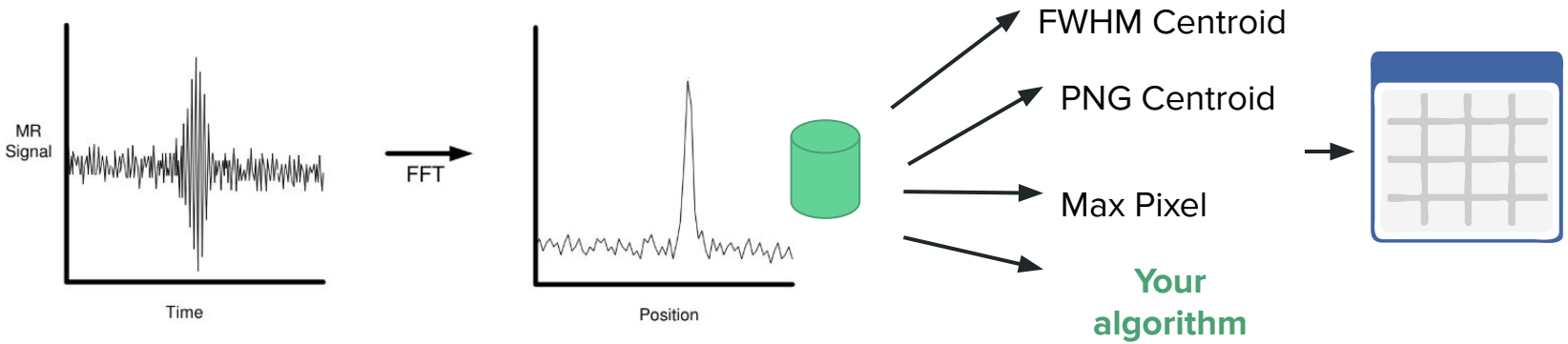

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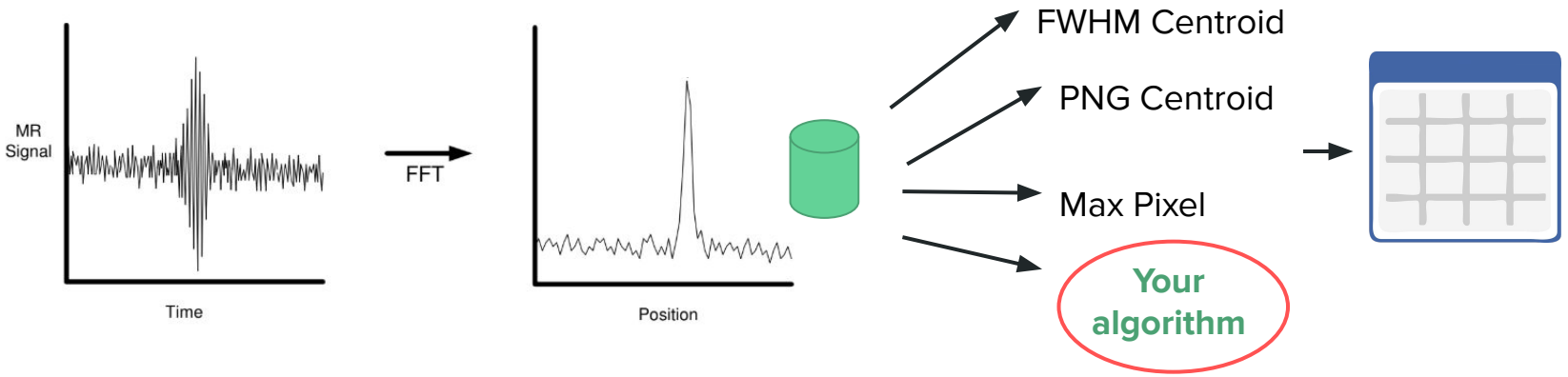

Platform

- Jupyter Notebook
- Python 3.x