A 3-D Heart Model for Arrhythmia Simulation and Visualization

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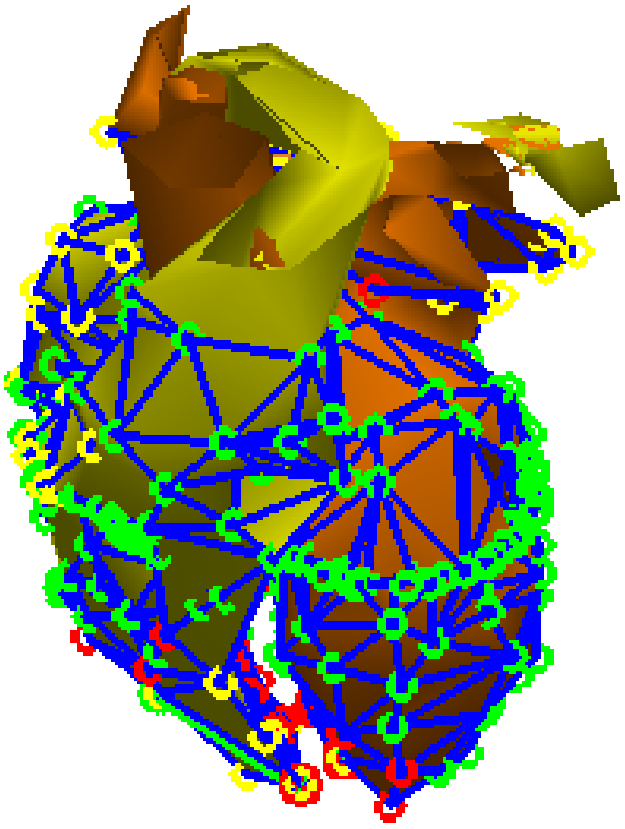

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Motivation: Cardiac Arrhythmias

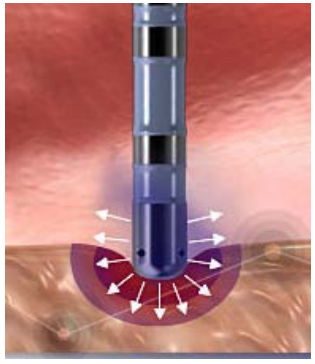
Normal Sinus Rhythm

Arrhythmic Rhythm

Remedies

Medication

Medical Devices



Ablation

Motivation: Arrhythmia Therapy

Problem

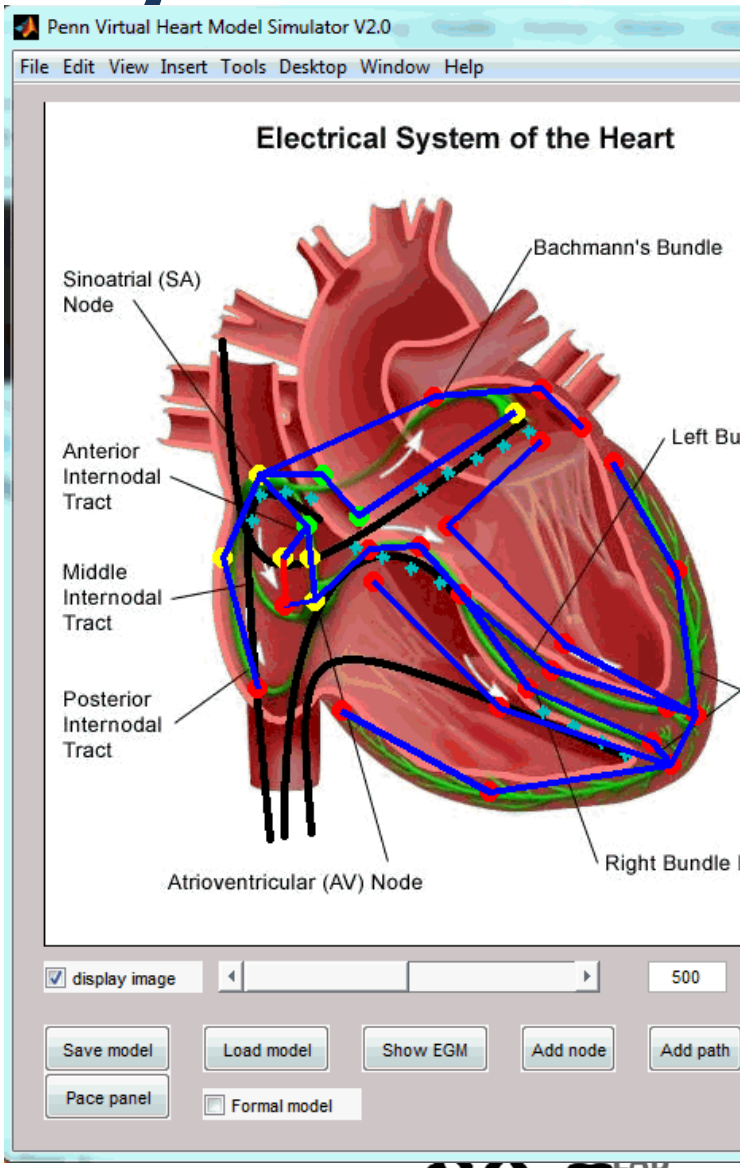
- Anti-arrhythmic drugs used by 1.5 million Americans do not offer health benefits
- Ablation procedures only yield success rates of 40-85%, thus requiring repeated procedures in half the cases

Goal

- Develop a 3-D Heart Model for Arrhythmia Simulation and Visualization

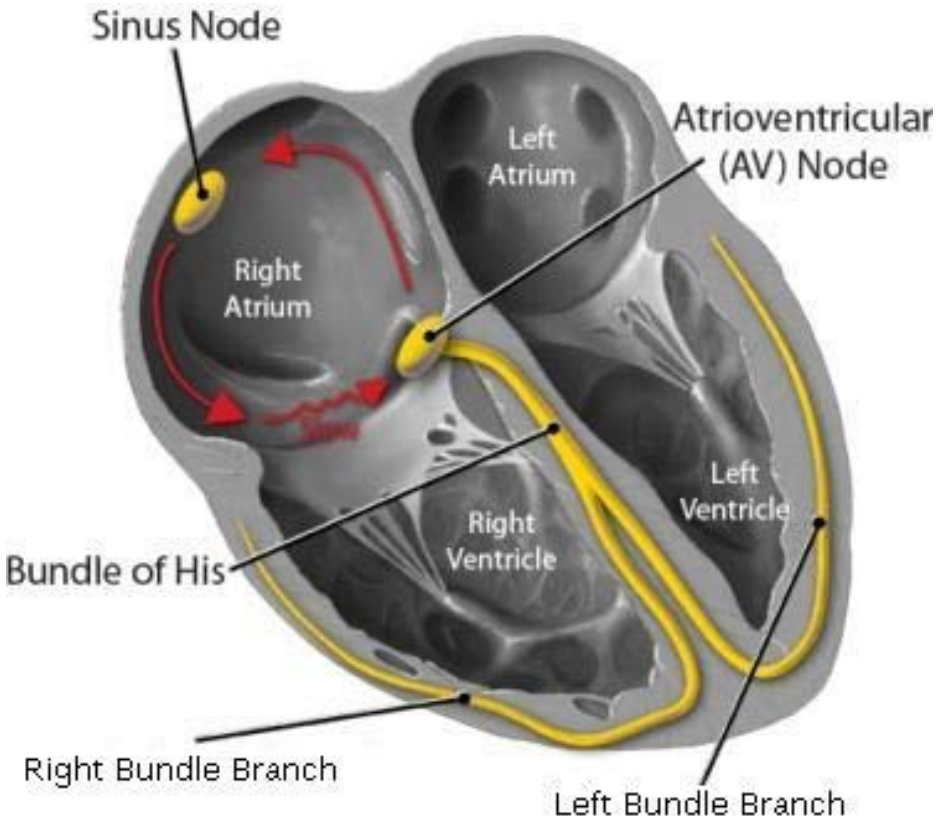
Heart Conduction System

- The electrical conduction system of the heart is important natural real-time system
- The coordinated contraction of the heart is governed by the electrical conduction system
- We model the heart by extracting their timing related properties



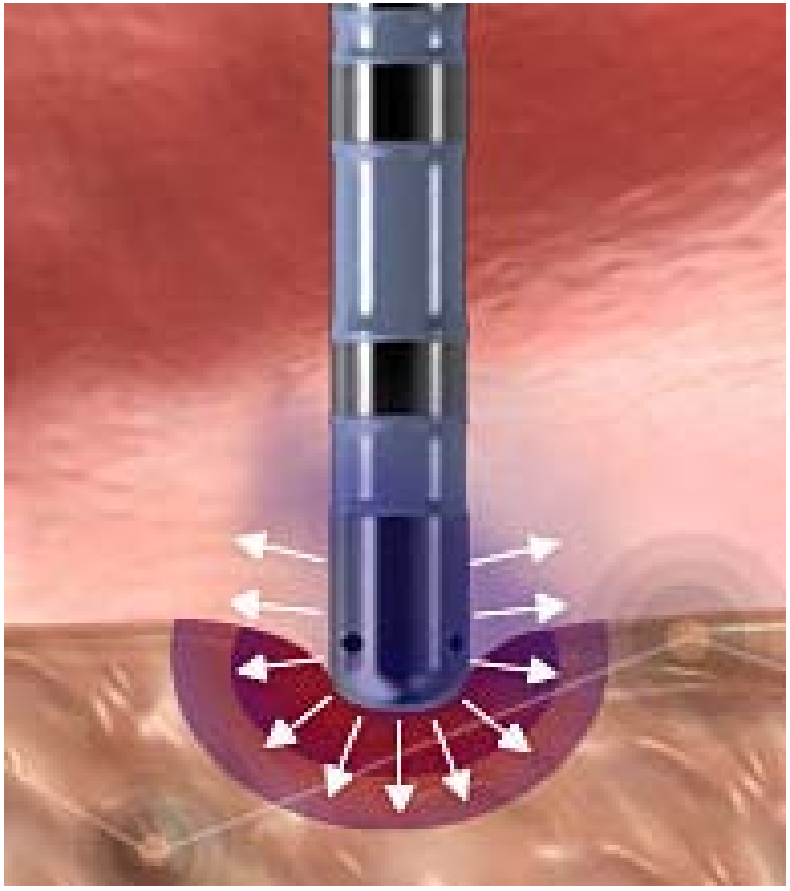
Common Cause of Cardiac Arrhythmia Circuit

Circular pathways in heart's conduction system is a common cause of arrhythmias



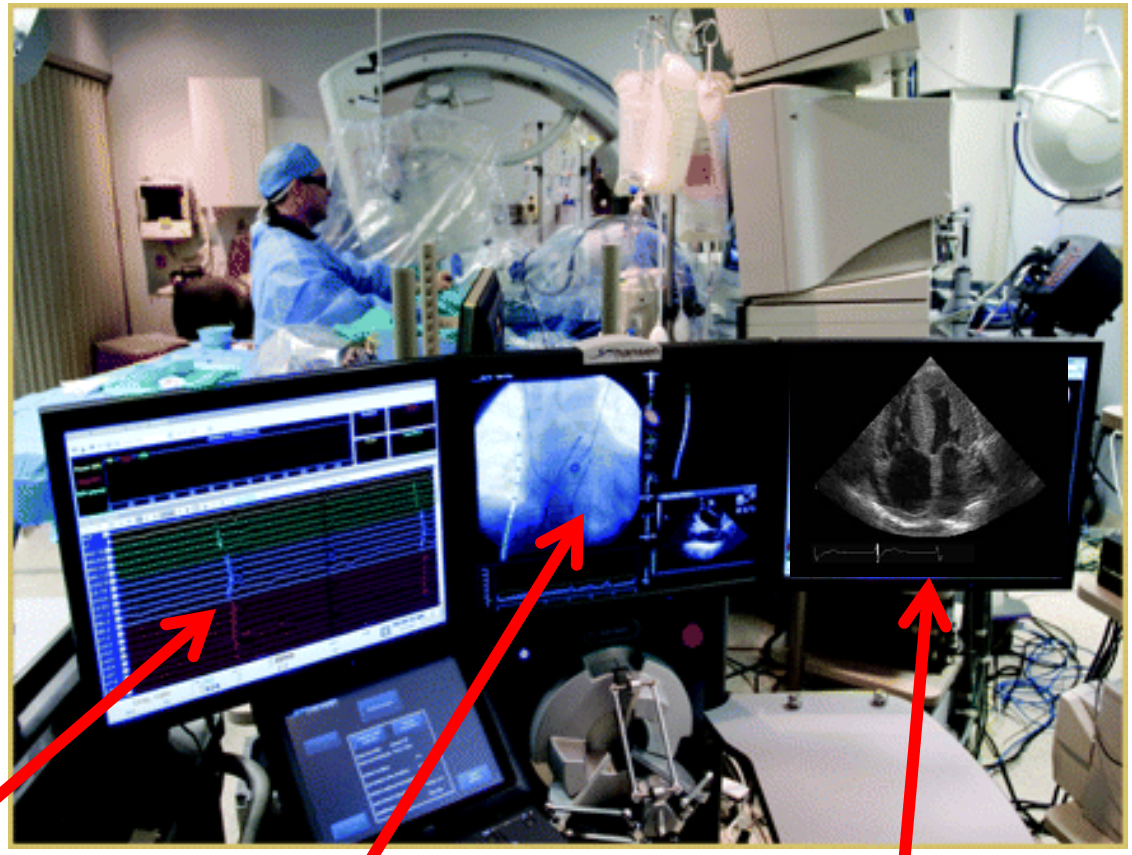
Ablation: Restoring Heart Rhythm

Ablation burns cells to eliminate rhythm abnormalities in patients



Catheter Ablation Procedure

- **Spatial**
  - Xray
  - Ultra-sound
- **Temporal**
  - Electrogram

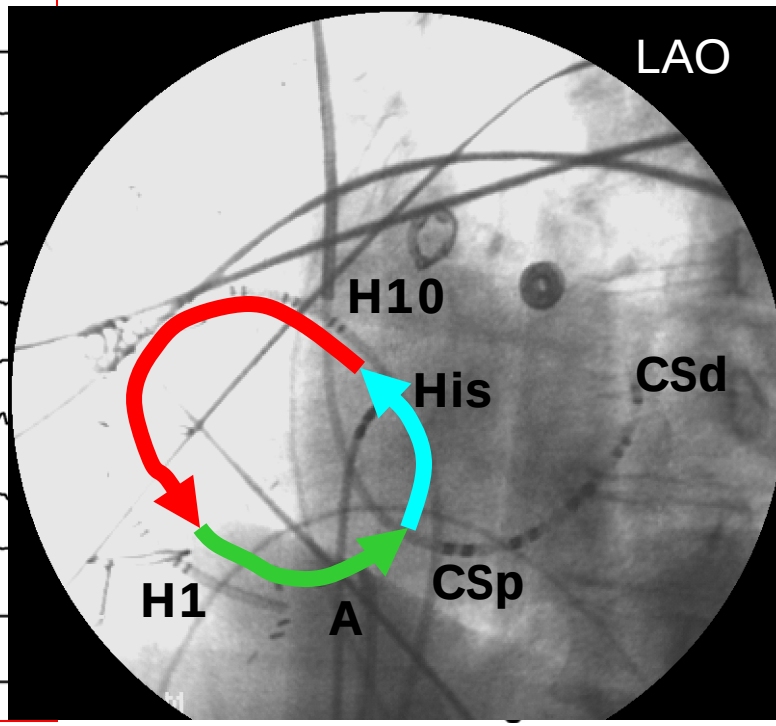


Electrogram **Xray** **Echocardiography**

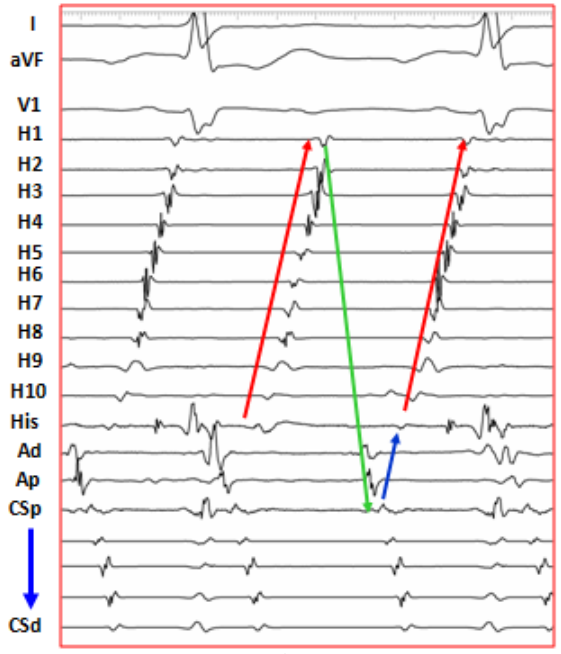
Temporal (Electrogram)

I
aVF
V1
H1
H2
H3
H4
H5
H6
H7
H8
H9
H10
His
Ad
Ap
CSp
CSd

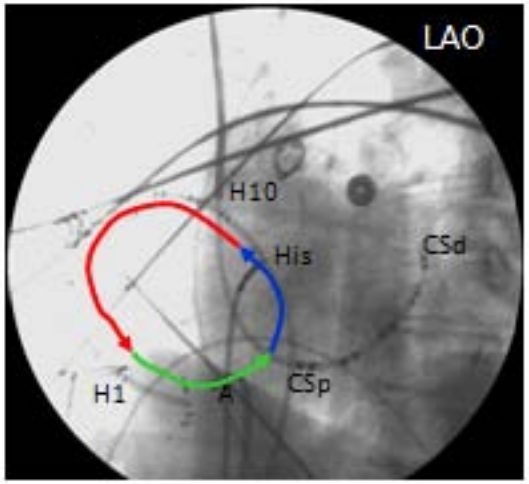
Spatial (Xray)



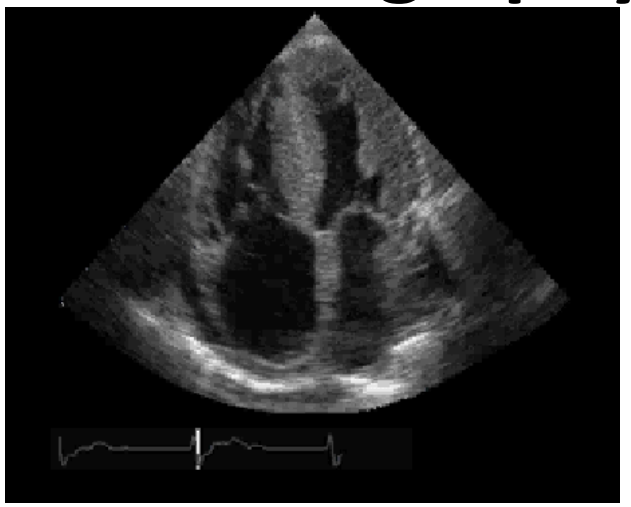
Electrogram

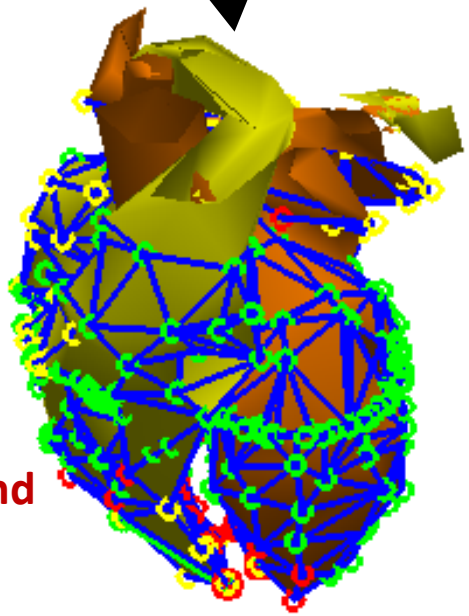


Xray



Echocardiography





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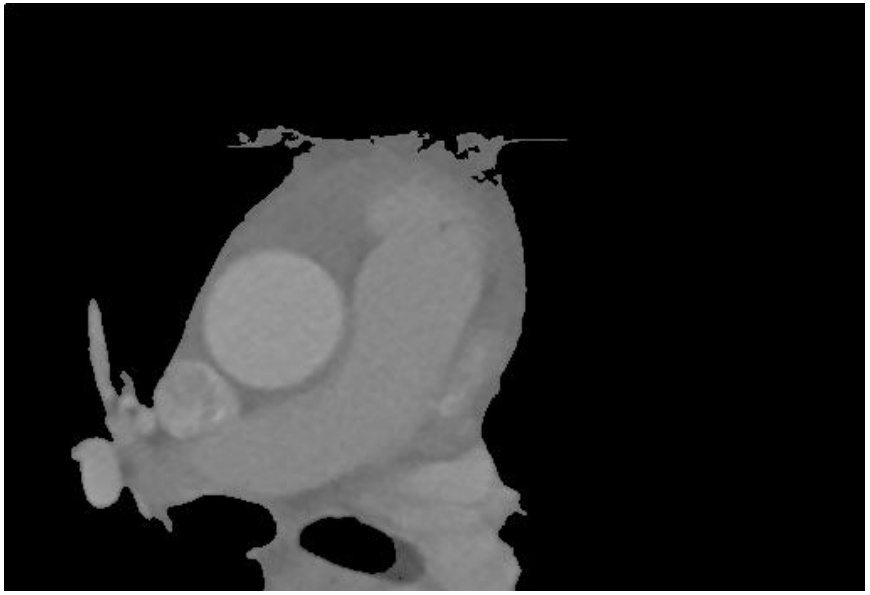
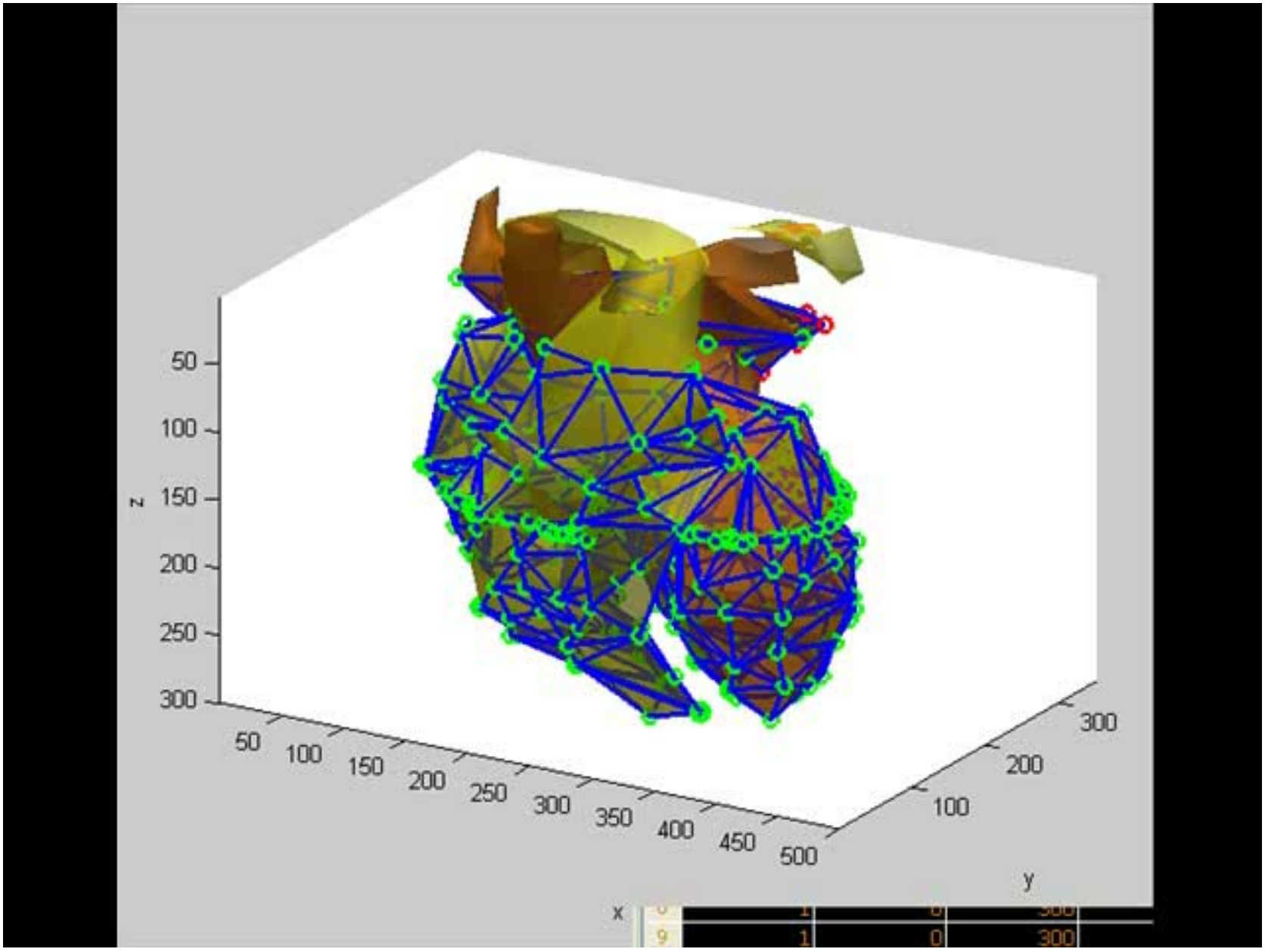
3D Heart Geometry

Accurate Anatomical Spatial Information

- MRI of the heart from the 3 different axes were processed
- Number of vertices on 3D surface reduced from 7,807 to 437 nodes (93% reduction)



MRI heart scans: Horizontal View



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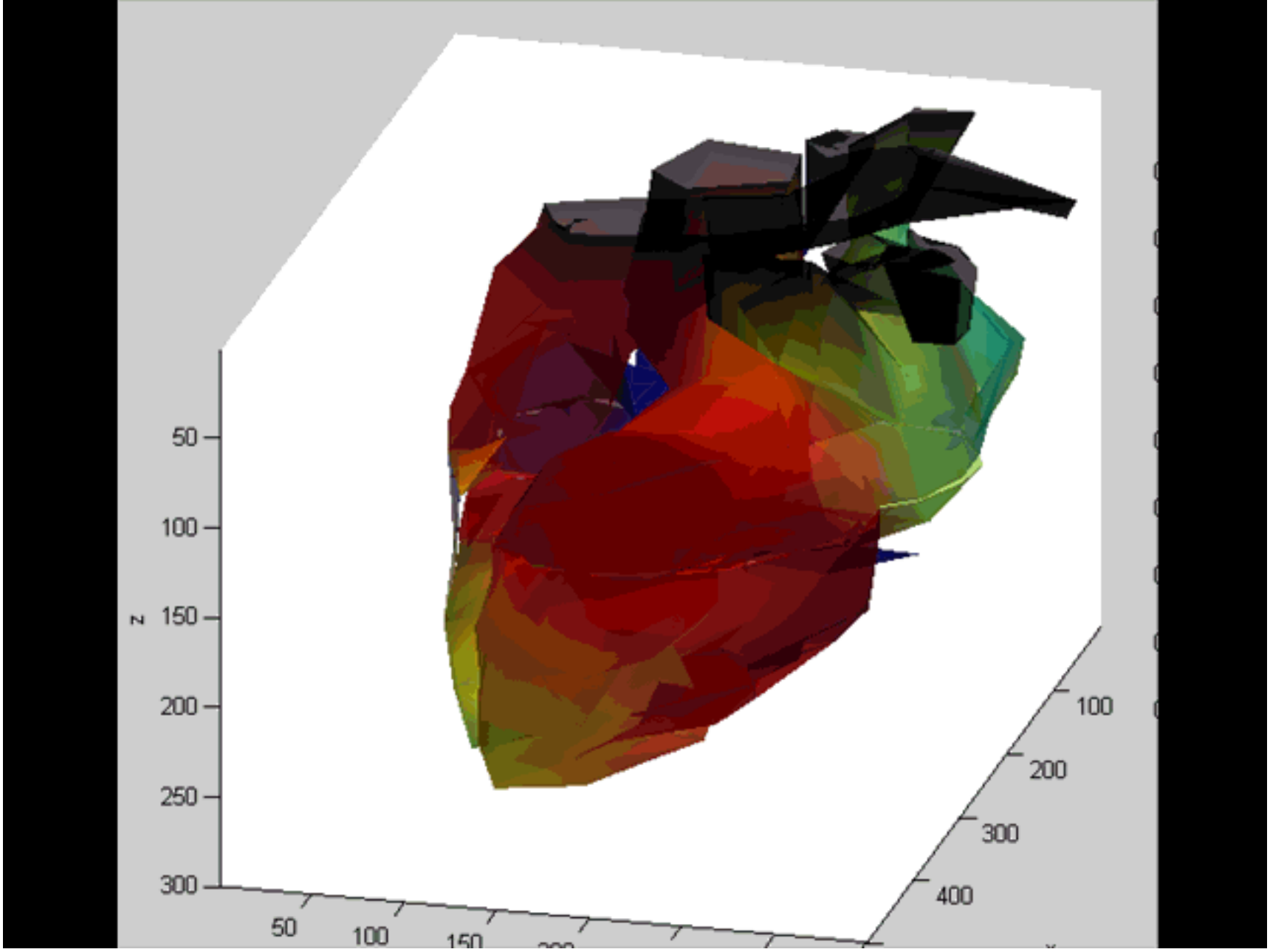

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Conclusion

- Current 3D model is first step towards building automated guidance tool for surgeons conducting EP studies
- Such a tool will make surgeon's work faster, more precise, and reduce the intellectual demand on the surgeon

Future Work

- Atrial Flutter Case Study
- Develop patient-specific model, connect to real patient data
- 3D model to operate in real-time and guidance tool for physician

Acknowledgements

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