

Personalized Heart Models for Atrial Fibrillation Therapy

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Challenge:

- Atrial fibrillation electrical activation is spatiotemporally complex.
- Lack of technology for obtaining detailed fiber organization and propagation anisotropy.
- Contact electroanatomical mapping system gives unsynchronized electrical recordings.

Solution:

- High resolution patient electroanatomical map of the left atrium is exported.
- Patient data is processed to extract spatiotemporal electrical activations and fed into our heart model.
- An optimization process locally tune model parameters for the entire atrium.
- The personalized heart model can accurately reproduce patient atrium activations.

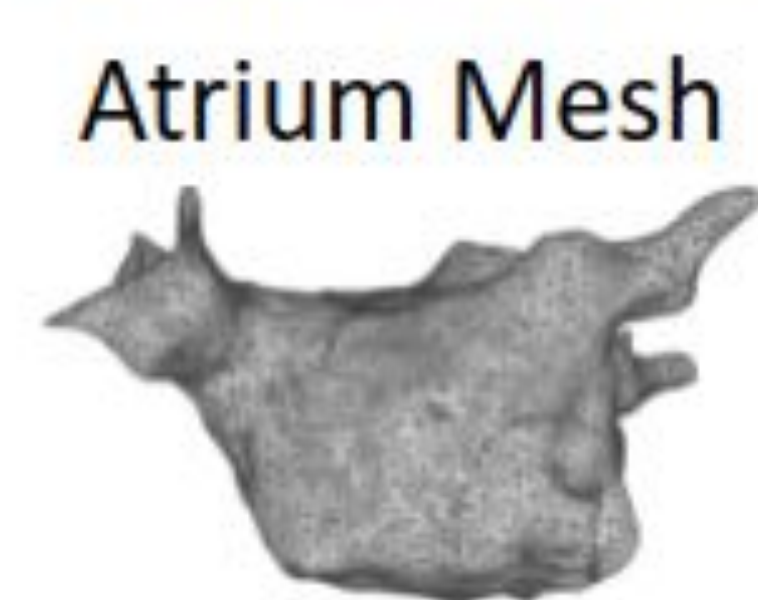
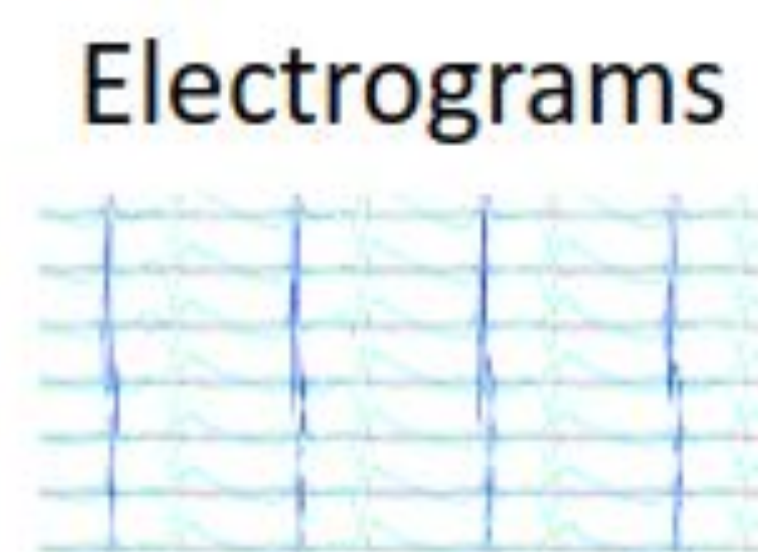
Broader Impact:

- More than 6 million people in United States have atrial fibrillation.
- Personalized heart models can aid catheter ablation of persistent atrial fibrillation in finding ablation targets.

Scientific Impact:

- To show the importance of local fiber organization and propagation anisotropy to a clinically practical heart model.
- To present a heart modeling framework that is capable of incorporating real-time clinical data.
- To share a whole-atrium optimization that tunes parameters locally.

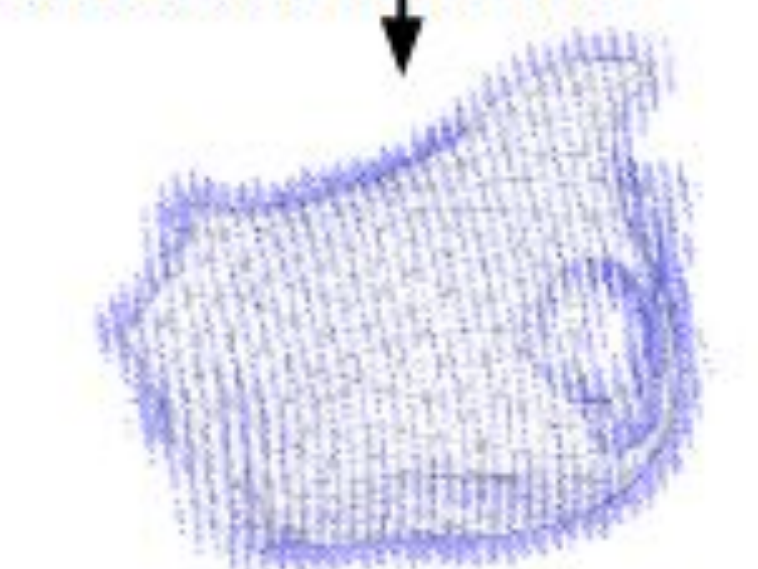
Electrode Locations



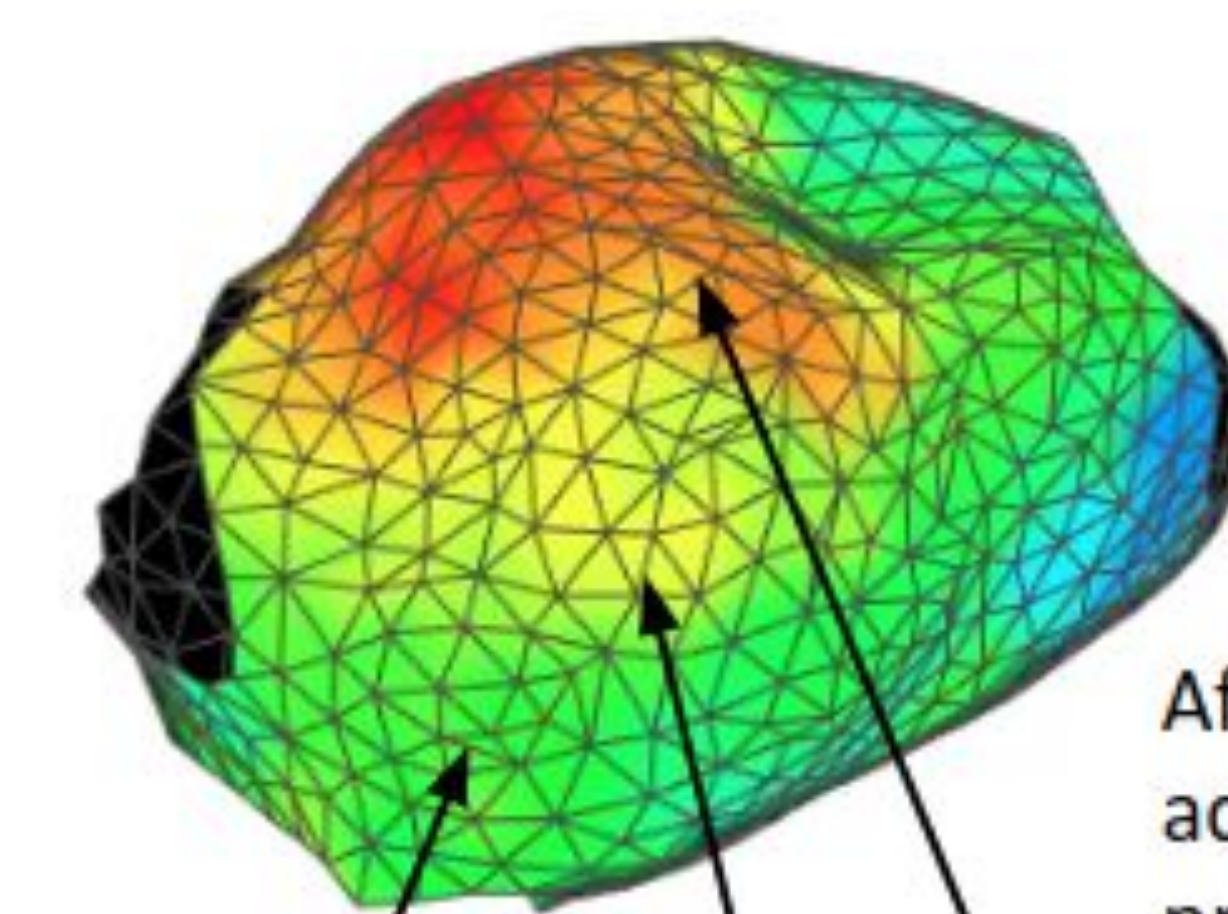
Fiber



Cartesian Grid



Every vertex has its own set of parameters

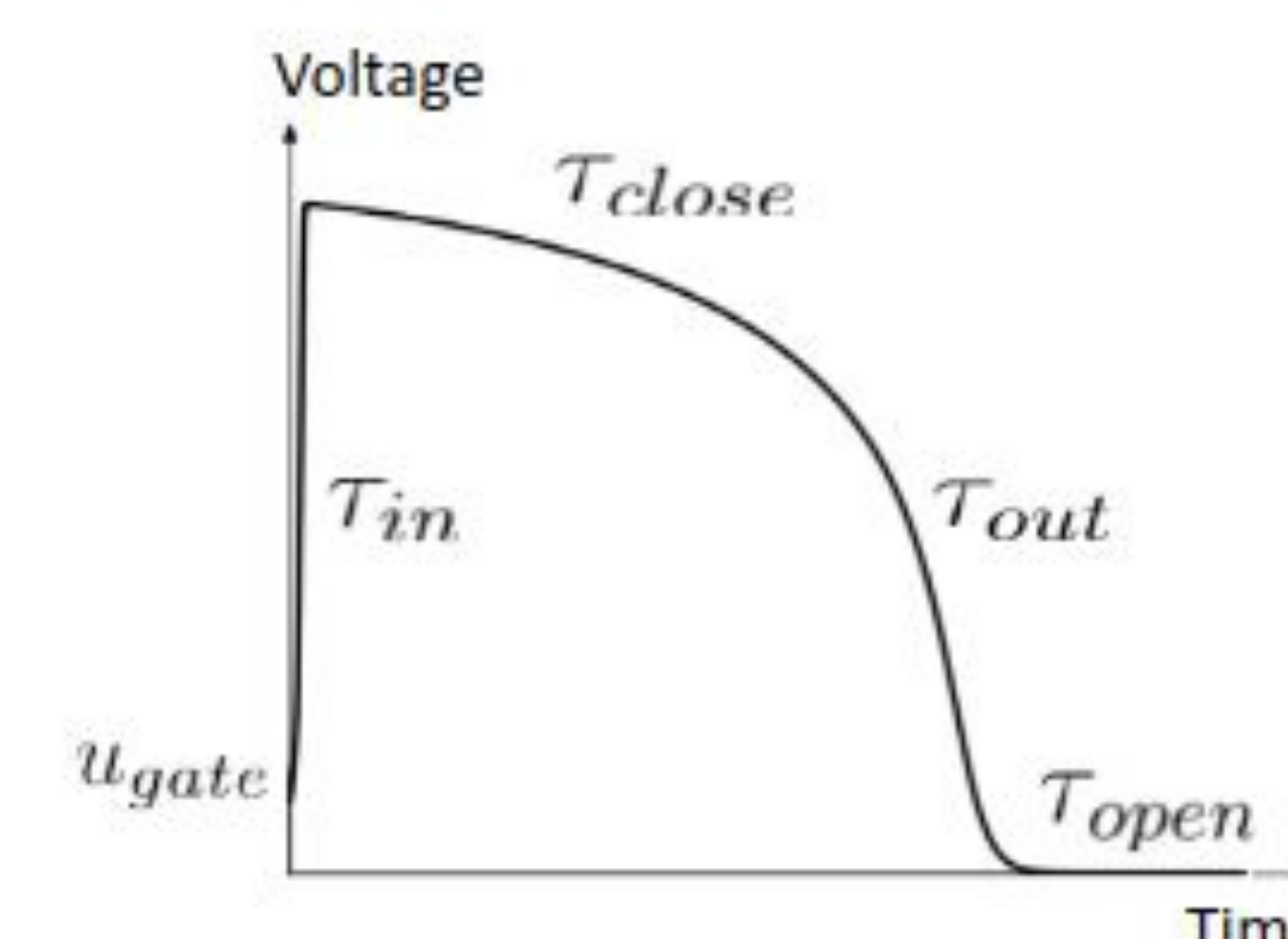


Affects the activation propagation speed

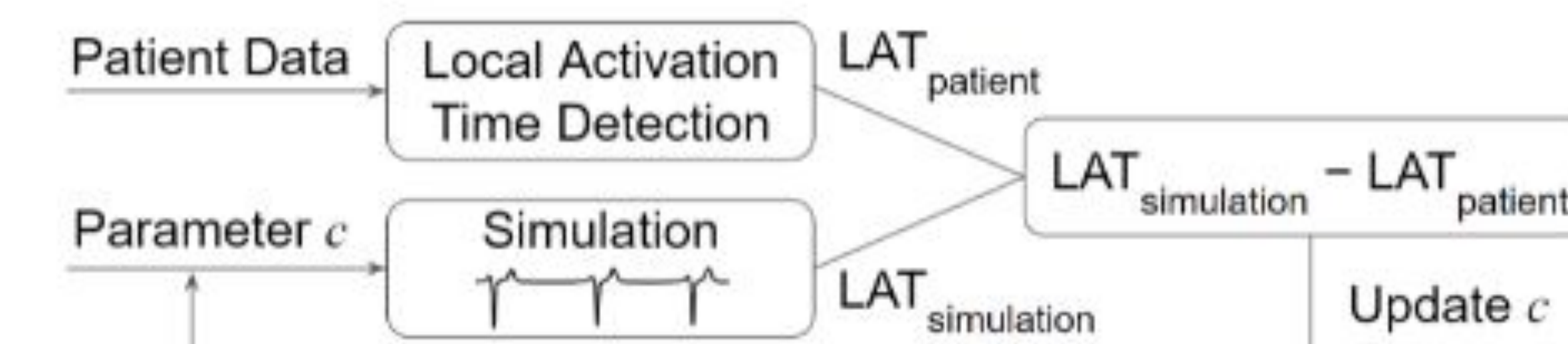
$$\frac{du}{dt} = \frac{hu^2(1-u)}{\tau_{in}} - \frac{u}{\tau_{out}} + J_{stimulus} + \nabla \cdot (D \nabla u)$$

$$\frac{dh}{dt} = \begin{cases} \frac{1-h}{\tau_{open}} & \text{if } u < u_{gate} \\ -h & \text{if } u > u_{gate} \end{cases}$$

Affects the shape of action potential



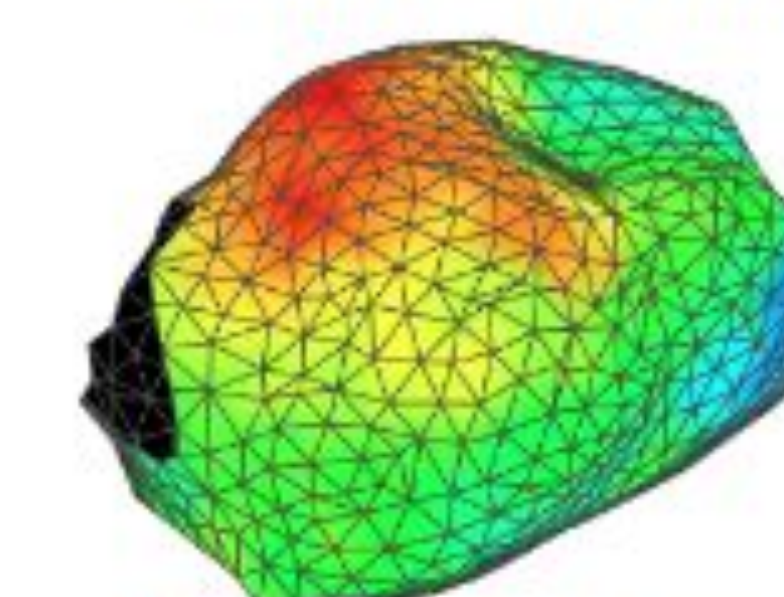
Patient-specific Parameter Optimization



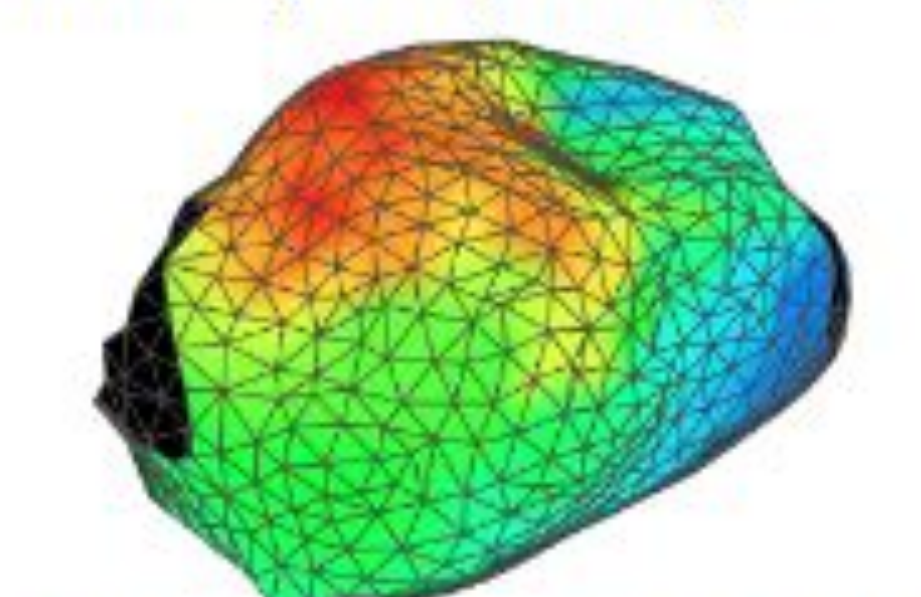
$$c^* = \underset{c}{\operatorname{argmin}} \operatorname{mean} (|LAT_{simulation}(c) - LAT_{patient}|)$$

$$d_{new} = d_{old} + (LAT_{simulation} - LAT_{patient}) \epsilon$$

Local activation time (LAT) map

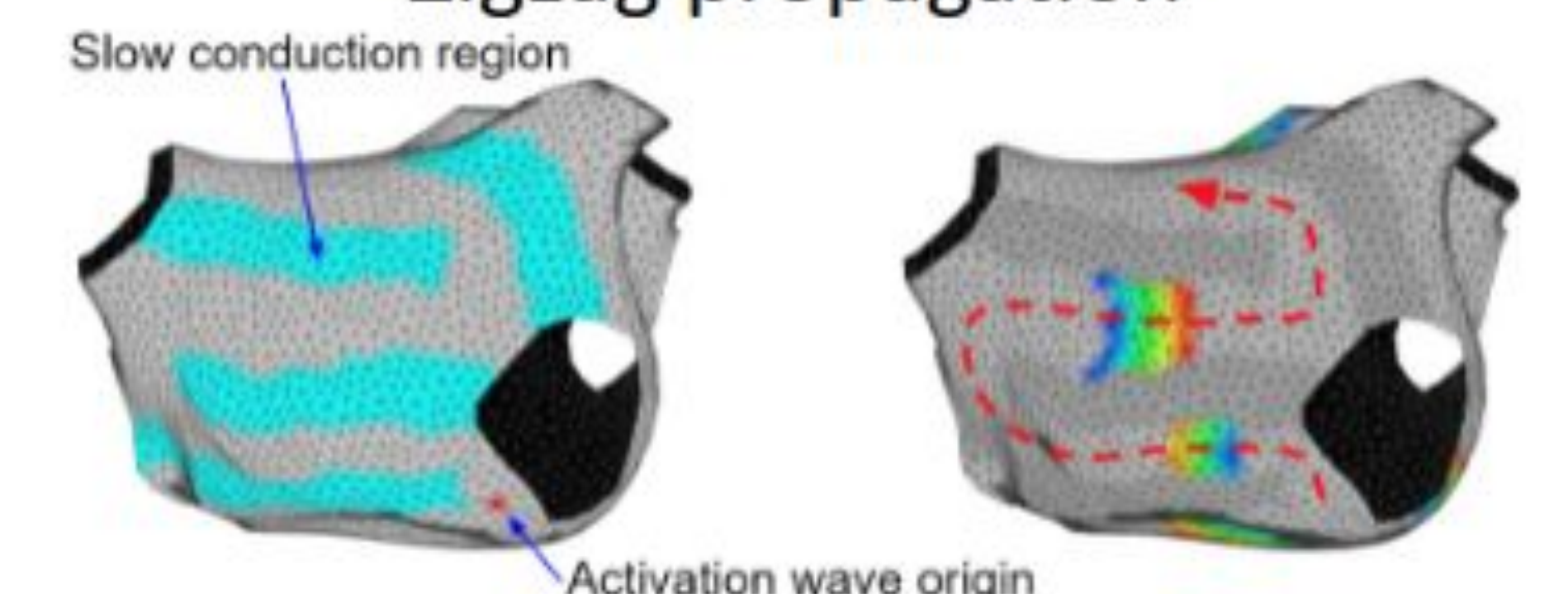


Patient data



Simulation result

Zigzag propagation



Rotor

