Imperial College London

Identifying Sources of Atrial Fibrillation on a Spatial Network

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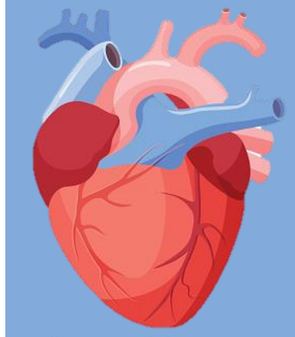
1. Introduction & Background

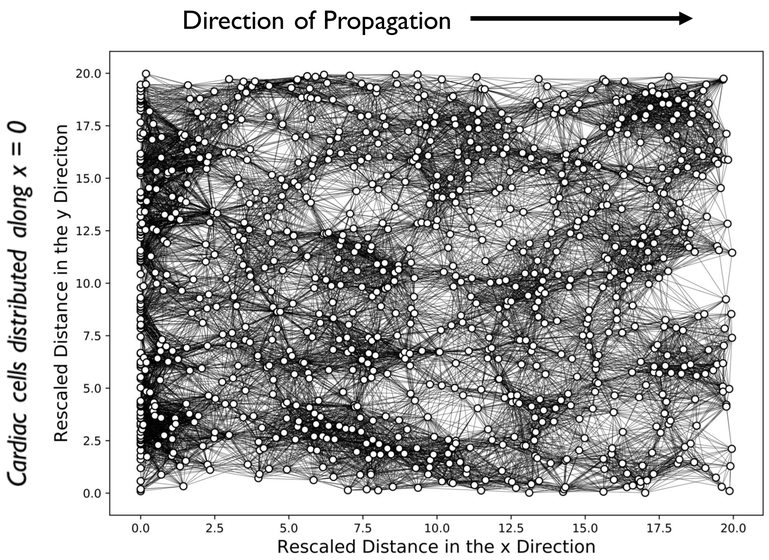


Our model concerns the atria , indicated by the darker red in the figure above [2]

Atrial Fibrillation (AF) is the biggest cardiac killer, globally affecting 30 million people [1]. A network inspired model of cardiac tissue was used to identify spatially the triggers. A cylindrical topology is used to model the atrial chambers. Clinically, this information can be used to inform **ablation treatments.**

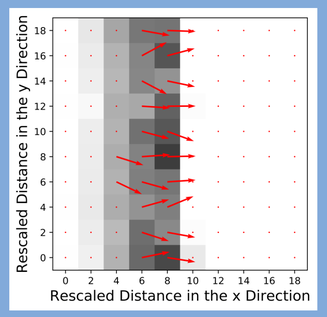
- **Muscle cells** are represented as **nodes**
- Nodes are connected to nearby neighbors
- Activation travels as a wavefront from activated cells, to cells at rest
- Impulses are generated periodically from "**pacemaker cells**"

Our goal is to accurately locate the sources of AF within our simulation

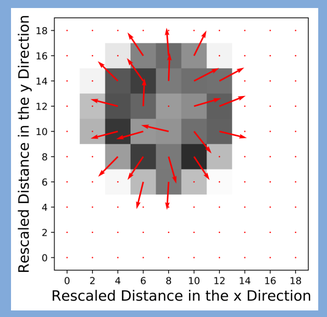


A random geometric graph in which nodes are connected if they are within a given distance of each other

2. Method



Planar propagation

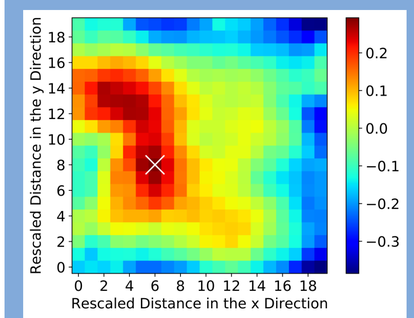


Initiation of an AF focal point

Model is coarse grained. Vectors are generated by the propagation of charge between cells, allowing a vector treatment of the behaviour of the system.

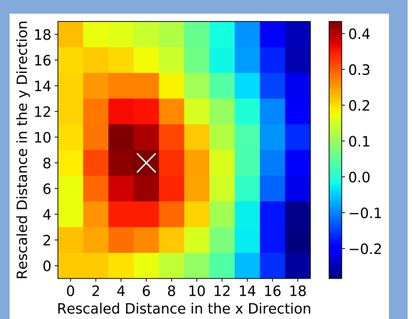
3. Results

A **measure of the divergence** of vectors over the course of a simulation is measured and shown here as a heat map.



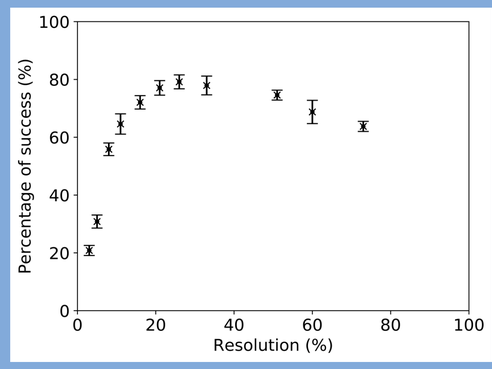
The white cross on the divergence heatmap indicates the location of the sustained focal point identified

*From the **same data** at a **lower resolution**, it is clear that the divergence-based method is still able to identify the same focal point, which the location responsible for driving AF in the system.*



Scan the QR code to view animations of the above divergence plots in time

4. Discussion



Developed algorithm was tested at different resolutions, and the average success at each was measured as shown above

- The **optimum resolution was found to be 26%.** As expected at lower resolutions it becomes more difficult to locate the source of the arrhythmia For resolutions **above** the optimum resolution the **decrease** in **success** is purely a result of the **discrete nature** of the model used
- Introduction of noise in the simulation could simulate imaging equipment used in clinical studies. In the future, for a **given signal to noise ratio**, the **minimum working resolution** could be determined

5. Conclusion

We have extended previous models of AF on a lattice [3] to a spatial network, which captures the behavior of AF. By coarse graining and calculating divergence of the charge flow, we have shown the location of the source of AF can be accurately found.

By consideration of noise and resolutions, we have also demonstrated the possibility of applying these methods to real data taken using existing imaging equipment, with the ultimate goal of improving the way AF is treated surgically.

[1] Rappel, W., Zaman, J. and Narayan, S., 2015. Mechanisms for the Termination of Atrial Fibrillation by Localized Ablation. *Circulation: Arrhythmia and Electrophysiology*, 8(6), pp.1325-1333.
[2] Clipart-library.com. 2021. *Transparent background human heart clipart.* [online] Available at: <http://clipart-library.com/clipart/1578912.htm?fbclid=IwAR2iFplm4K0Edq9crAxG0nhxGeBh7AWBd5ztndC3TwqLshXEtM9aYQD0hOo> [Accessed 2 March 2021].
[3] Christensen, K., Manani, K. and Peters, N., 2015. Simple Model for Identifying Critical Regions in Atrial Fibrillation. *Physical Review Letters*, 114(2).