Basic summary of Synchronization-based reconstruction method

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"Synchronization-based reconstruction of electromechanical wave dynamics in elastic excitable media"

Previous method

- Heart : electric signal and elastic signal
- It uses the **electric signal** from system 1 (the real one we want to simulate) to drive the **electric signal** in system 2 (virtual system).

In this method

- It uses the **elastic signal** from system 1 to drive the **electric signal** in system 2. To achieve similar deformation patterns in both two systems, i.e., reconstruction.

Electric signal

- Following equations describe the excitation (u) and recovery (v) of electric signals.

$$\frac{\partial u}{\partial t} = \nabla^2 u - ku(u-a)(u-1) - uv, \tag{1}$$

$$\frac{\partial v}{\partial t} = \epsilon(u,v) \cdot (-v - ku(u-b-1)), \tag{2}$$

$$\epsilon(u,v) = \epsilon_0 + \frac{\mu_1 v}{\mu_2 + u} \tag{3}$$

Elastic signal

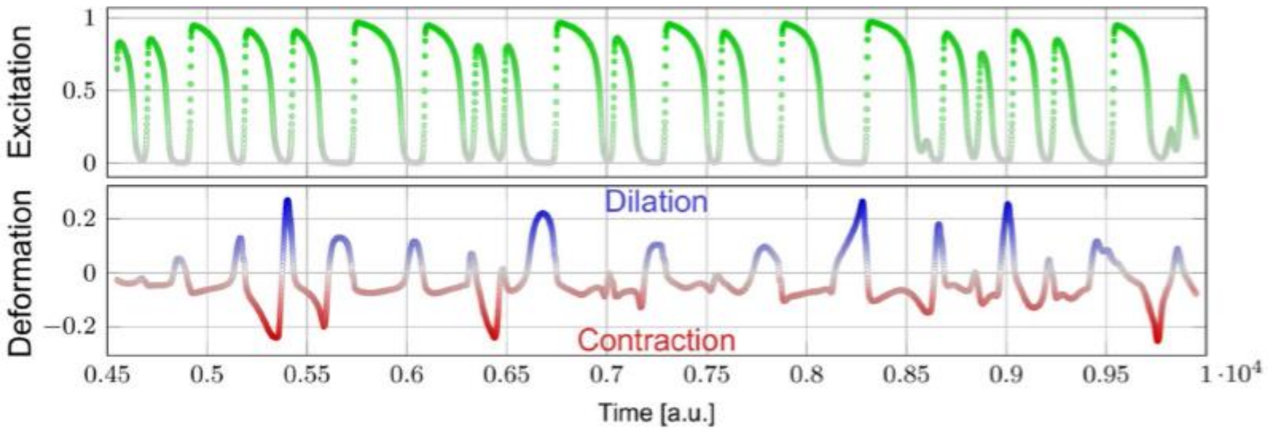
- Ta is the elastic signal generated by electric signal

$$\frac{\partial T_a}{\partial t} = \epsilon(u)(k_T u - T_a). \qquad (4)$$

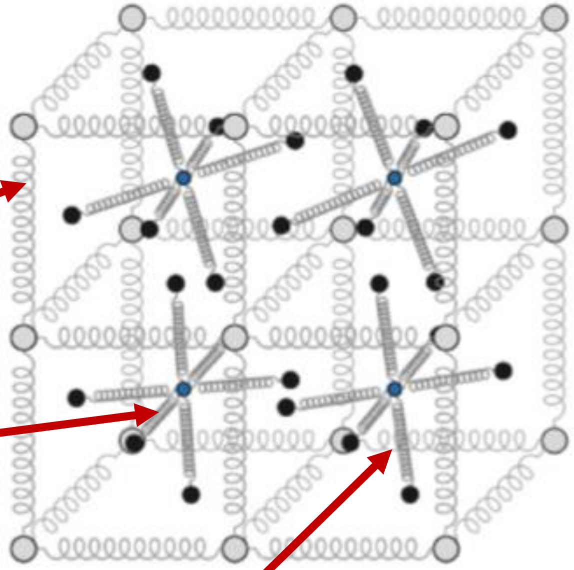
$$\epsilon_T(u) = \begin{cases} 10 & \text{for } u < 0.05, \\ 1 & \text{for } u \geq 0.05. \end{cases} \qquad (5)$$

Electric signal

Elastic signal



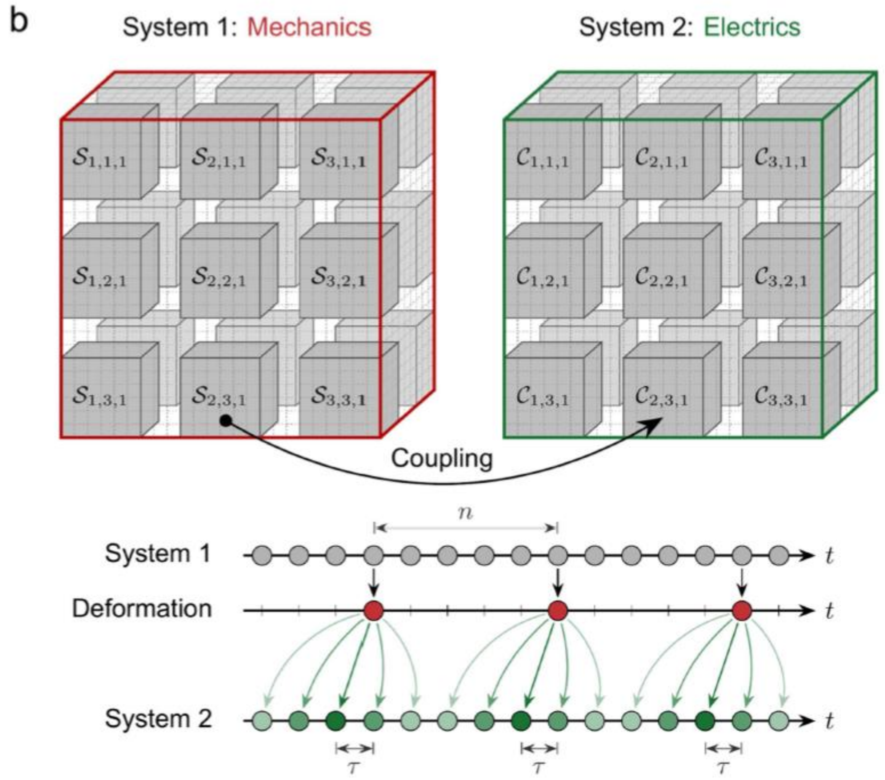
The spring model



- hexahedral cells (cube)
- barycenter xb
- To simulate cardiac muscle fiber anisotropy, the **spring orientations** can be set individually to point into **any direction**, connecting two faces
- intersection points qj

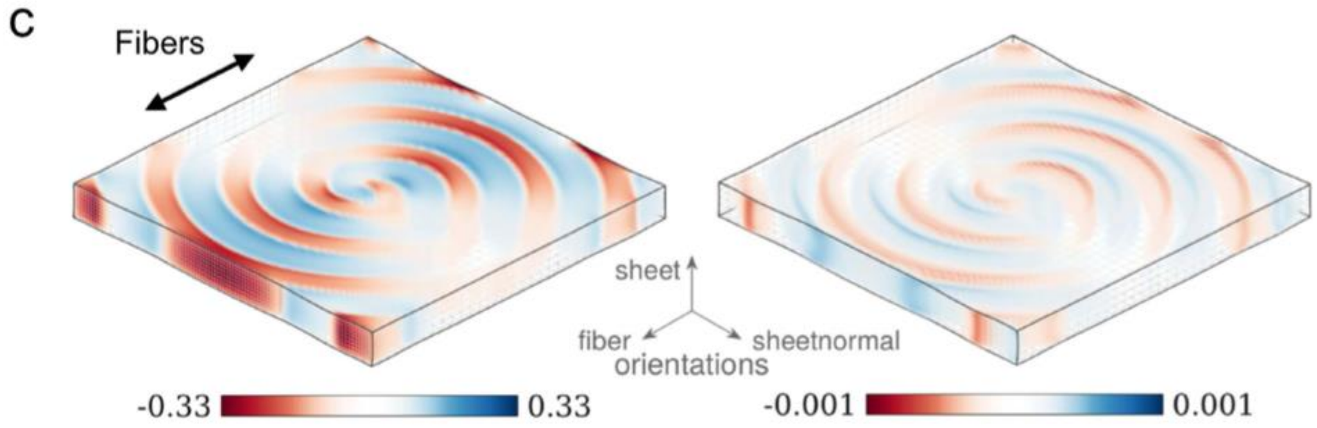
Sparse Sensors and Controllers

- Sensors in system 1 will record the input of **elastic** signals form system 1
- When there is any **deformation**, the signal will be transmitted to system 2 as the **electric** signals.
- The sensors and controllers are **sparsely** distributed; thus, it can only represent an average measurement.



The model used in this paper

- The model perform a **max** deformation (Volume change) in the direction **parallel** to fiber direction.
- A **min** deformation in **perpendicular** to fiber direction.



Coupling of two systems

- Eq. 12 describes the evolution for system 1
- Eq. 13 describes the evolution for system 2 and is disturbed by K
- Eq. 14 15 describe the coupling between two systems that will disturb the system 2's evolution.
- Parameters in it need normalization

$$\frac{\partial u_1}{\partial t} = F(u_1, \nabla^2 u_1, v_1), \tag{12}$$

$$\frac{\partial u_2}{\partial t} = F(u_2, \nabla^2 u_2, v_2) + \kappa(\tilde{\mathbf{x}}_1, u_2), \tag{13}$$

$$\kappa(\tilde{\mathbf{x}}_1, u_2) = \begin{cases} \kappa_{ijk}(t) & \text{if } \tilde{\mathbf{x}}_1 \in \mathcal{S}_{ijk}, \\ 0 & \text{else}, \end{cases} \tag{14}$$

$$\kappa_{ijk}(t) = \frac{k_{\pm}(t)}{N} \left(\sum_{\mathbf{x} \in \mathcal{S}_{ijk}} s_1(\mathbf{x}, t - \tau) - \sum_{\mathbf{x} \in \mathcal{C}_{ijk}} u_2(\mathbf{x}, t) \right). \tag{15}$$