Supplemental Material

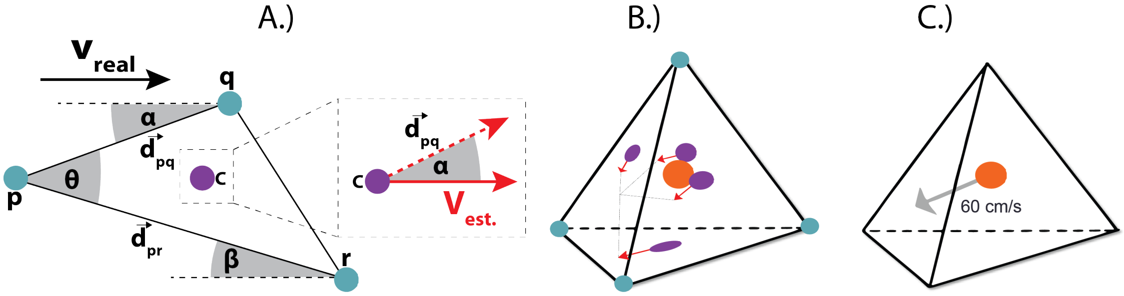

Fig. 1. Estimation of the 3D CV vector via triangulation and 3D superposition. A.) Parameterization of each face of the tetrahedra for the purposes of triangulation. INSET: Representing the vector at the center of the triangle. B.) Superposition of each triangle's 2D CV C.) Visualization of the 3D CV vector.

Implementing equations #1 - #6 guided by Figure 1: The node that see the activation front earliest are denoted as **p** (on a triangle by triangle basis), and the second and third nodes are denoted **q** and **r**. The center of the triangle is identified with a **c**. $\mathbf{V_{real}}$ indicates the directionality of the activation front and $\mathbf{V_{est.}}$ is the estimated speed ($\mathbf{V_{Mag.}}$) and directionality of that same activation front. $\vec{d}_{pq}$ and $\vec{d}_{pr}$ denote the vectors defining the edges of the triangle between **p** and the following edges **q** and **r**. α and β denote the angle of the incident wavefront on the edge between the respective node and **p**. $\mathbf{t_{pq}}$ and $\mathbf{t_{pr}}$ are the differences in activation times measured at the respective nodes.

θ in Eq.#1 is defined as the angle at node **p** and is calculated using the edge lengths of all three edges via the law of cosines.

$$\theta = \arccos\left(\frac{\|\vec{d}_{pq}\|^2 + \|\vec{d}_{pr}\|^2 - \|\vec{d}_{qr}\|^2}{2 \cdot \|\vec{d}_{pq}\| \cdot \|\vec{d}_{pr}\|}\right) \tag{1}$$

Using θ, relative differences in activation times, and edge lengths, we can then calculate the orientation of the wavefront relative to one of the triangular edges, specifically $\vec{d}_{pq}$using Eq.#2.

$$\alpha = \arctan\left(\frac{\frac{t_{pr}\cdot\|\vec{d}_{pq}\|}{t_{pq}\cdot\|\vec{d}_{pq}\|} - \cos\theta}{\sin\theta}\right) \tag{2}$$

Theta is related to α and β via Eq.#3. α and β describe the orientation of the activation front relative to one of the edges of the triangle.

$$\cos\beta = \cos(\theta - \alpha) \tag{3}$$

We may now determine the speed of that front using one of the edges connecting the earliest activated node (node **p**), which can be done with $\vec{d}_{pq}$ and α in Eq.#4 or $\vec{d}_{pr}$ and β in Eq.#5.

$$V_{Mag.} = \frac{\|\vec{d}_{pq}\| \cdot \cos\alpha}{t_{pq}} \tag{4}$$

$$V_{Mag.} = \frac{\|\vec{d}_{pr}\| \cdot \cos\beta}{t_{pr}} \tag{5}$$

We use Eq.#6 to translate the estimated CV vector to the centroid of the triangle.

$$\vec{V}_{Est.} = \left((V_{Mag.} \cdot \widehat{\vec{d}_{pq}}) \circ \begin{bmatrix} \cos\alpha & -\sin\alpha \\ \sin\alpha & \cos\alpha \end{bmatrix}\right) + \vec{d}_{pc} \tag{6}$$

, where $\widehat{\vec{d}_{pq}}$ is the unit vector of $\vec{d}_{pq}$.

Finally, once the 2D CV vector was computed for each face of the tetrahedral element, the face vectors were summed to produce the 3D CV vector using Eq.#7.

$$\vec{V}_{3D} = \vec{V}_1 + \vec{V}_2 + \vec{V}_3 + \vec{V}_4 \tag{7}$$