EP Workbench*:* A computational platform for identifying fibrotic regions and conduction disturbances in the atria using conduction velocity.

Vinush Vigneswaran[1], Ali Gharaviri[1], Magdalena Klis[2], Neil Bodagh[2], Iain Sim[2], Irum Kotadia[2], Steven Niederer[3], Mark O'Neill[2], Steven E Williams[1].

(1) The University of Edinburgh (2) King's College London (3) Imperial College London

Background

Fibrotic remodelling in the atria, associated with atrial fibrillation (AF), creates areas of slowed and heterogenous conduction. These areas act as substrates that promote AF maintenance and perpetuation. Hence, detecting these regions is crucial for understanding and managing AF. One promising approach for identifying these regions is the estimation of conduction velocity (CV). However, the correlation between fibrotic regions and conduction disturbances and how effectively estimated CVs can be used to identify these regions remains uncertain. A better understanding of this relationship could significantly help clinicians to locate and eliminate these regions during ablation procedure, therefore, improve AF treatment outcome.

Purpose

The aim of the study is to enhance OpenEP Workbench software for researchers by:

(1) incorporating three well established method for CV estimation and CV divergence calculation to detect conduction disturbances;

(2) assessing the performance of these three CV calculation methods in identifying fibrotic regions, using simulated data as the ground truth

(3) developing a histogram analysis tool to enable identification of slow conduction regions at the optimal classification threshold attained from (2).

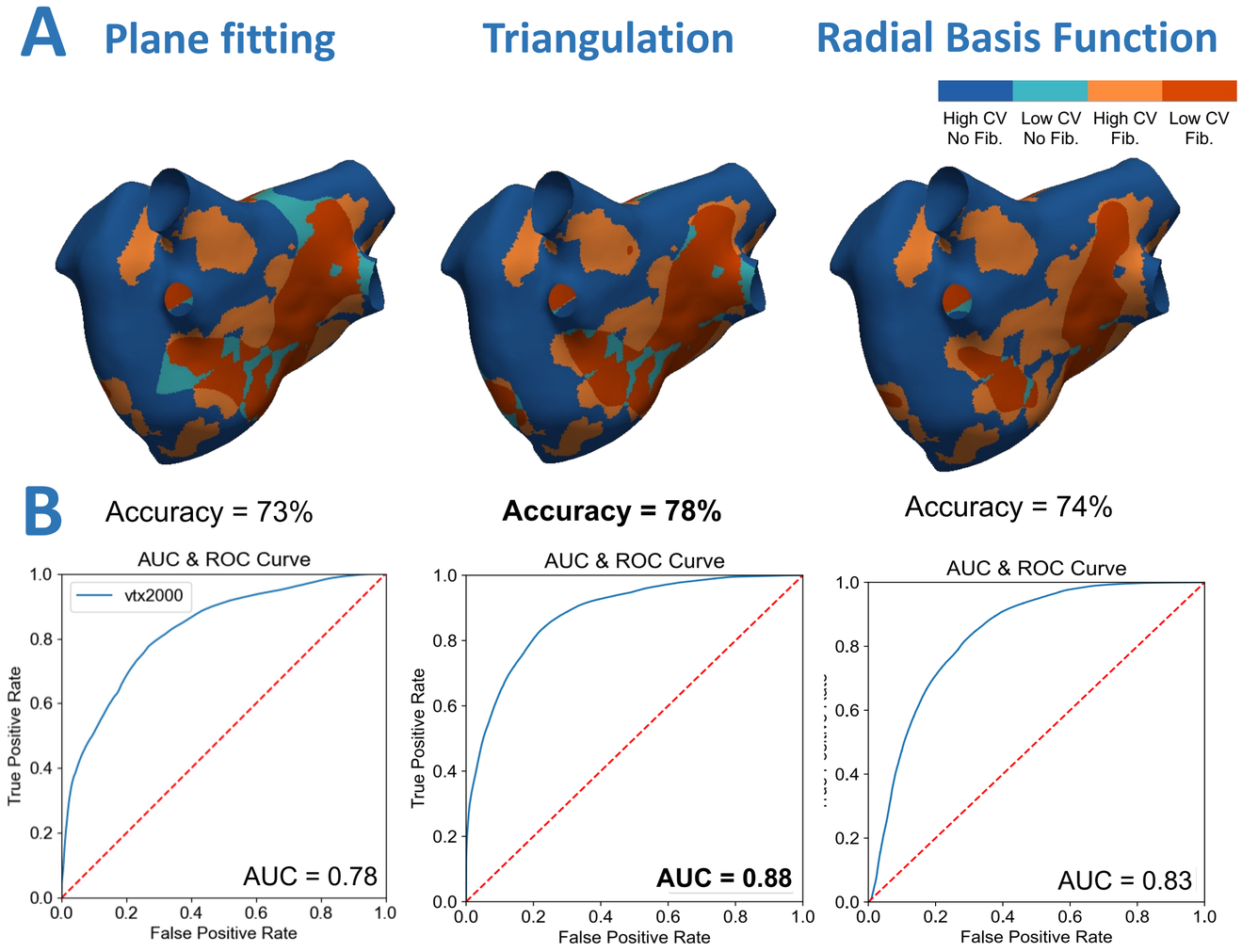

Figure 1: (A) Maps contrasting low and high conduction velocities (CVs) with simulated fibrotic and normal atrial regions. (B) Classification accuracy and AUC metrics for CV estimation methods.

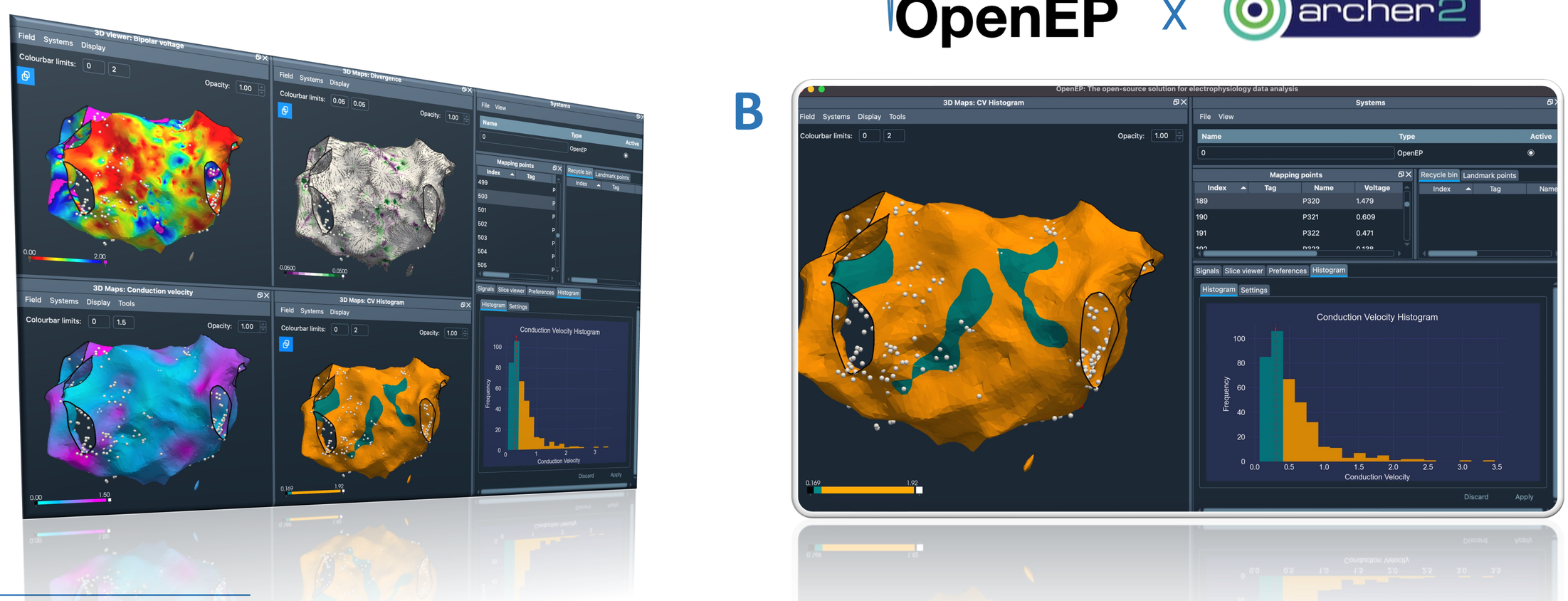

Figure 2: (A) EP Workbench generated visualisation for bipolar voltage, CV divergence and CV maps. (B) The histogram tool identifying regions below the 0.3 m/s CV threshold.

Method

- Integrated 3 previously published algorithms for CV estimation **(i.e. triangulation, planar fitting, radial basis function interpolation)** into EP Workbench with user controls.
- Estimated CVs were further enhanced by omitting areas with artificially high CVs due to either **wave collisions or focal discharges.** These were identified using **the divergence** of the CV vector field.
- Utilised **simulated atrial activations with fibrotic regions** to assess the classification accuracy of the low conduction areas in identifying fibrotic regions.
- Using the **ROC curve** generated from these analyses, we defined the best **CV threshold** to identify fibrotic regions.
- Finally, this threshold was used to **parameterise the voltage map over the surface mesh**, visualising the low voltage area – **histogram analysis tool**.

Results

- **Four color-coded maps** shows how low CV (CV < 0.3 m/s) and high CV regions calculated using each method **overlap with the fibrotic and normal regions in the simulated atrial activation** - **Figure 1A.**
- Out of the three CV methods the classification accuracy and AUC was highest for the **triangulation method (78%, 0.88)** in identifying fibrotic regions - **Figure 1B.**
- EP Workbench shows **generated voltage, CV, divergence and the parametrised voltage map** using electro-anatomical mapping data - **Figure 2A**.
- The **histogram analysis tool** can be used to identify regions of slow conduction velocity from electroanatomic mapping data. Using a threshold of <0.3m/s, two slow conducting regions are visualised on the posterior wall of a test case - **Figure 2B**.