

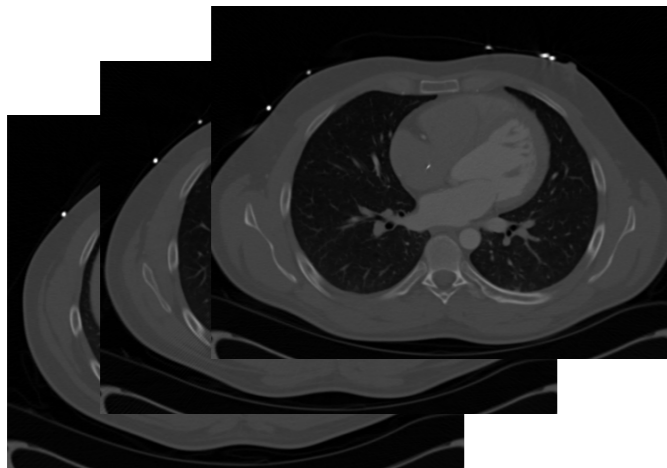
Effect of Segmentation Variation on ECG Imaging

Jess Tate, Nejib Zemzemi, Wilson Good,
Peter van Dam, Dana Brooks, Rob MacLeod

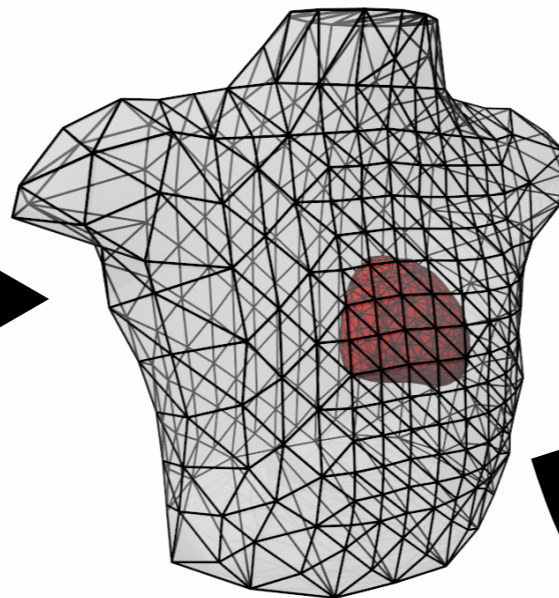
University of Utah
Inria Bordeaux Sud Ouest
Radboud Nijmegen University
Northeastern University

ECG Imaging

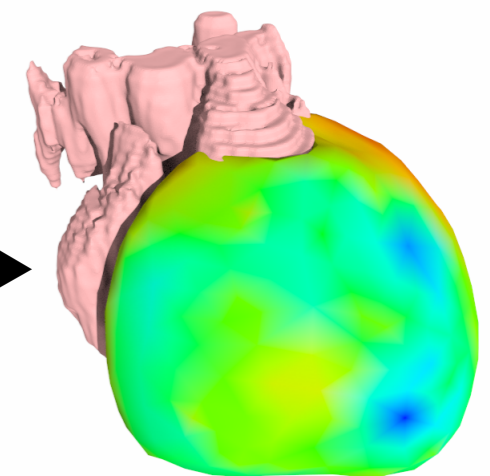
Medical Imaging



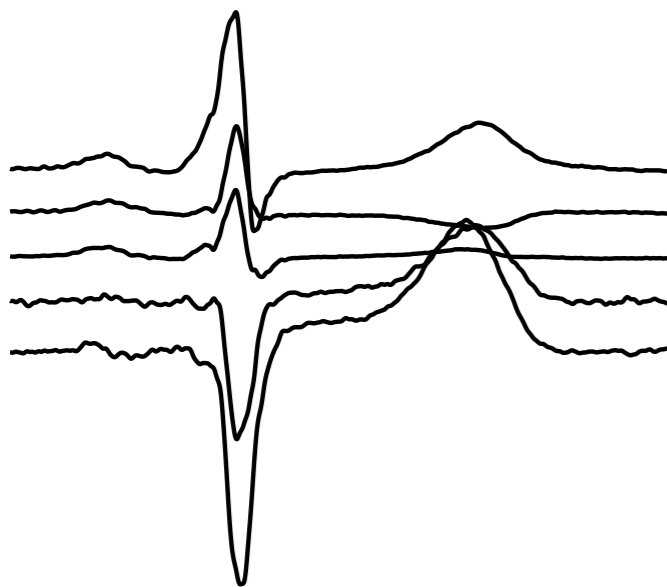
Geometric Model



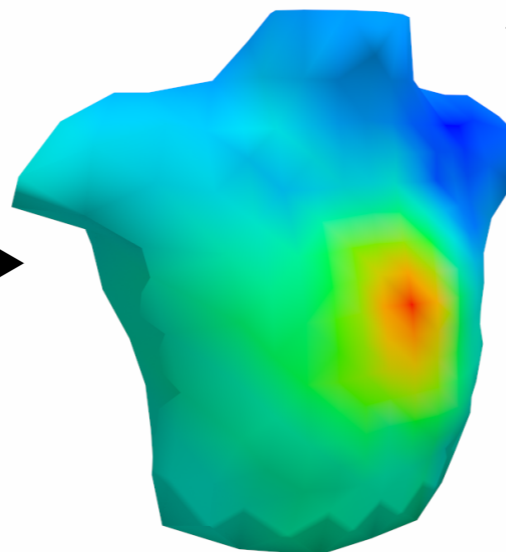
Cardiac Activity



ECG Recordings



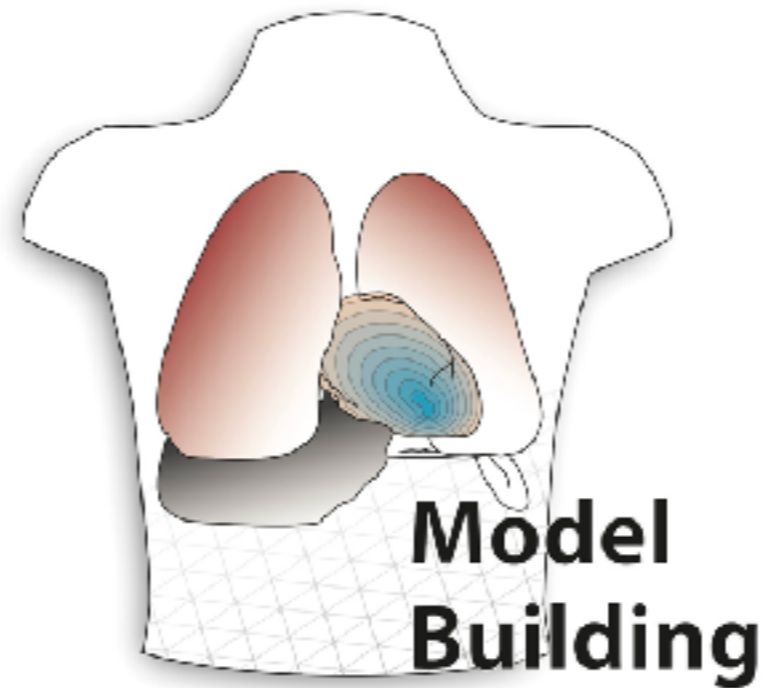
Potential Maps



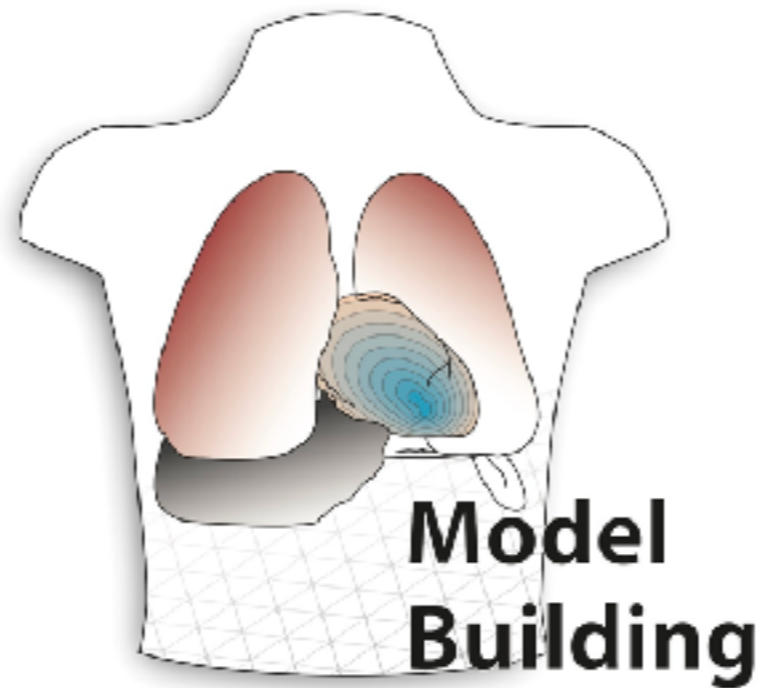
Forward
Model

Solve
Inverse

CEI: Modeling Error Workgroup (Consortium for ECG Imaging)



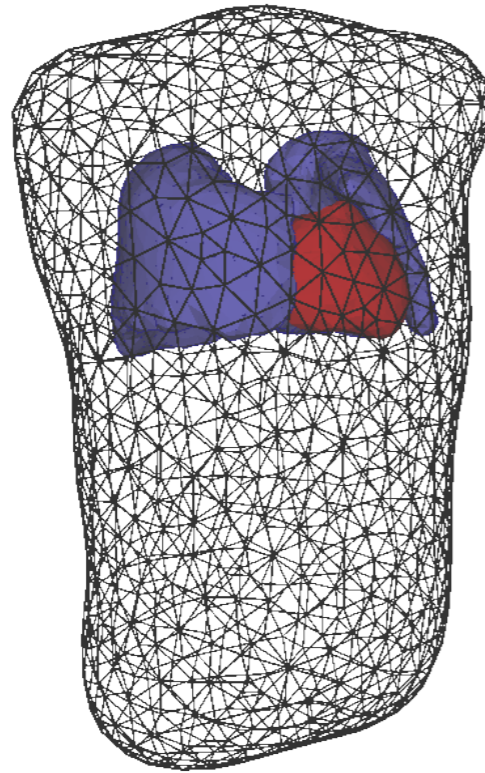
CEI: Modeling Error Workgroup (Consortium for ECG Imaging)



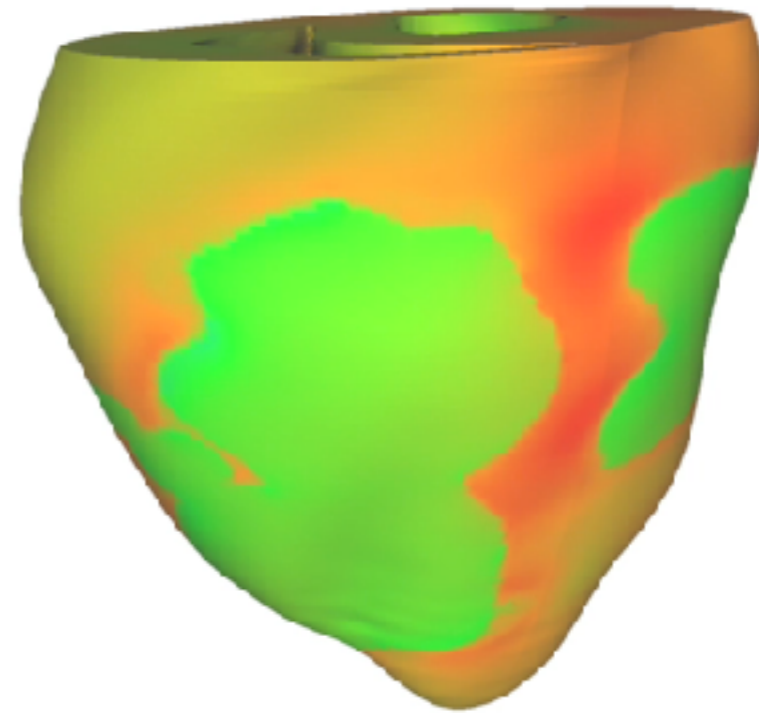
Quantify the effects of error

Origins of Error

Geometry

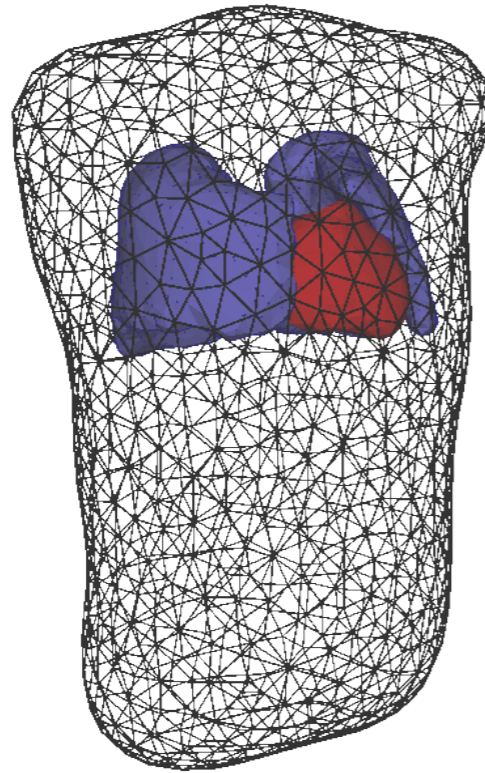


Sources

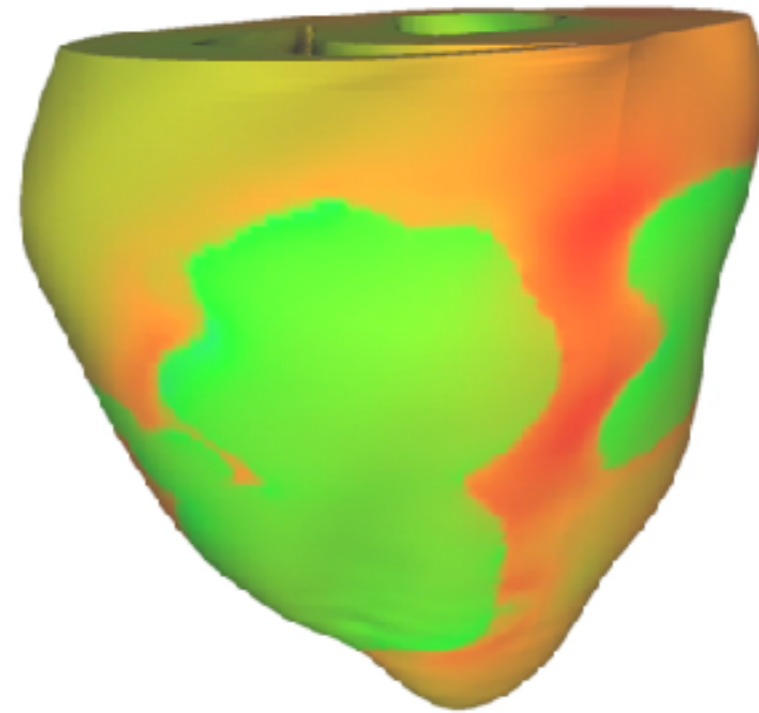


Origins of Error

Geometry

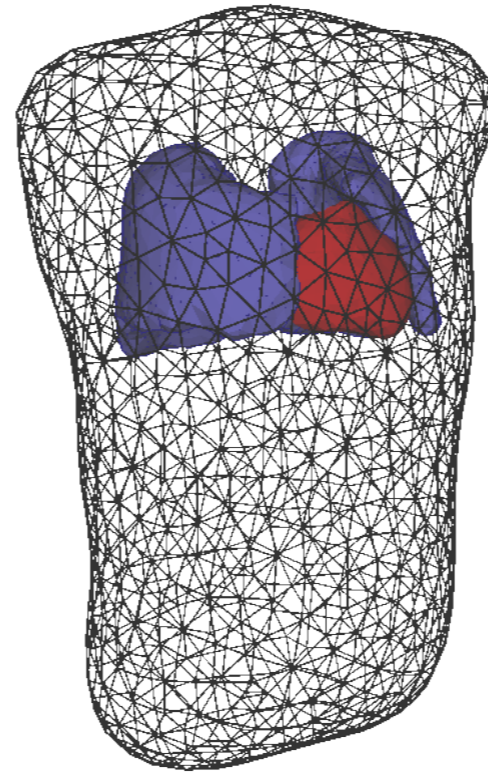


Sources



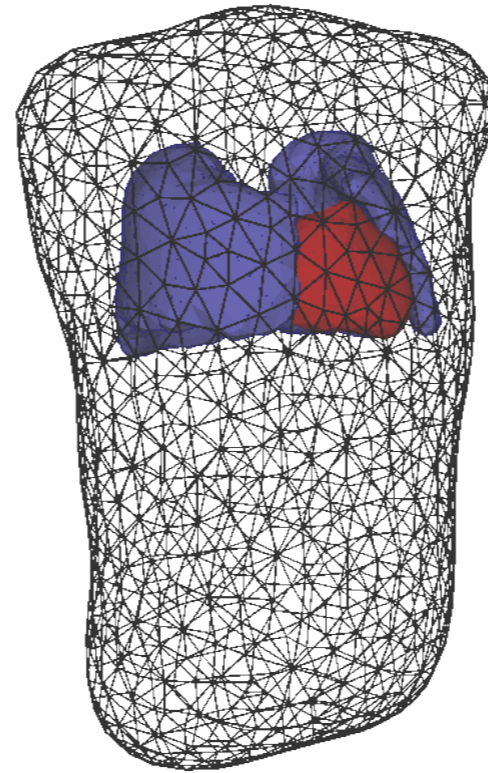
Origins of Error

Geometry



Origins of Error

Geometry

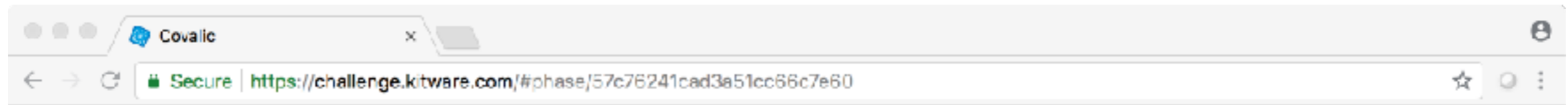


Segmentation

Segmentation Error



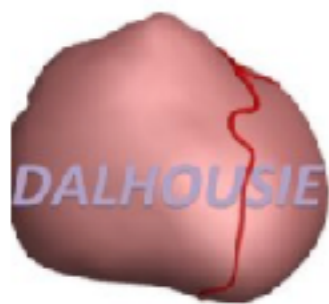
Data Collection



Jess Tate

CEI Model Building > Stage 1: Dalhousie Segmentation

OVERVIEW



This phase is to upload the segmentation of torso, ventricles, left lung, and right lung from the Dalhousie CT scan. Four files will need to be submitted simultaneously:

- LLung.nrrd - left lung
- RLung.nrrd - right lung
- Torso.nrrd - Torso surface (everything in the torso should be 1)
- Ventricles.nrrd - Ventricular Myocardium (with endo and epicardial surfaces)

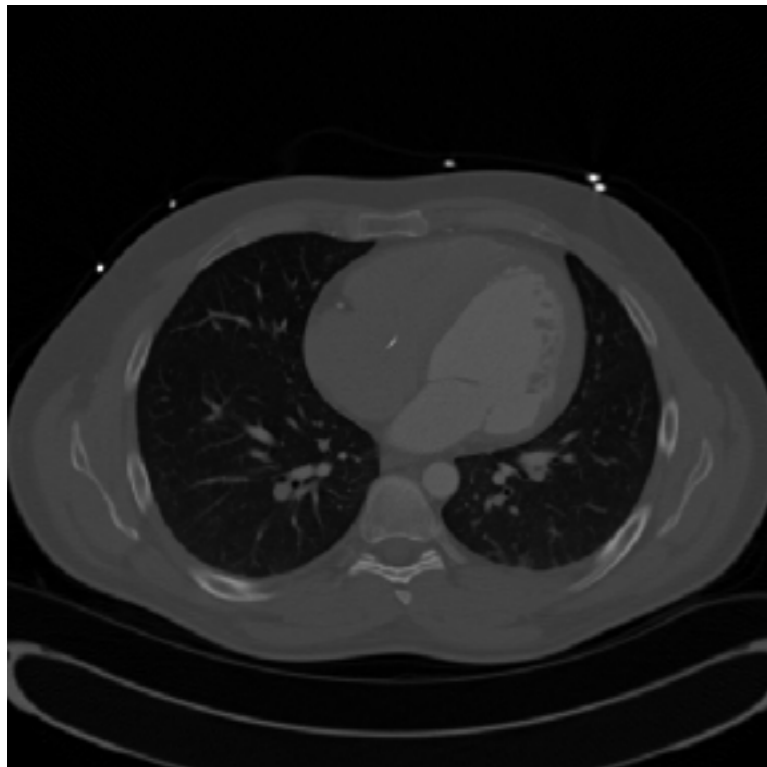
Each file will need to be of the same image size and spacing as the original CT scan (512x512x54, 0.7422x0.7422x3). Select all of the files when in the file finder dialogue. Your submission will be compared to a "Ground Truth" which is just one of the possible segmentations, so do not worry what your scores or metrics are, but if they are not calculated (it may take several minutes), or if there is an error, you will need to resubmit the segmentations. If you wish to, you can create an empty file (nrrd of the same size with all zeros) to skip one of the tissues. Once all the participants submit a segmentation of each of the tissues, we will create a common segmentation to use for the next stage.

Download test dataset

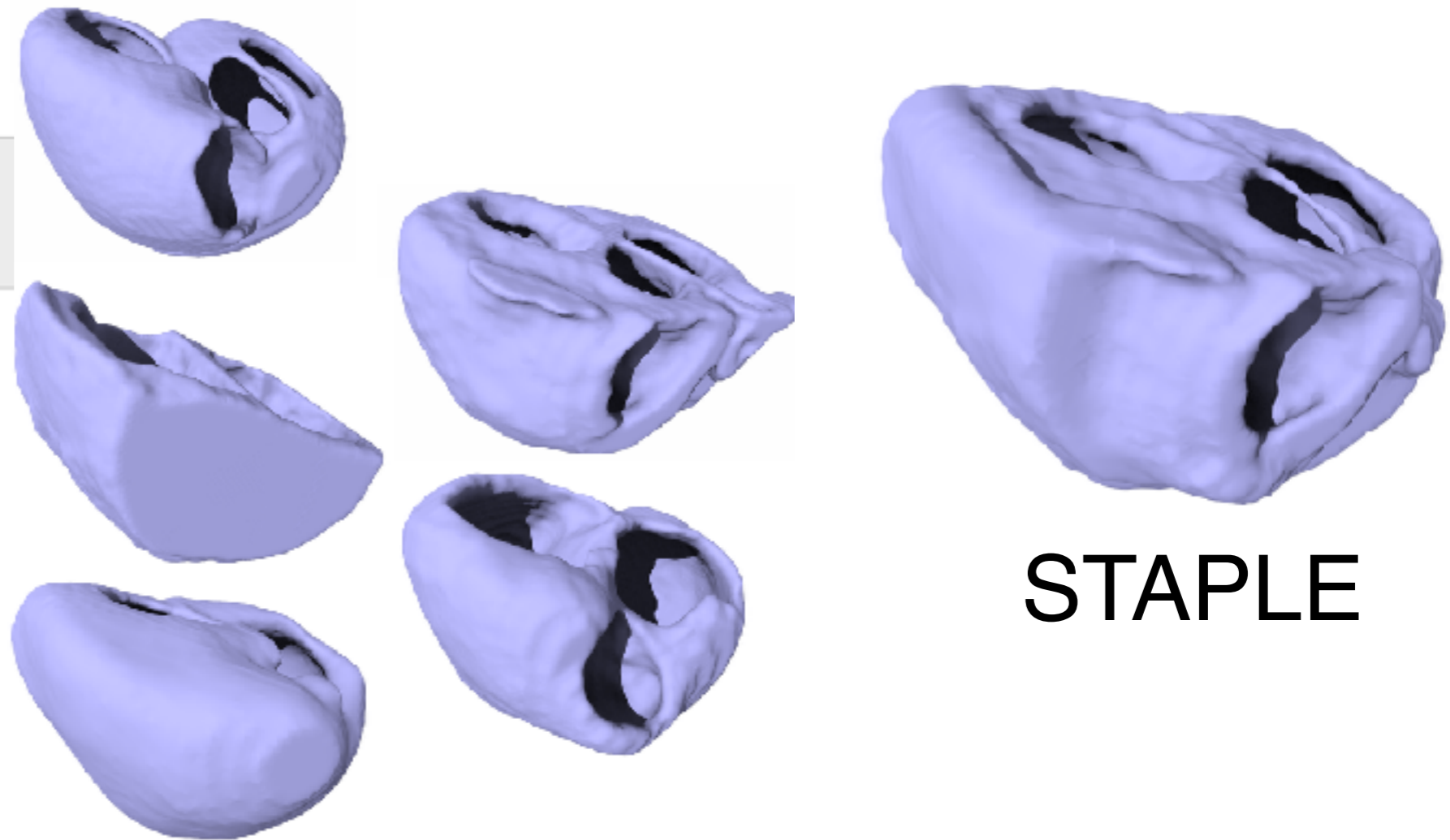
Download ground truth data

Submit your results

Segmentations



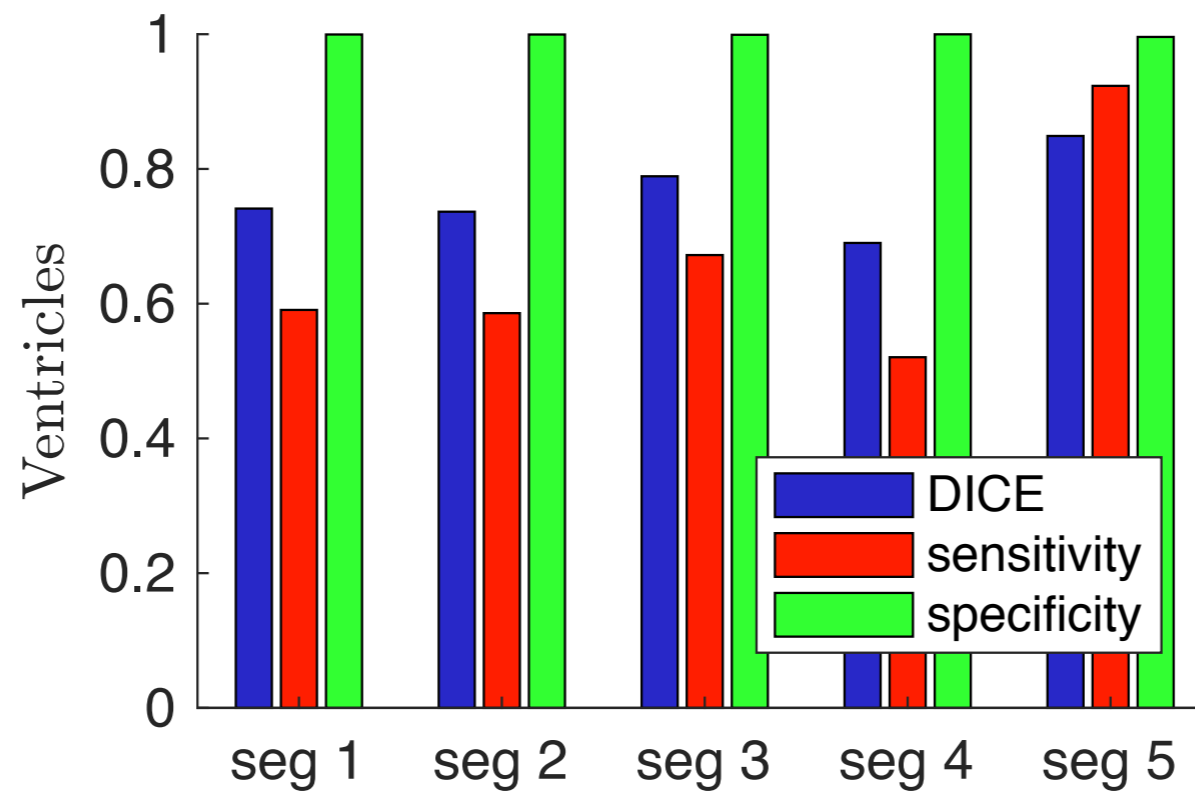
CT scan



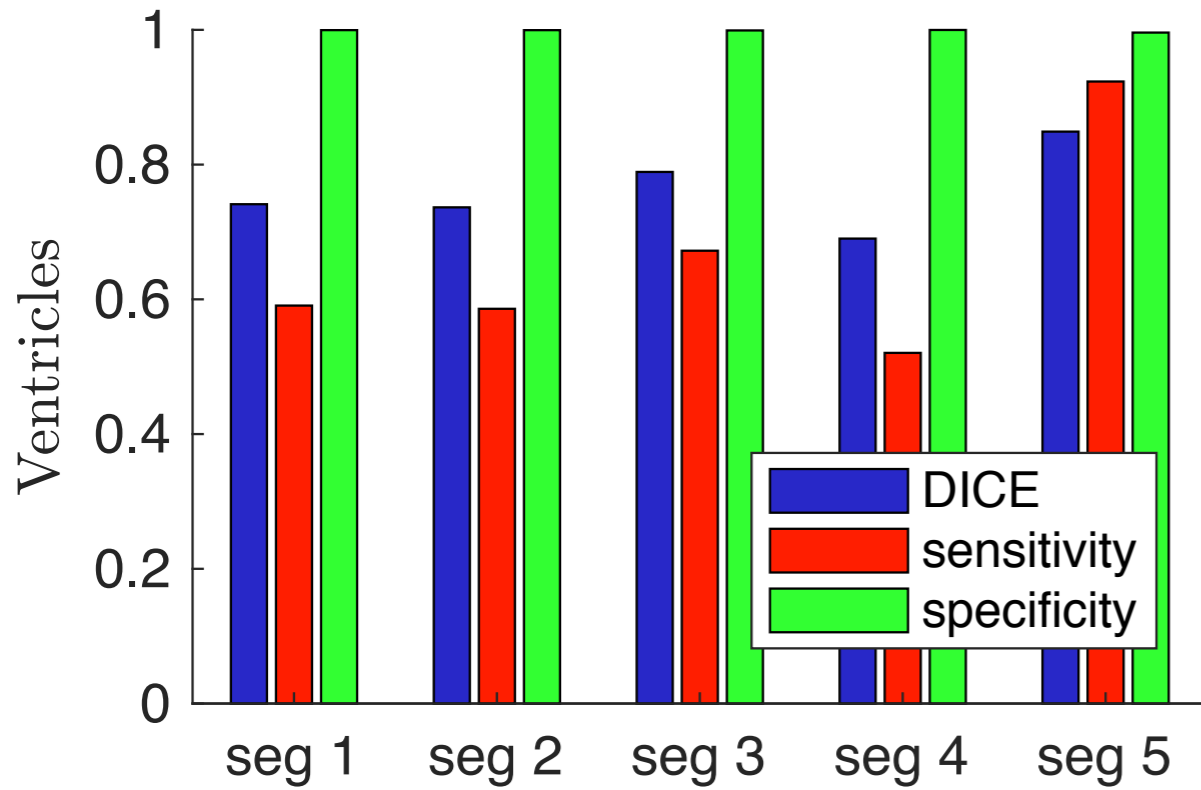
Covalic

STAPLE

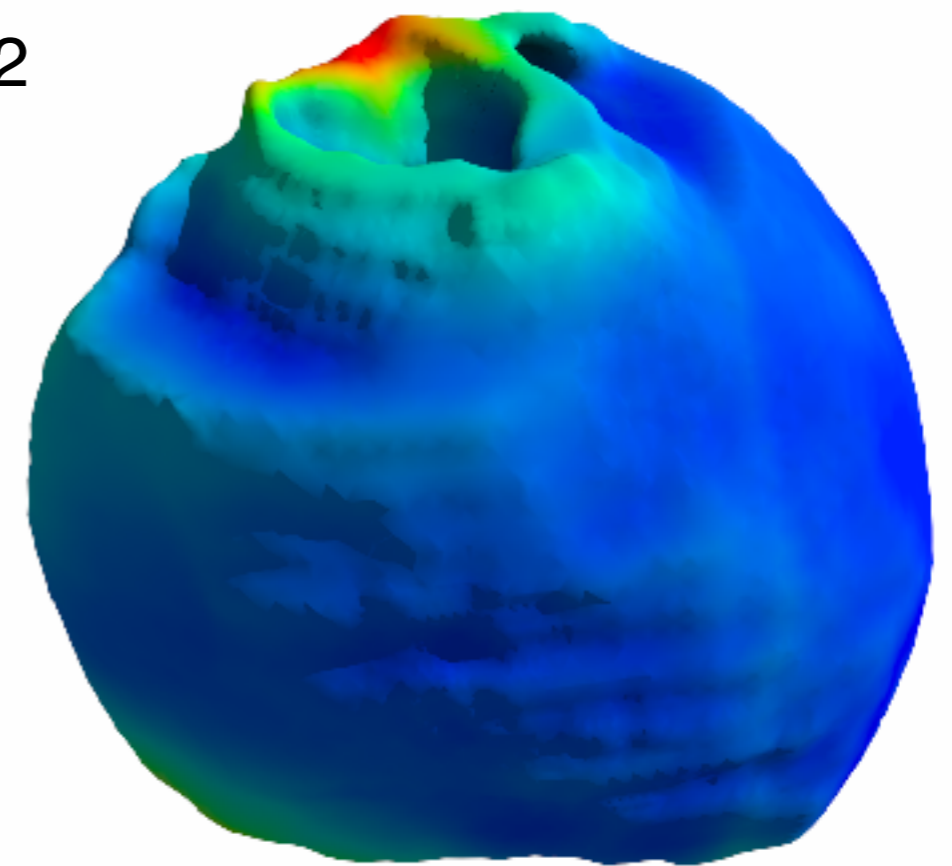
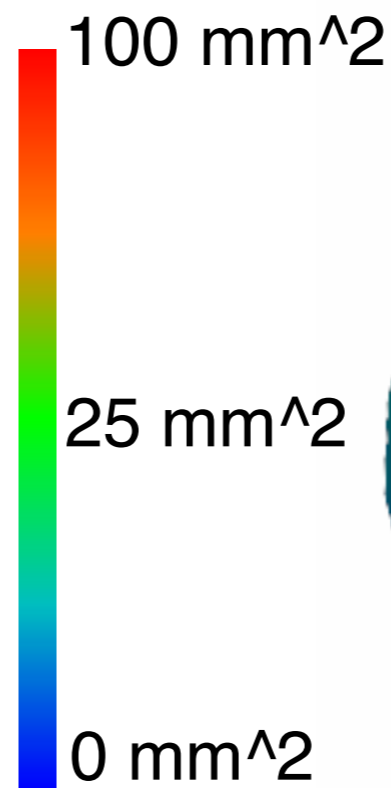
Segmentation Variation



Segmentation Variation



Variance of min distance



Quantify the effect of segmentation variation on ECGI solutions

Covalic

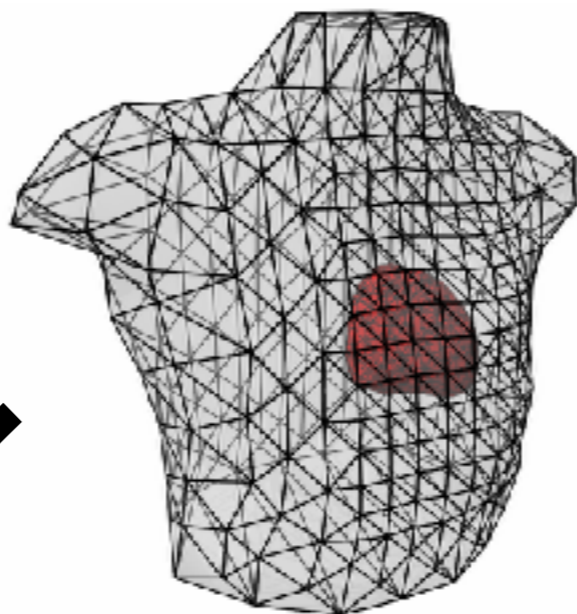


Segmentation



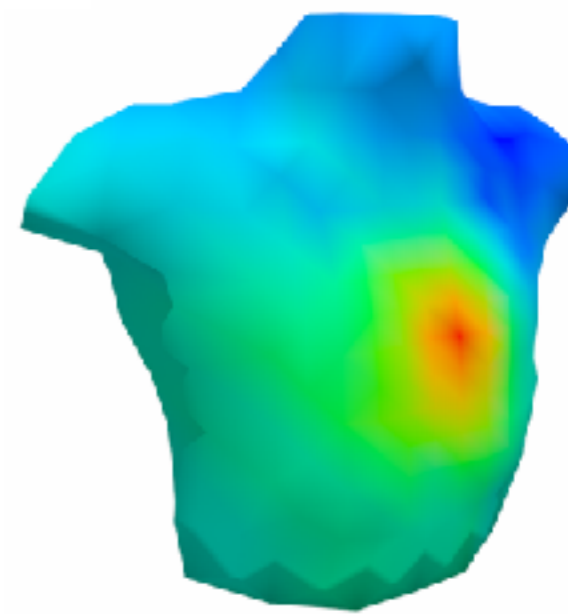
Heart Mesh

x6

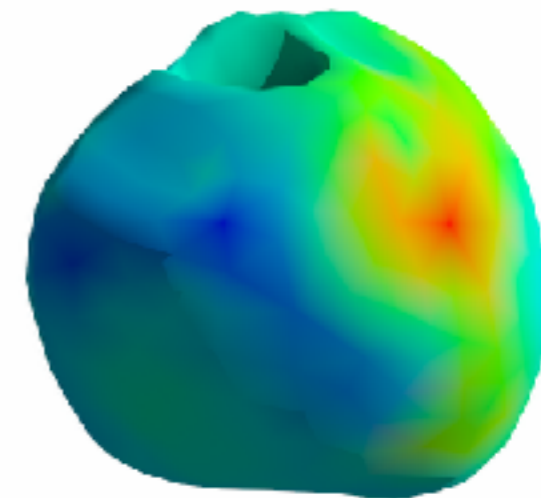


Torso Mesh

[Forward Matrix]



BSPM

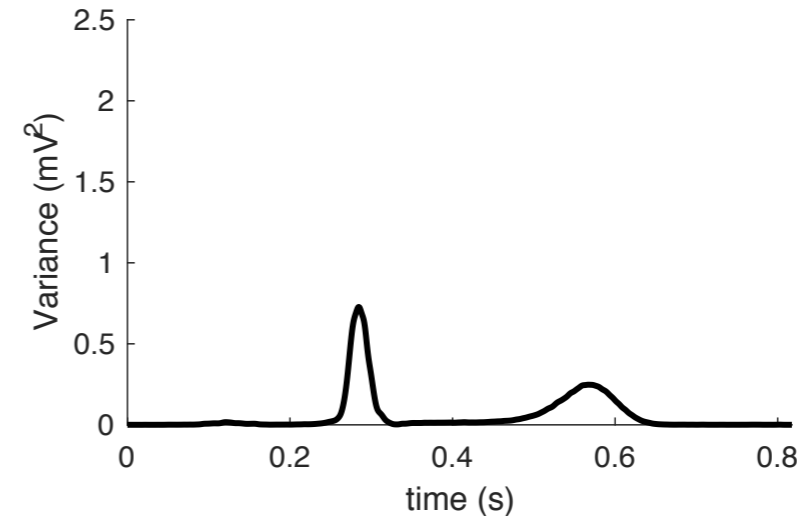
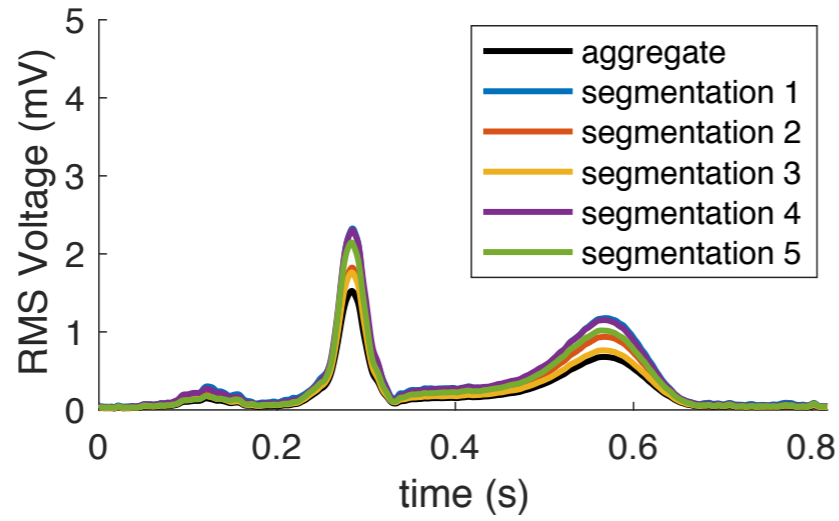


ECGI

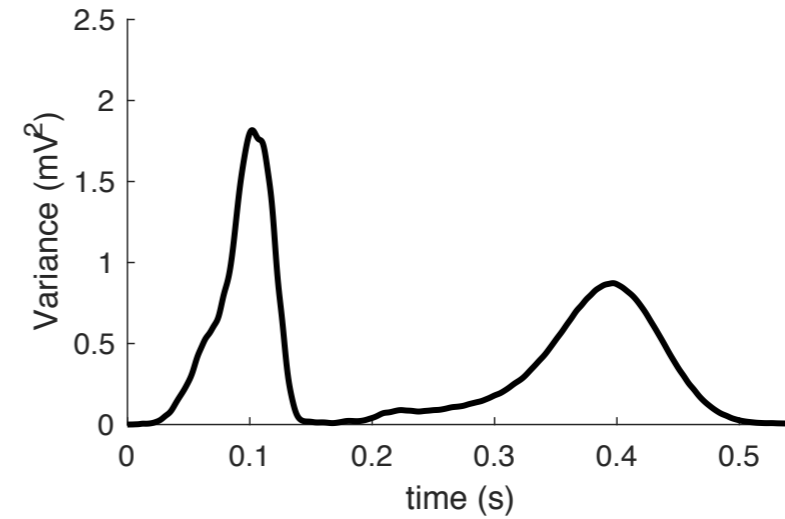
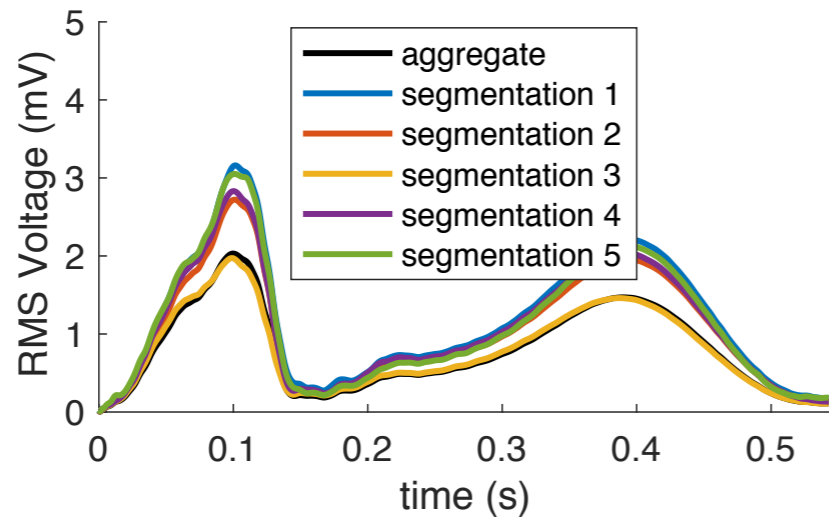


Variance Over Time

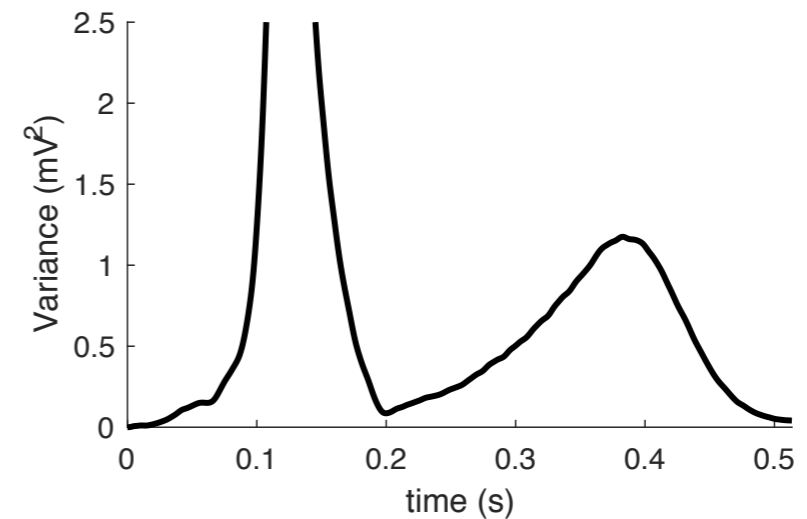
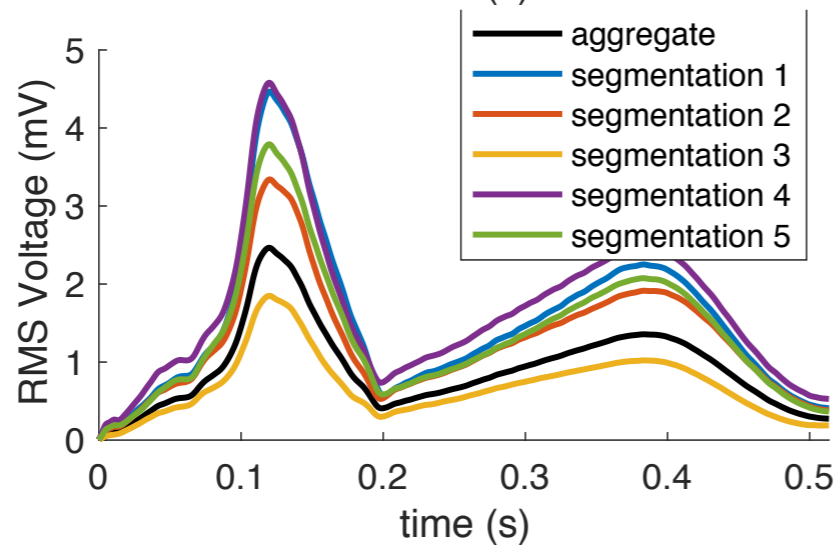
Sinus



LV stim

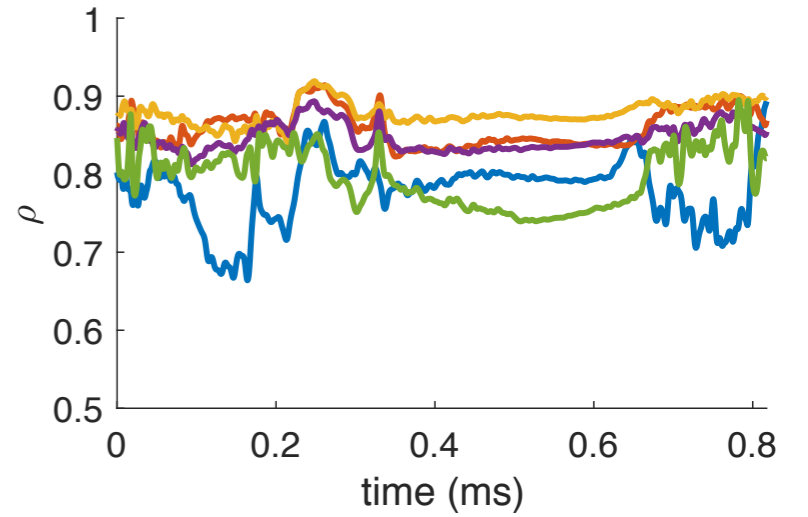
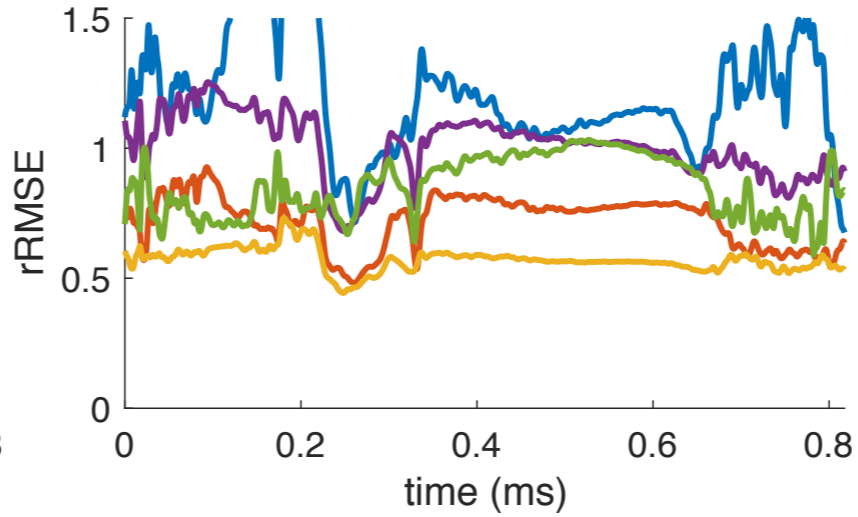
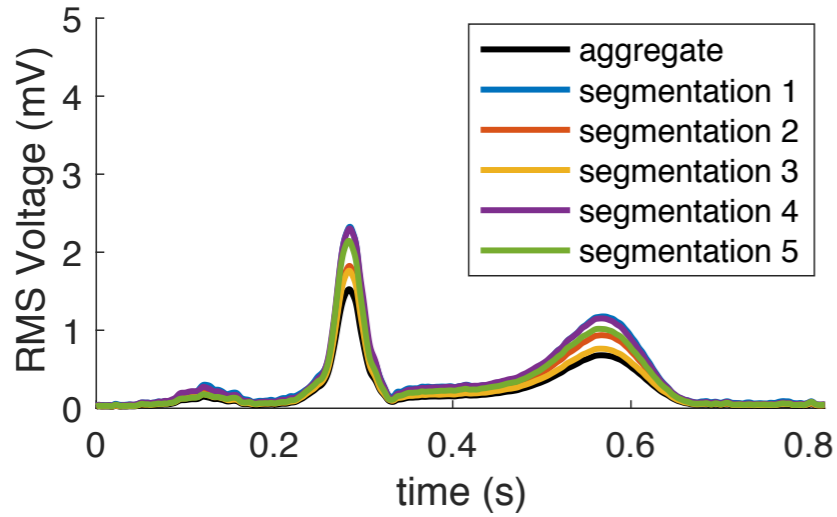


RV stim

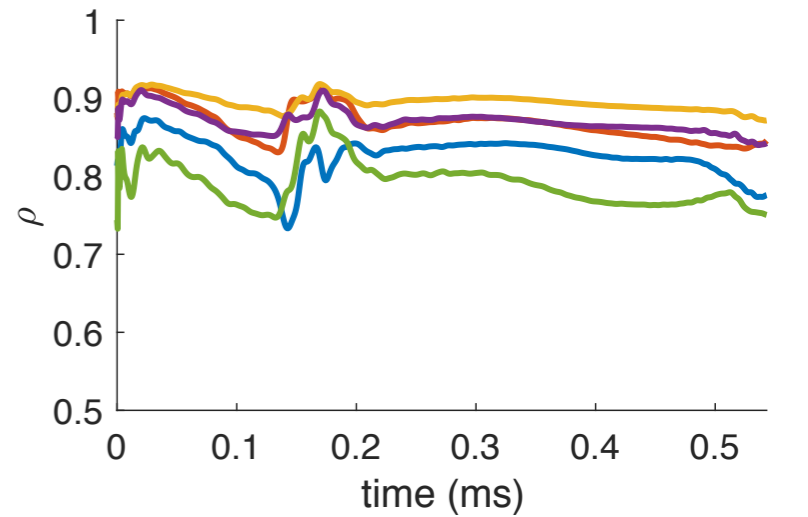
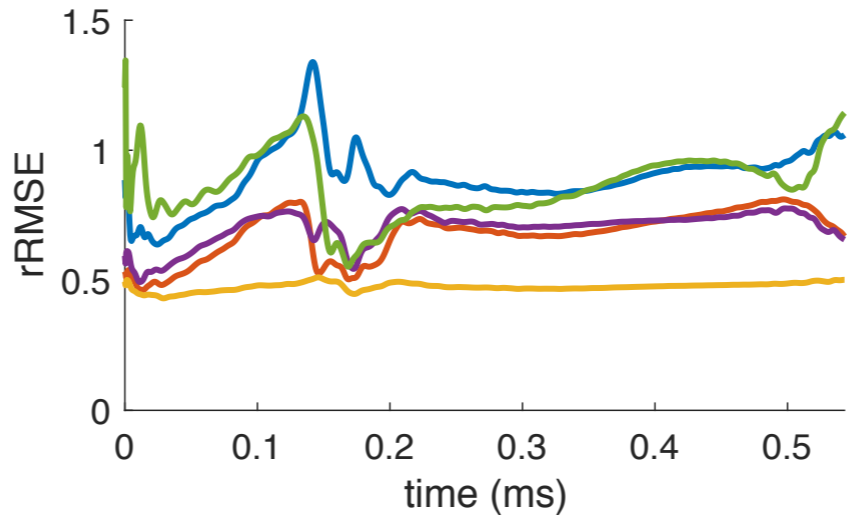
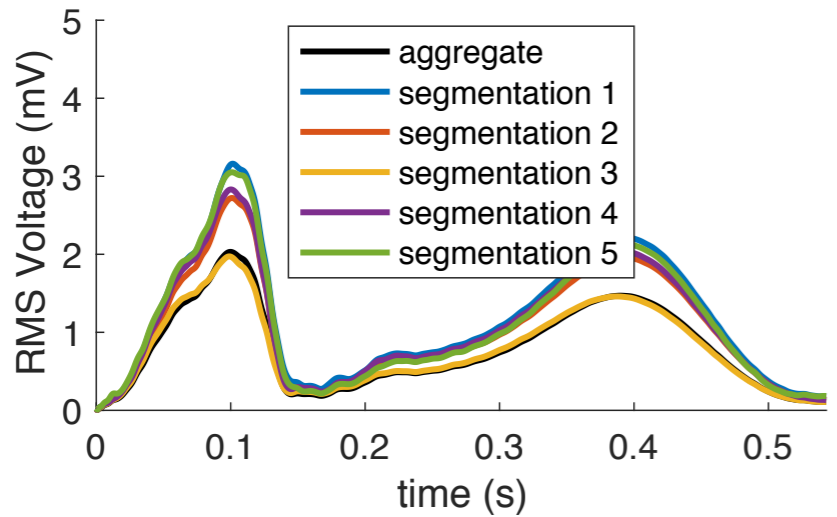


Variation Over Time

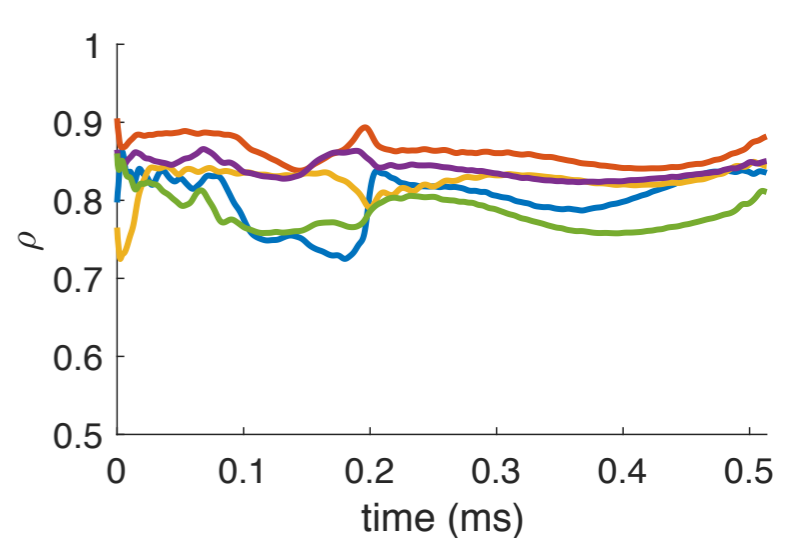
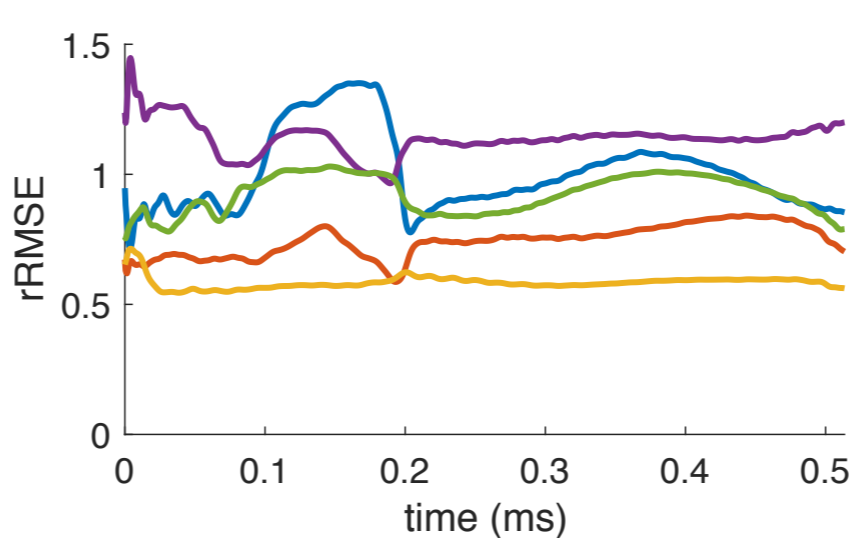
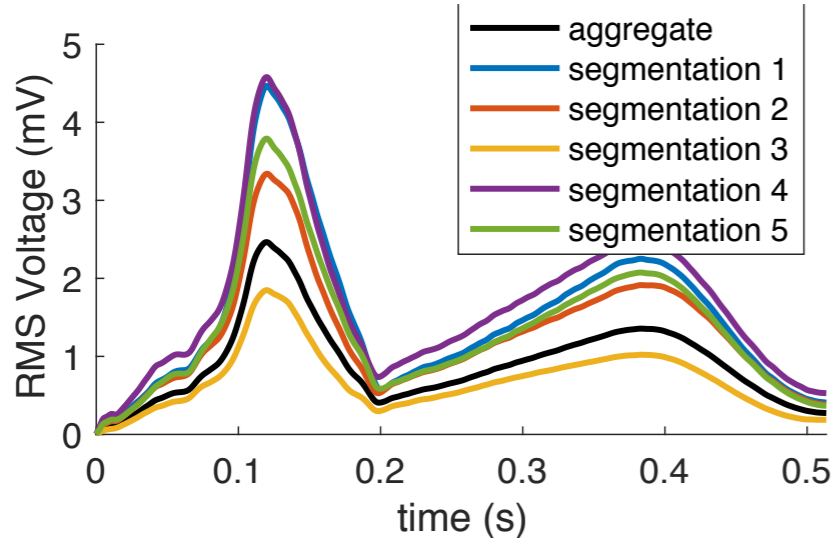
Sinus



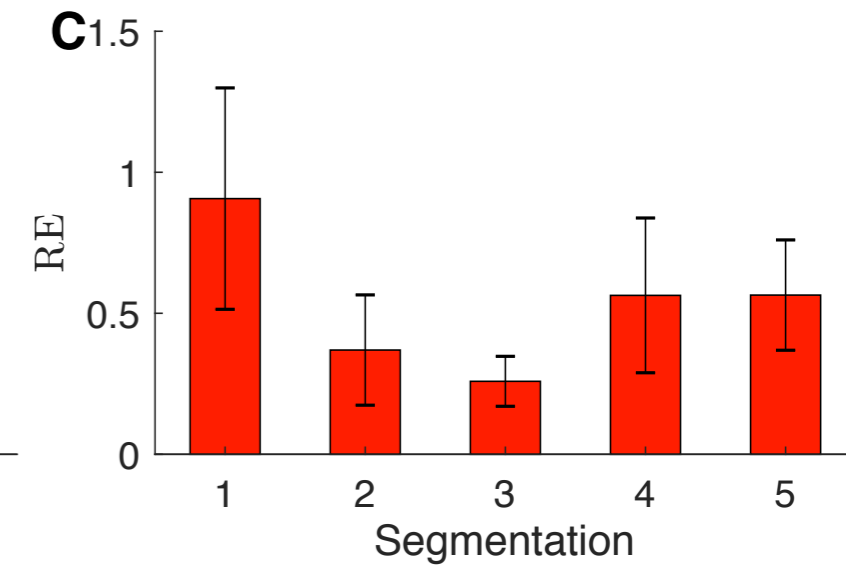
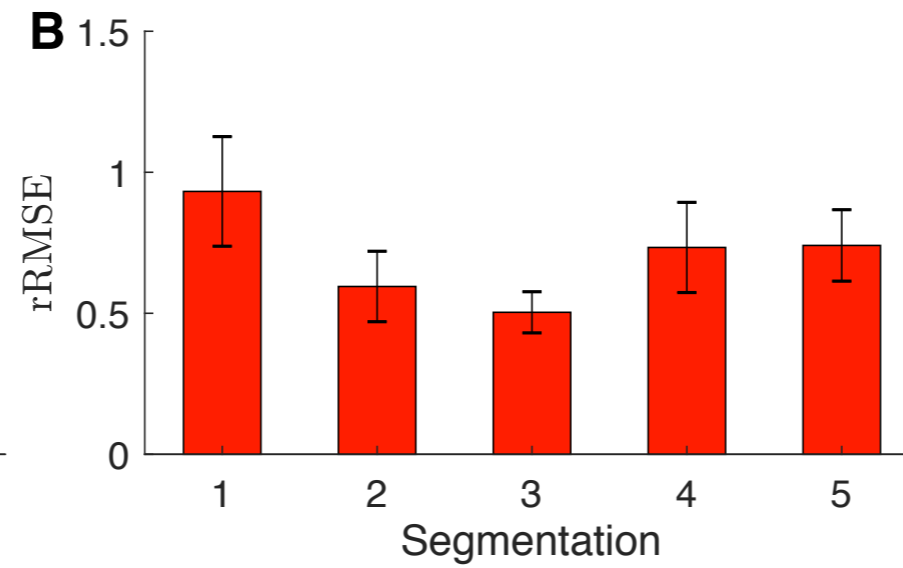
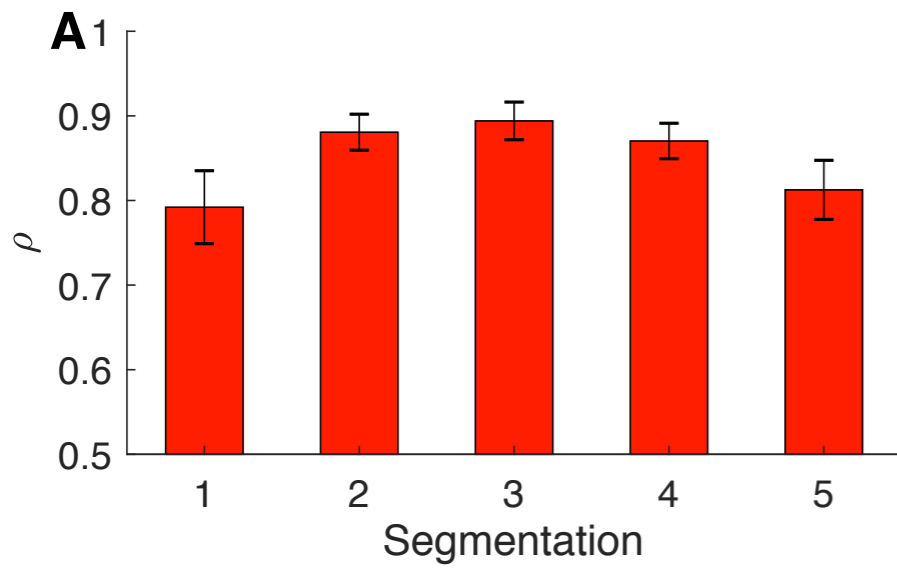
LV stim



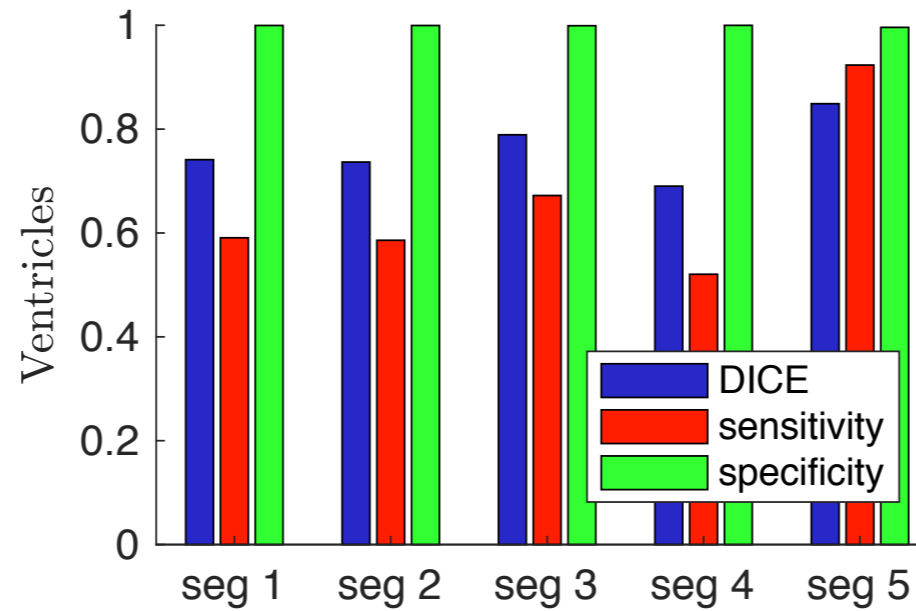
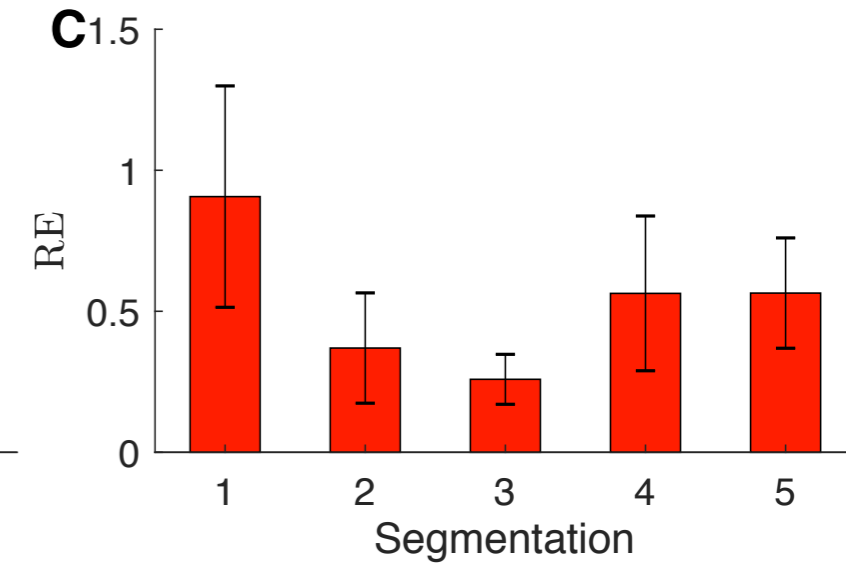
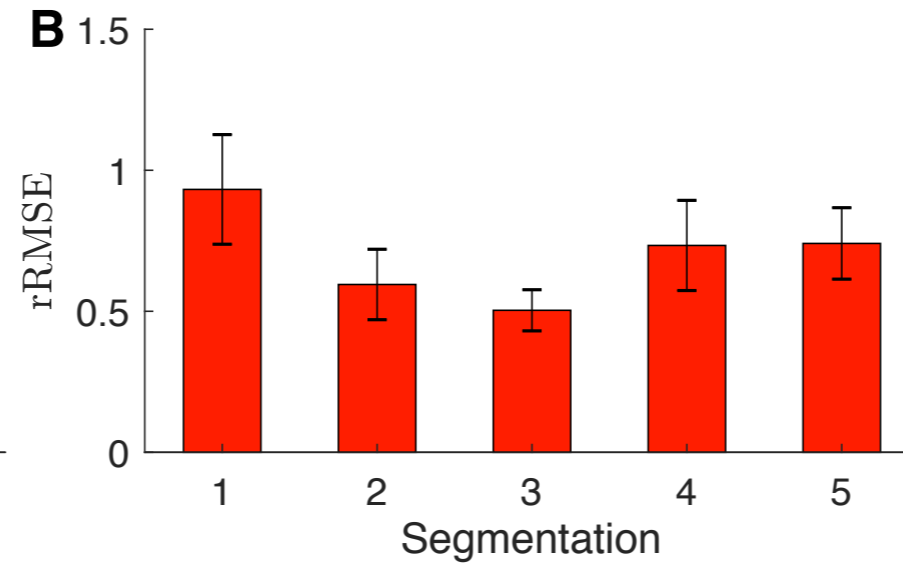
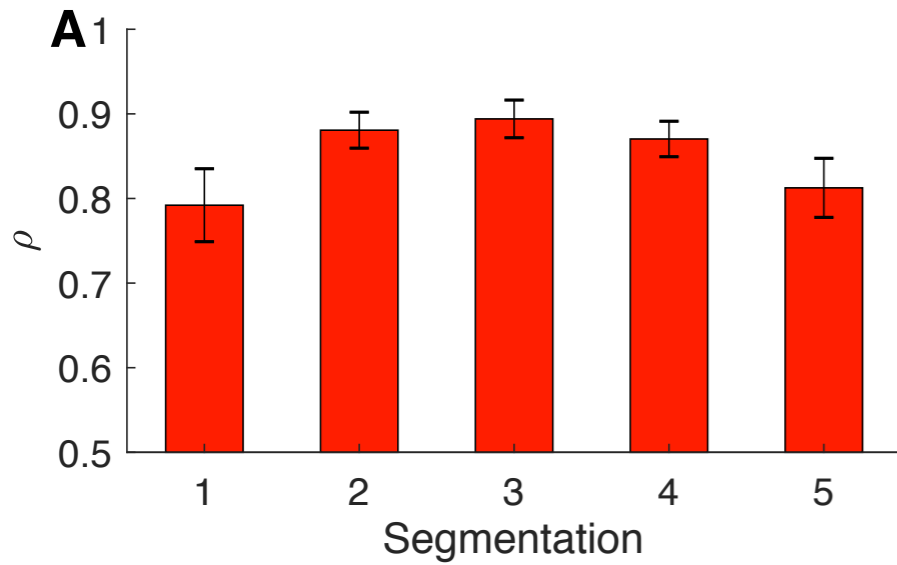
RV stim



Total Error



Total Error

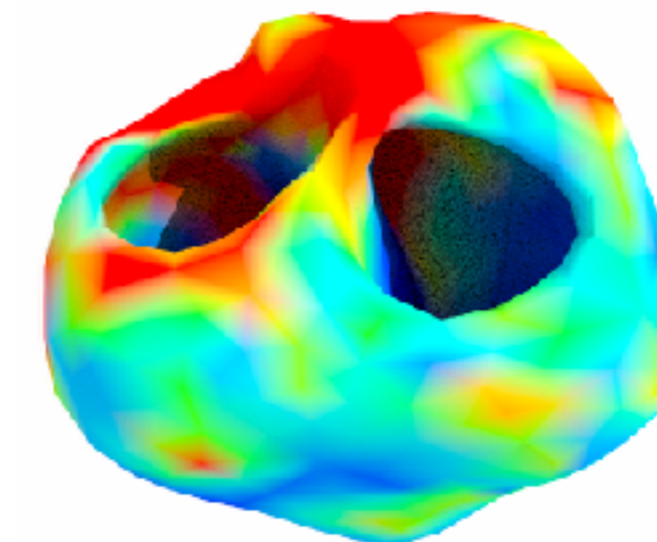
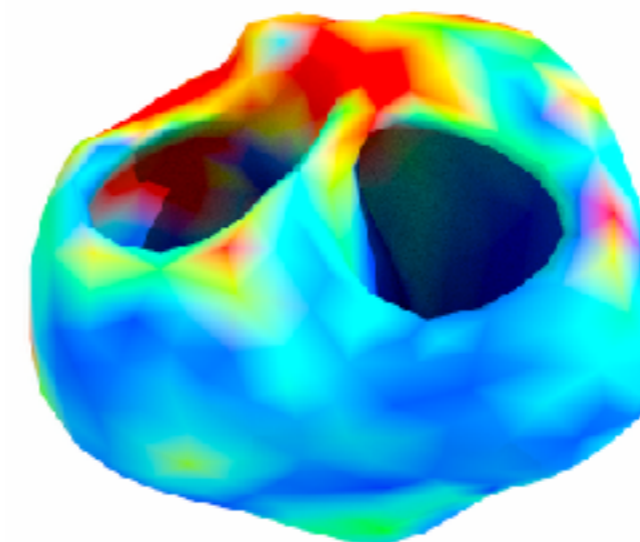
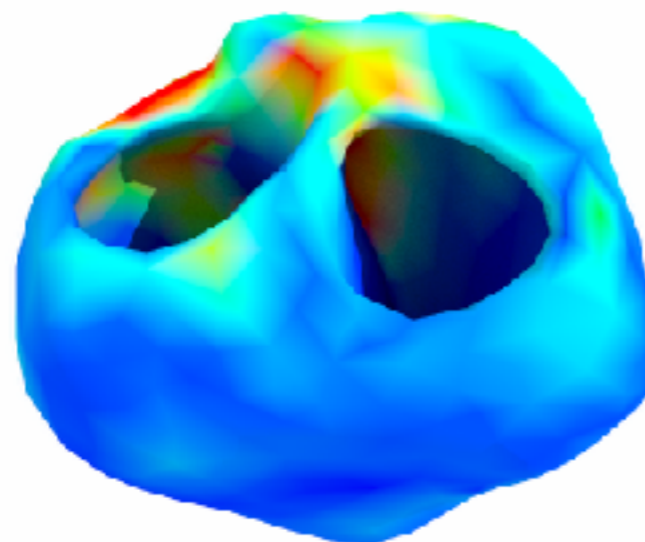
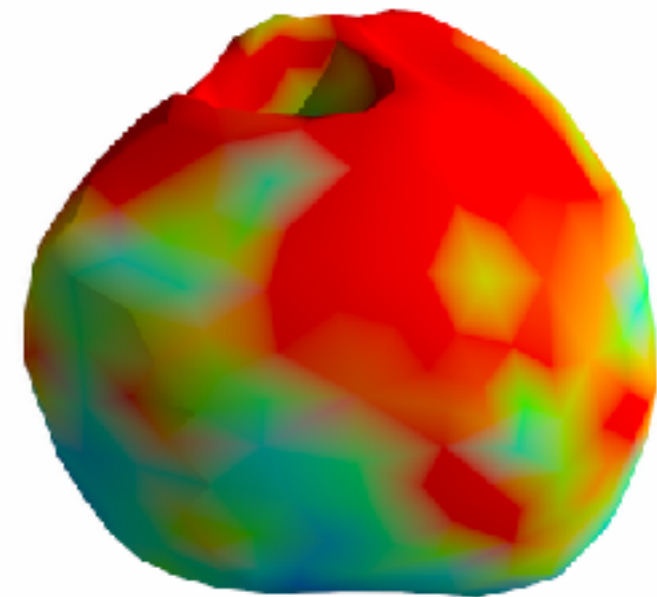
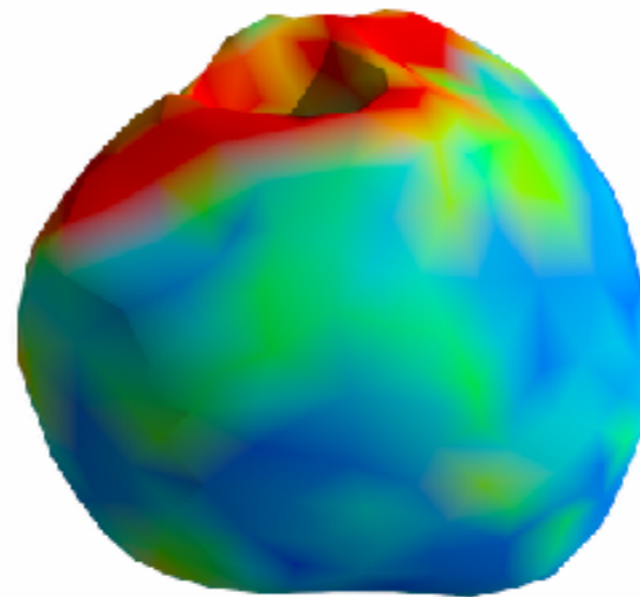
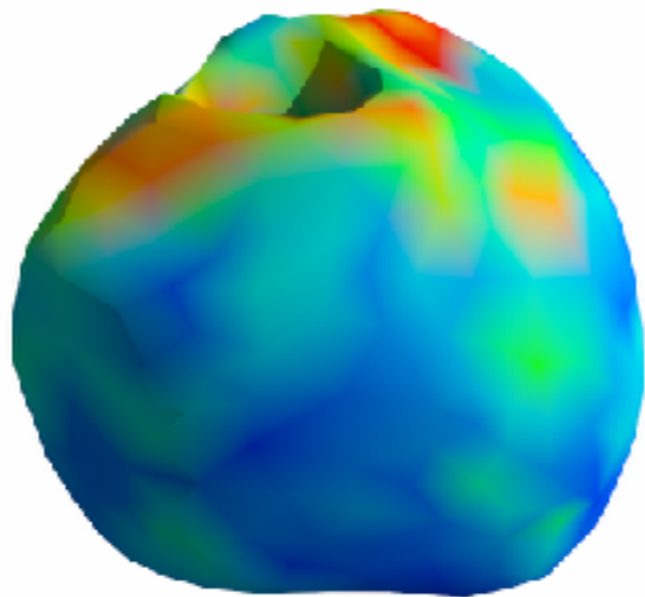
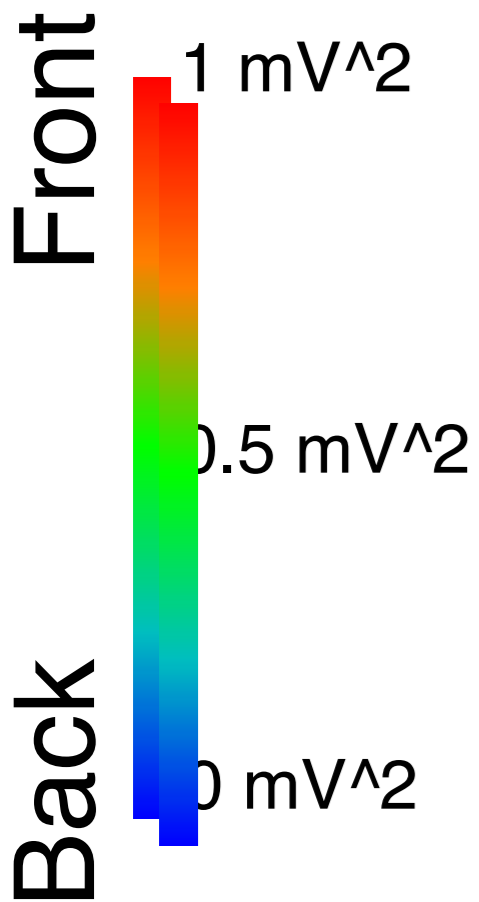


Locations of High Variance

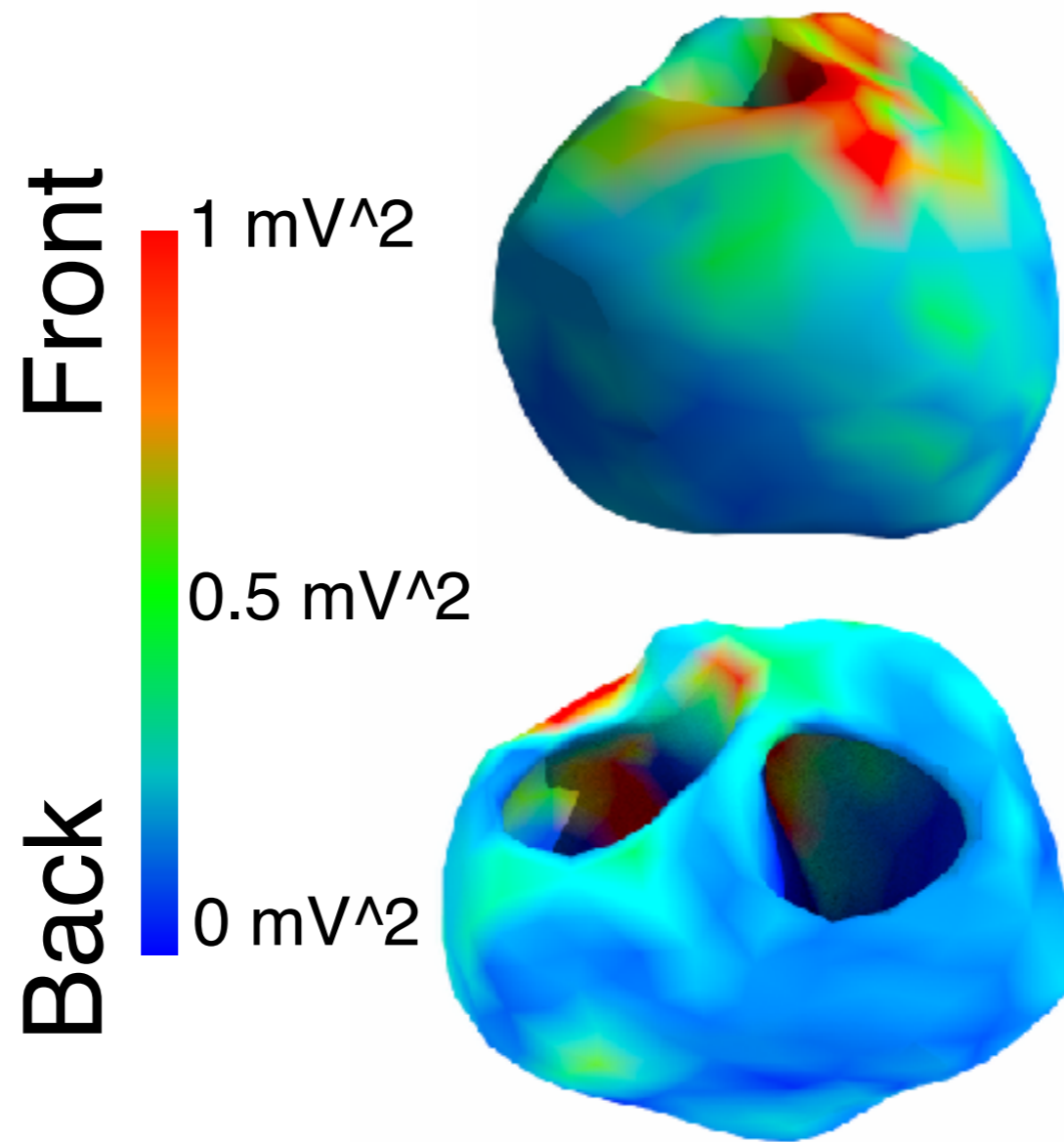
Sinus

LV stim

RV stim



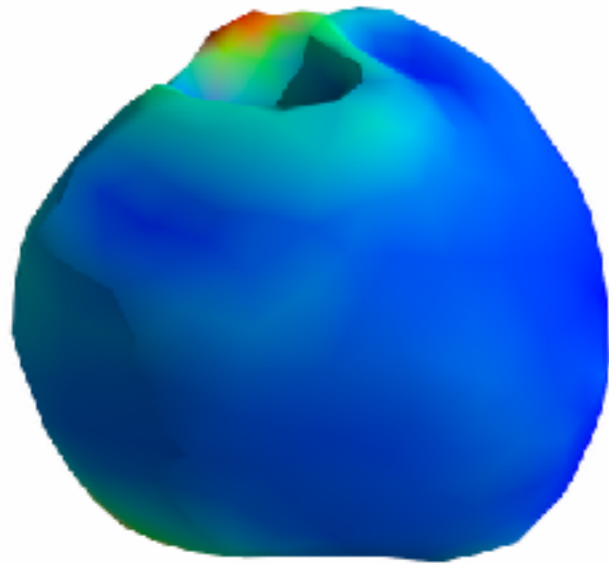
Variance of Solutions and Meshes



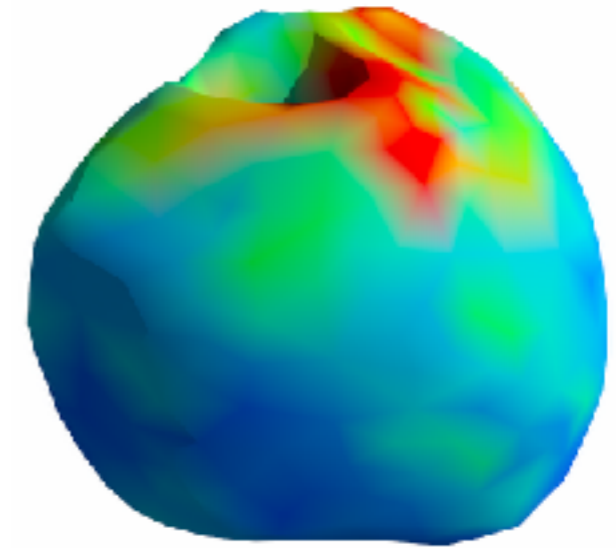
Solution Variance

Variance of Solutions and Meshes

Front

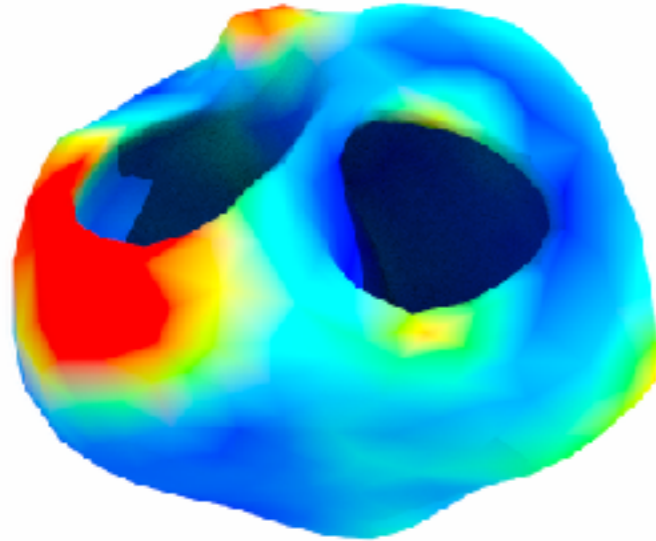


80 mm² 1 mV²

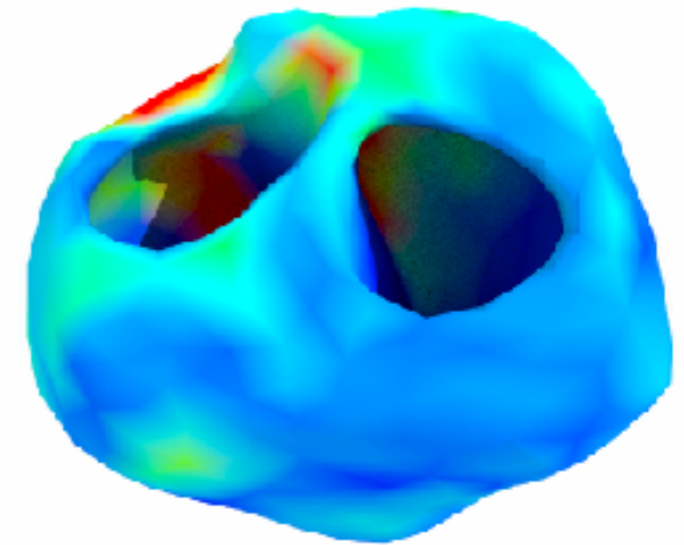


40 mm² 0.5 mV²

Back



0 mm² 0 mV²



Mesh Variance

Solution Variance

ECGI can be
sensitive to
segmentation errors

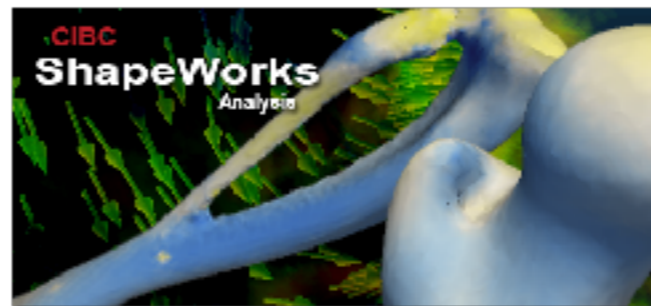
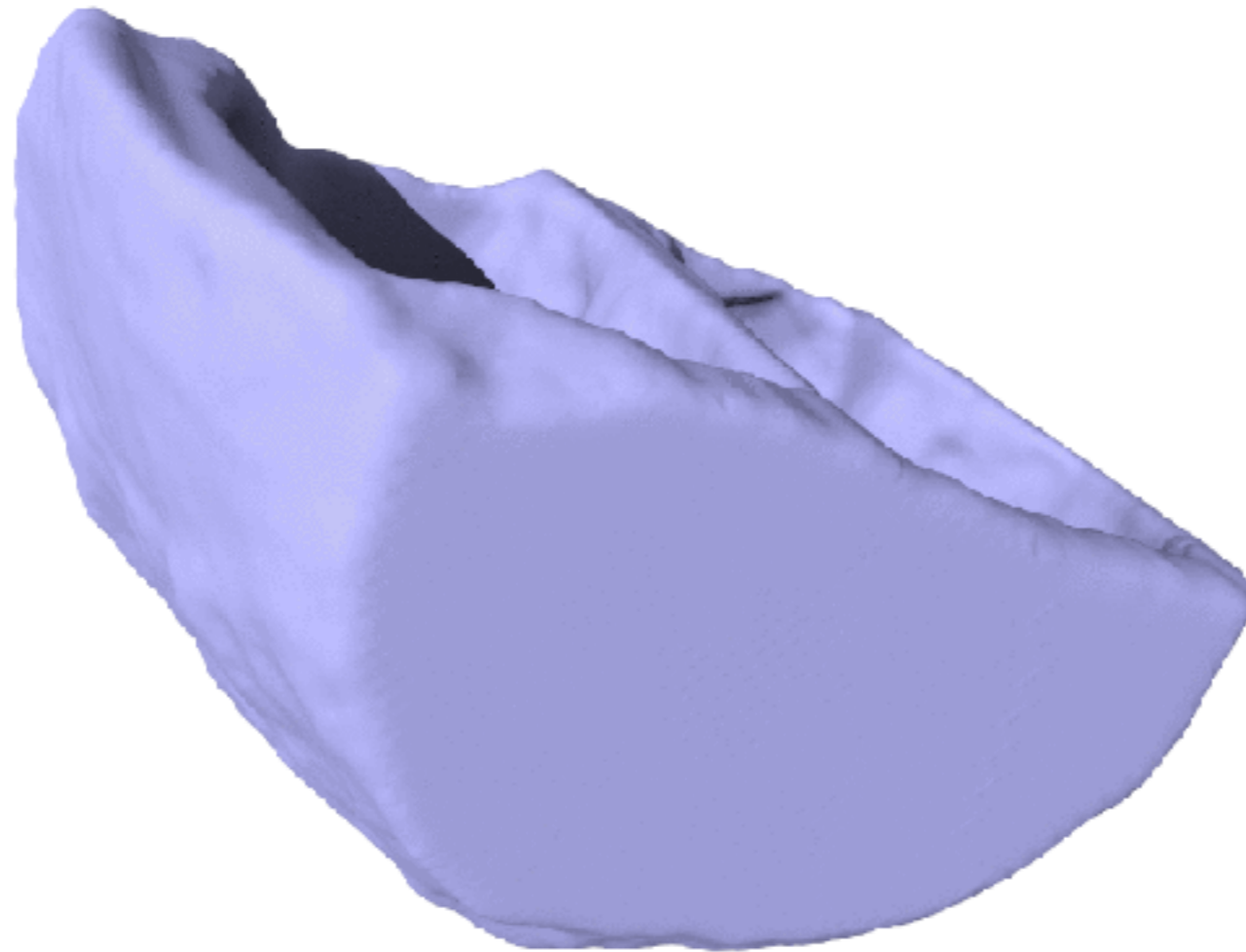
High variance in ECGI solution corresponds to high variance in Segmentation

High variance in ECGI solution
corresponds to high variance
in Segmentation

Anterior region is more
sensitive to segmentation
variation

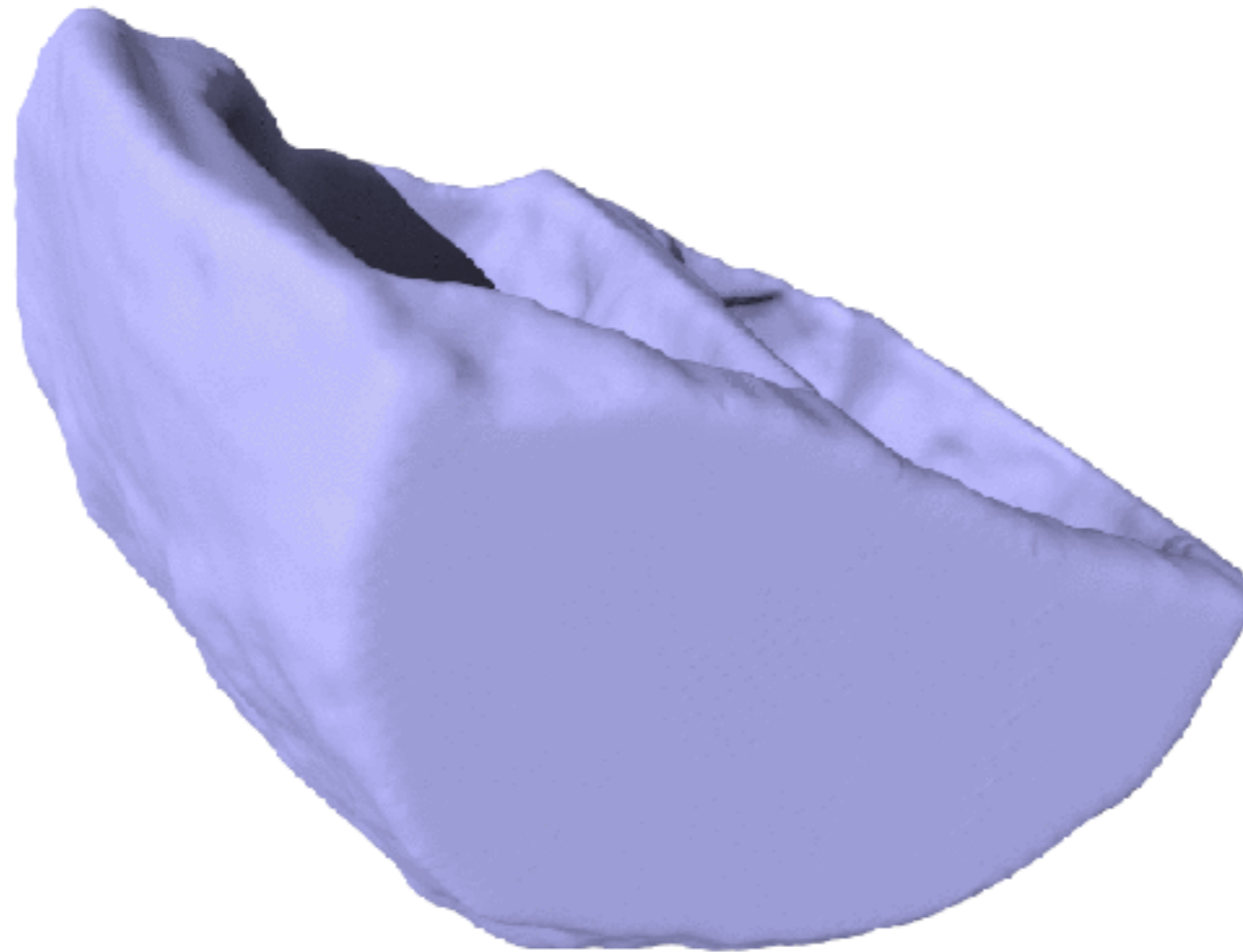
What's Next?

Shape Analysis

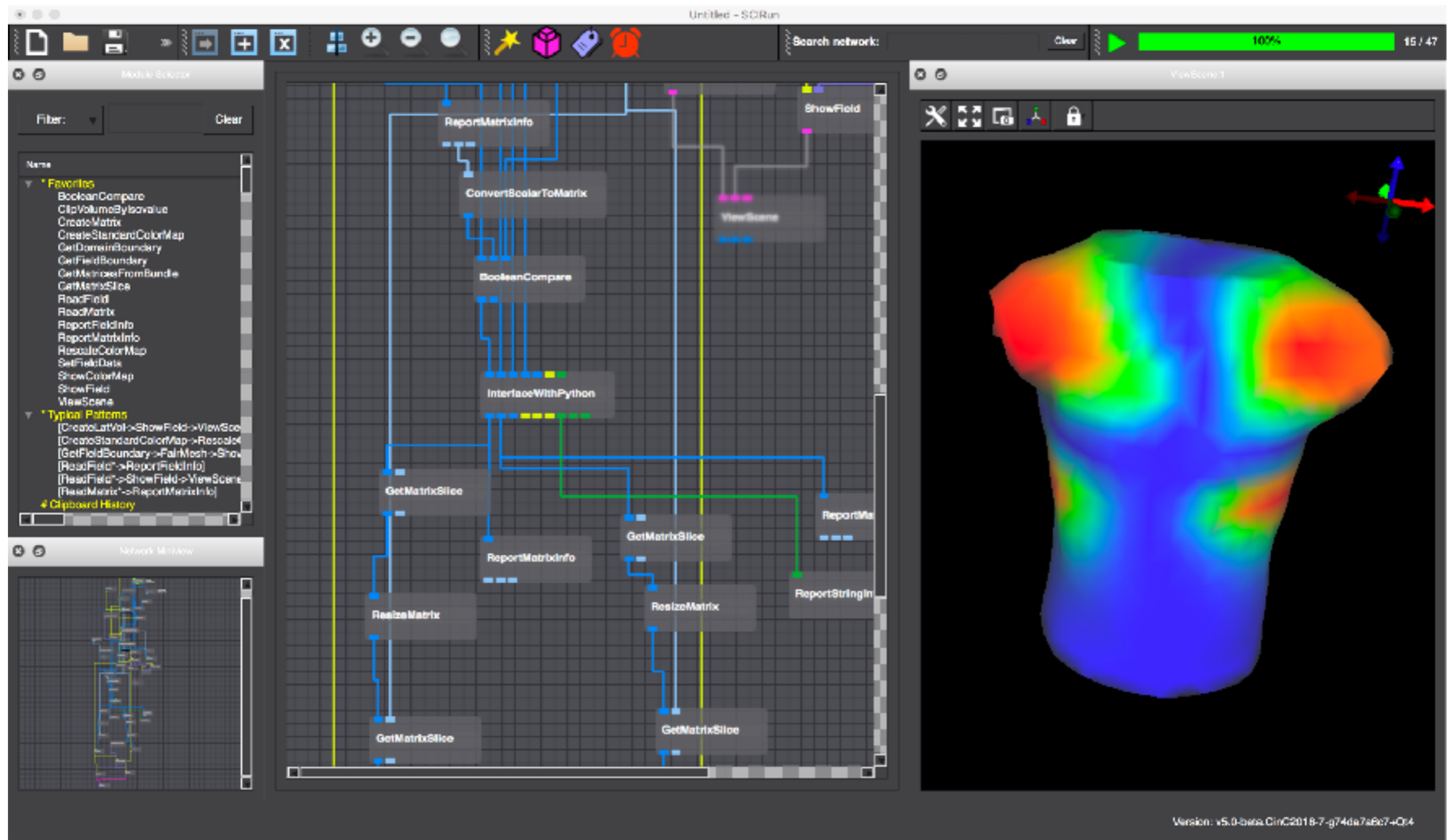


What's Next?

Shape Analysis



What's Next?

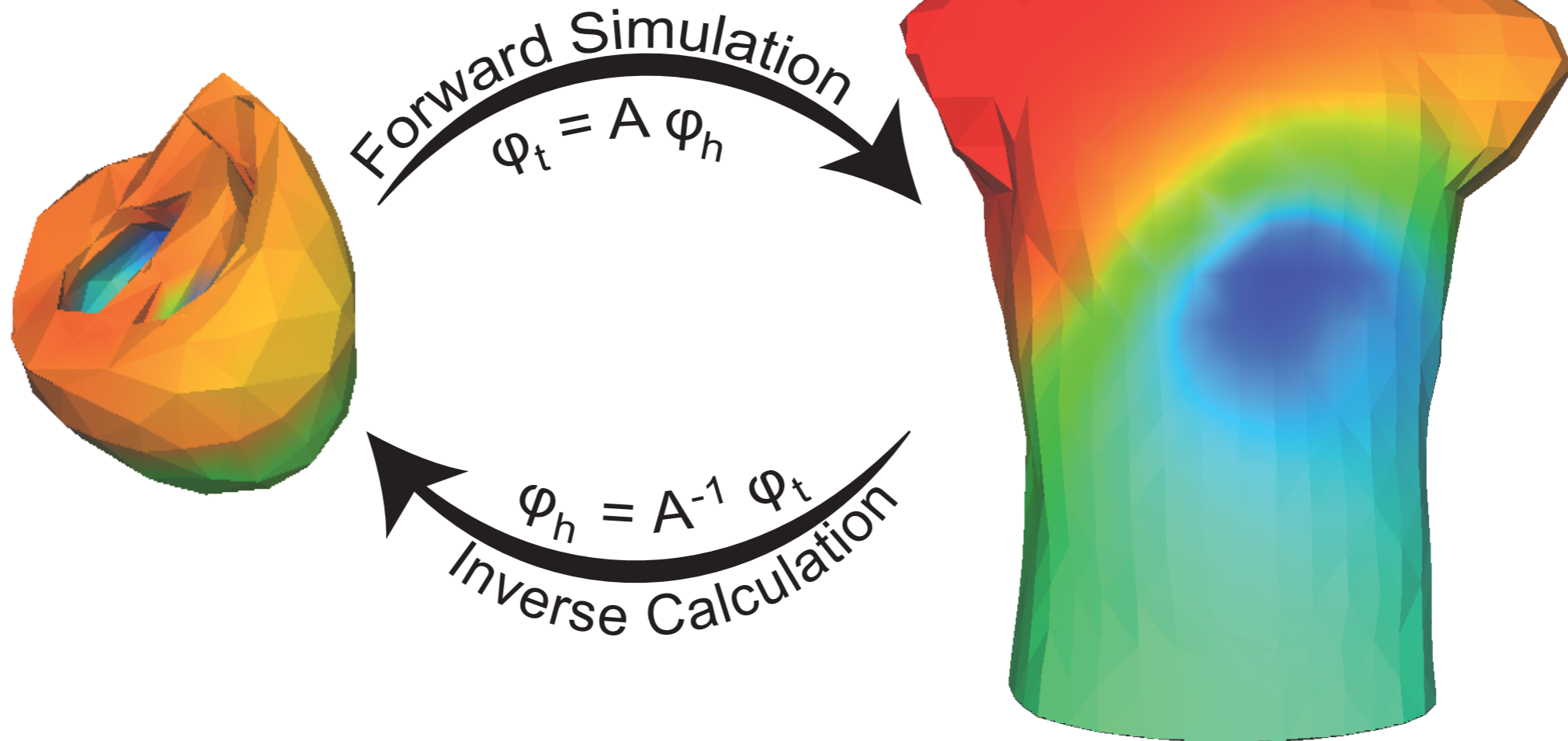


Uncertainty Quantification

Improve ECGI

Heart Potentials (φ_h)

Torso Potentials (φ_t)



Quantify Uncertainty

Acknowledgements

People

Jaume Coll-Font
Sandesh Ghimire

Data Submissions

Wilson Good
Nejib Zemzemi
Sophie Giffard-Roisin
Eric Perez-Alday
Peter van Dam

Clinical Data

John Sapp and Milan Horáček and
Dalhousie University

Support

Center for Integrative Biomedical Computing
NIGMS NIH P41 GM103545-18

Consortium for ECG Imaging (ecg-imaging.org)

More Submission Needed

<https://challenge.kitware.com/>

The image data for a nrrd file is a stream of numbers. The order of the data should iterate x first, then y, then z. If the data is a 3D matrix M of size n_x by n_y by n_z , the data array (D) should match to the matrix index ($M[i, j, k]$) as:

$$D[i*n_x*n_y + j*n_x + k] = M[i, j, k]$$

assuming zero based indexing and i, j, k are the indices for the x, y, z directions respectively. Make sure that the data type field in the header matches the value that the data will be written in. Now to write the file, write the header string, with a new line at the end, then write the data.

If there are questions, do not hesitate to [ask](#).

Stage 2: Mesh Generation

With this stage we will quantify differences in meshing techniques used by different groups. We will be making the meshes based of an average of the submissions from Stage 1, therefore, we will have more details on this stage at a later time.

Stage 3: Forward Transform Matrix

With this stage we will quantify differences in techniques of calculating the forward matrix for ECG used by different groups. Again, we will base this calculation on a common input from the submissions from Stage 2, therefore, we will have more details on this stage at a later time.

PHASES FOR THIS CHALLENGE

 [Stage 1: Dalhousie Segmentation](#) 

 [Stage 1: Auckland Segmentation](#) 

 [Stage 1: Nijmegen Segmentation](#) 