How To: Panoramic Imaging

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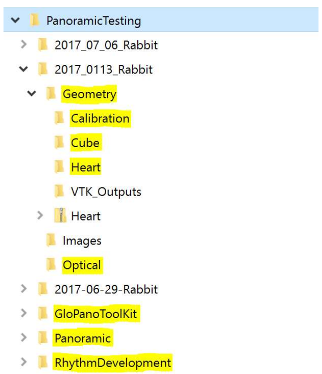
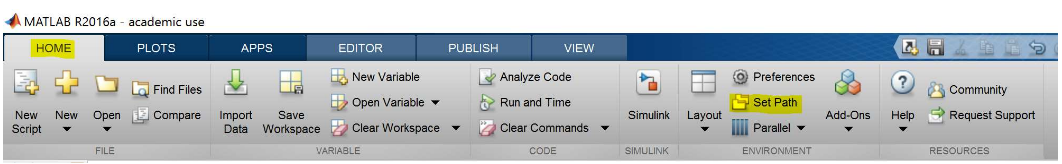
This manual will teach you how to use the Panoramic Imaging software.

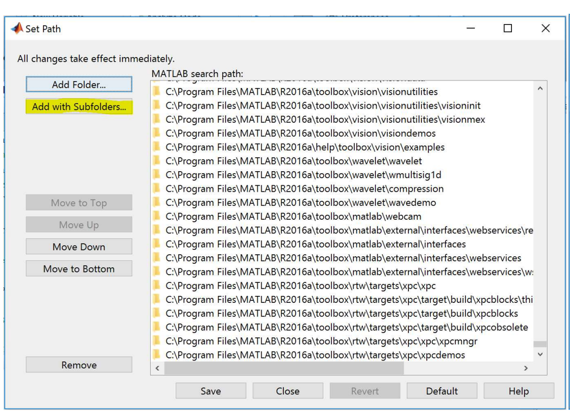
First, you should ensure your folder structure follows the below image. You should have one big folder (‘PanoramicTesting’), in which you have your datasets, the ‘GloPanoToolkit’, Panoramic’ and ‘RhythmDevelopment’ folders. In your data set folder, you should have a ‘Geometry’ folder consisting of the ‘Calibration’, ‘Cube’, and ‘Heart’ folders. The ‘Calibration’ folder consists of the calibration files that is generated later, the ‘Cube’ folder consists of images of a calibration cube from the 5 different cameras, and the ‘Heart’ folder consists of the images of the heart from the rotation. In addition, you should have an ‘Optical’ folder with all your optical data. It is important to keep the same names to avoid errors later on.

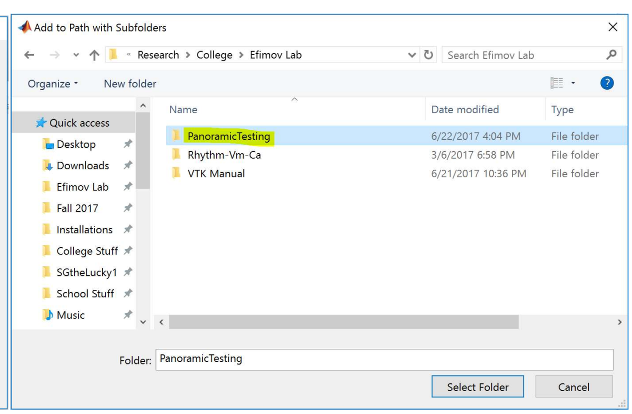


You will need to add the path to all the related files into the MATLAB path. To do so, click ‘Set Path’ in the Home tab.



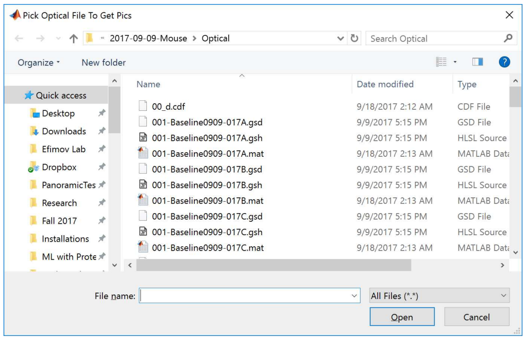
Next, click ‘Add with Subfolders…’. Select the ‘PanoramicTesting’ folder (or wherever you saved all the files to).



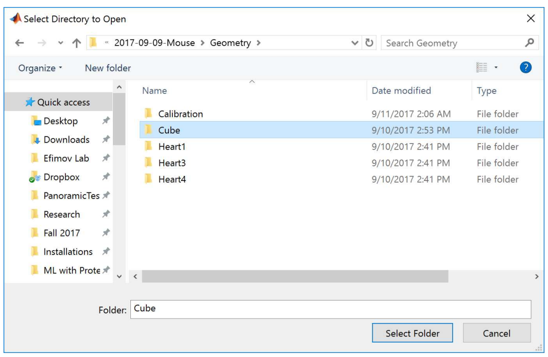


<u>**FIT3 – Camera Calibration**</u>

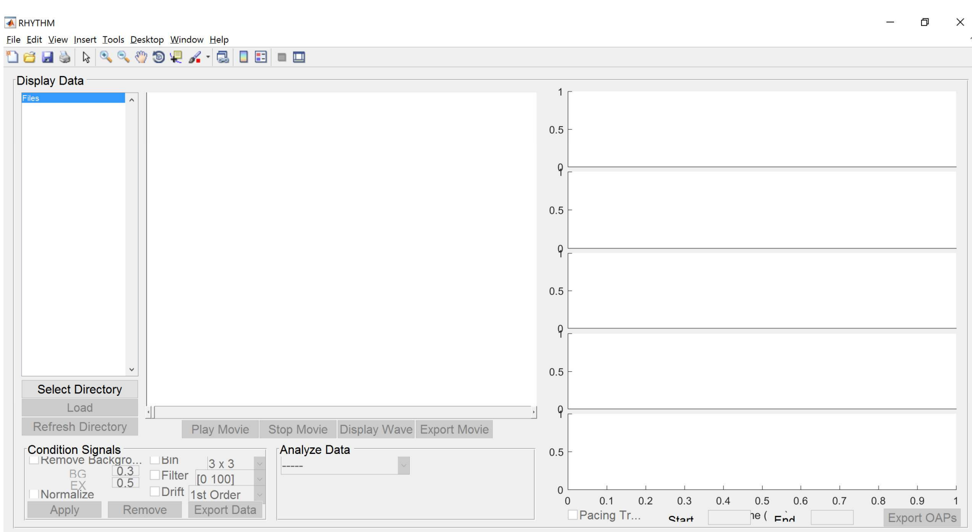
FIT is a program used to calibrate the geometry camera. You will first need 5 images of the calibration cube from the 5 different cameras. If you have '.gsh' or '.gsd' files, you can run a script to grab the images from the optical cameras. Open 'getOpticalCamImages.m' in the 'RhythmDevelopment' folder and click the green 'Run' arrow in the 'Editor' tab.



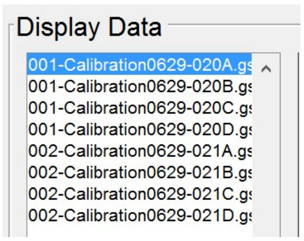
Choose any of the '.gsh' or '.gsd' files. The next screen will ask you where you want to save the images. Choose the 'Cube' folder at 'Geometry/Cube' to save the images.



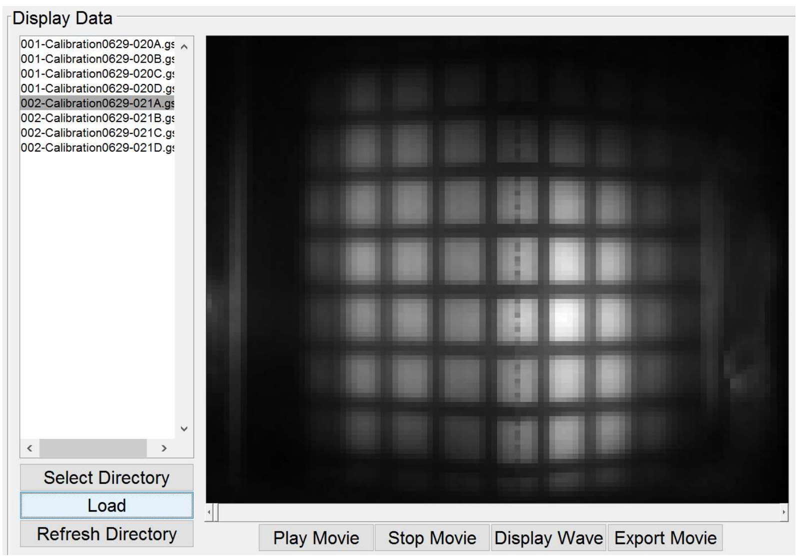
This should save the camera images in the 'Cube' folder. If it doesn't work, then you can load them in RHTHYM and get the images from there. Open 'rhythm.m' in the 'RhythmDevelopment' folder and click the green 'Run' arrow in the 'Editor' tab. You should see this screen.



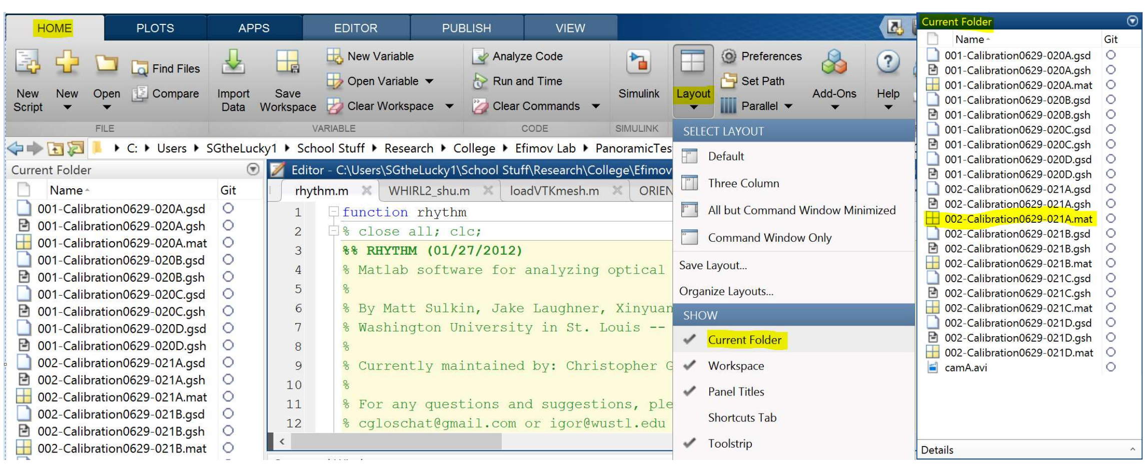
Click ‘Select Directory’ and navigate to the folder with your calibration ‘.gsh’ files. You should see the list of files in the window.



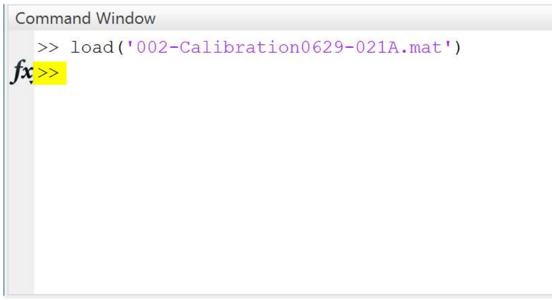
Select one of the files, and click ‘Load’. You should be able to see your image in the big window.



In MATLAB, you will see that there is a ‘.mat’ file with the same name as the file name you chose in the ‘Current Folder’ view. If you can’t see the view, go to the ‘HOME’ tab, click ‘Layout’, and then click ‘Current Folder’ under ‘SHOW’.



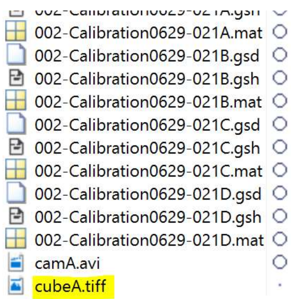
Double-click the ‘.mat’ file, and you should see a ‘load’ command in the Command Window. Make sure you wait before the ‘>>’ shows up before you continue.



In the Command Window, type this command:

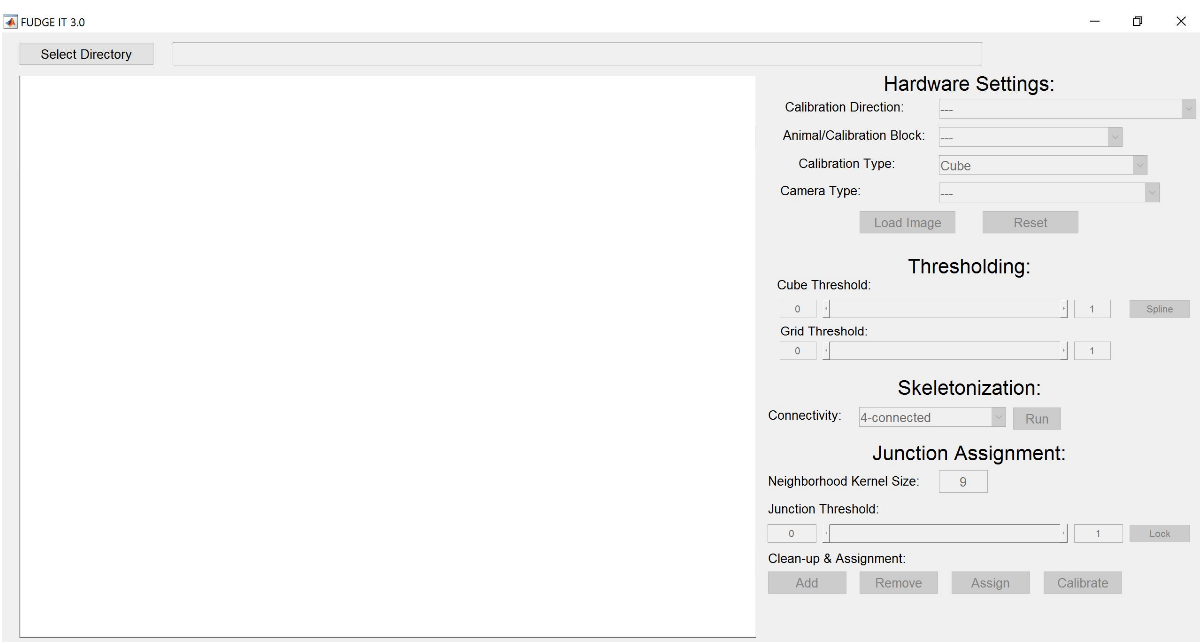
a = real2rgb(bgimage,'gray'); imwrite(a, 'cubeA.tiff');

This will save the image from the RHYTHM window in a '.tiff' file (in this case called 'cubeA.tiff') in the same folder as the '.mat' file.

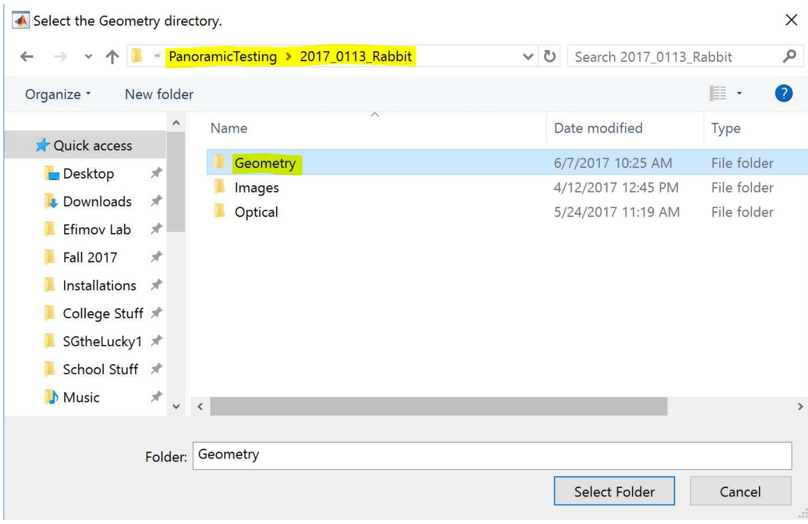


Copy this file to the 'Geometry/Cube' folder, and do this for the other files as needed.

Navigate to the 'RhythmDevelopment' folder and open 'FIT3_shu.mat'. Click the green 'Run' arrow in the 'Editor' tab. You should see this screen.

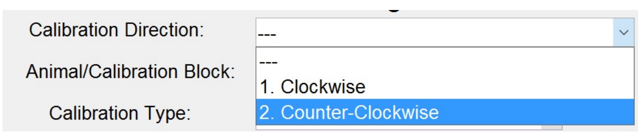


First click ‘Select Directory’ in the top left corner of the screen, and select the ‘Geometry’ folder in your data folder. If you downloaded the sample data, it should be under ‘PanoramicTesting/2017_0113_Rabbit’.

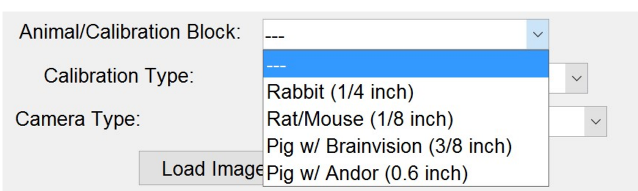


Press ‘Select Folder’ after selecting the folder. The Hardware Settings should now be unlocked.

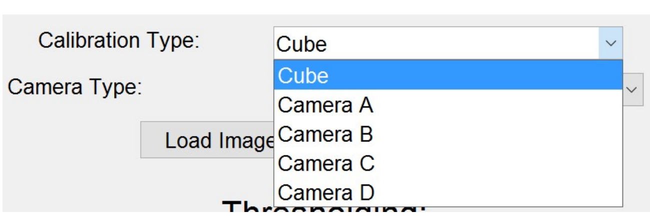
The Calibration Direction is usually counter-clockwise, unless you specifically set the direction to be clockwise while obtaining data.



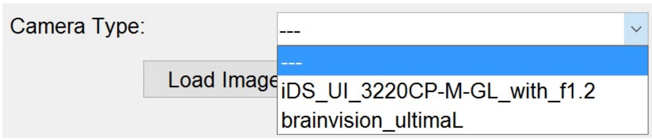
The Animal/Calibration Block is selected based on the type of heart your data is. For the sample data, select ‘Rabbit (1/4 inch)’.



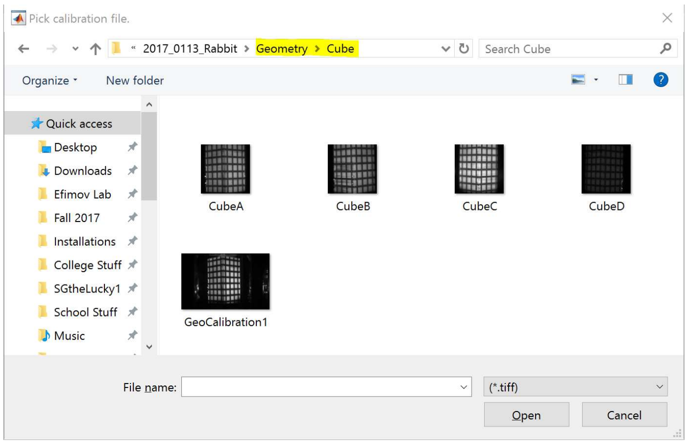
The Calibration Type is the camera you wish to calibrate. There are 5 options, the 4 optical cameras A through D and the 1 geometry camera called ‘Cube’.



After choosing the camera you want to calibrate, choose the Camera Type accordingly. For the geometry camera, choose ‘iDS_UI_3220CP-M-GL_with_f1.2’. For optical cameras, choose ‘brainvision_ultimaL’.



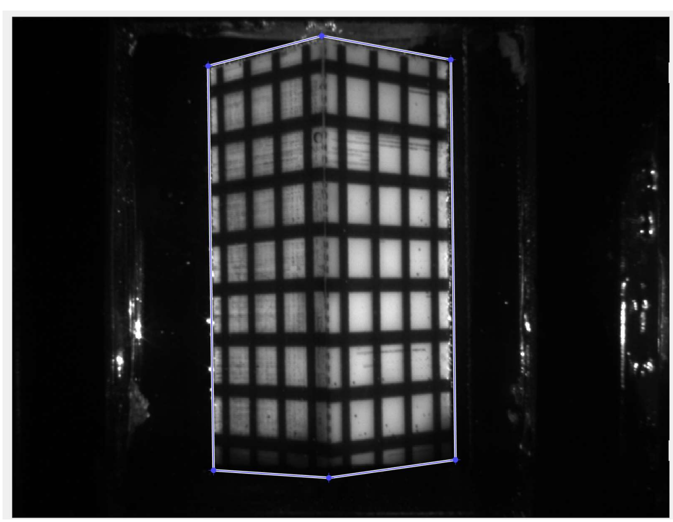
After selecting your desired values for the Hardware Settings, click 'Load Image'. Then select your image from the 'Geometry/Cube' folder.

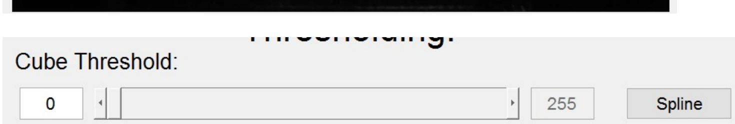


The white blank space should be populated with your selected image. The Thresholding and Skeletonization Tools should be enabled.

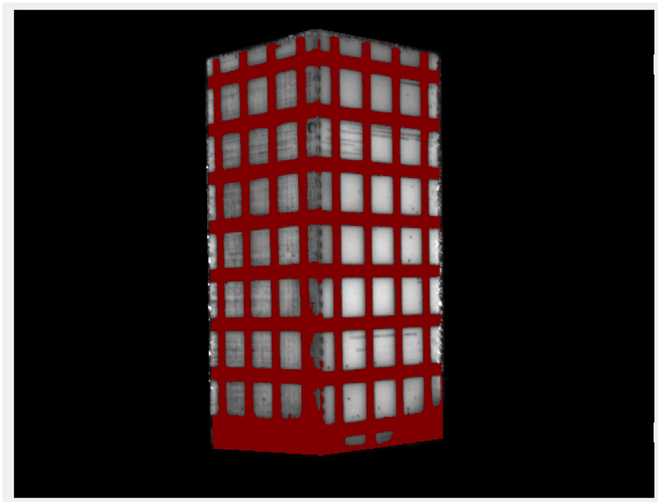
The Cube Threshold removes any background not part of the cube. The 'Spline' button allows you to trace out the shape and ignore anything outside the boundary. To use this, click 'Spline' and place points on the corners of the cube. Make sure the tracing is closed, and double-click the region to remove anything outside. You can ensure the last point touches the first if you see a black circle as your cursor instead of the crosshair, or if you right-click.

You can also drag the slider and have the computer remove the background, which may be less accurate.

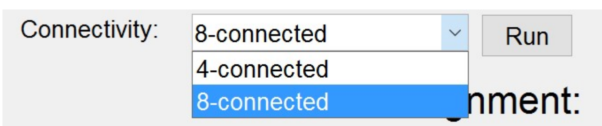


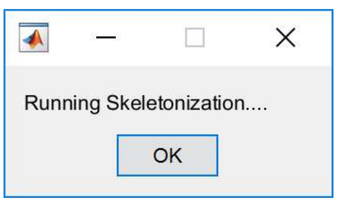


The Grid Threshold creates a mask over the image. Drag the slider until almost all the black lines are covered in red.

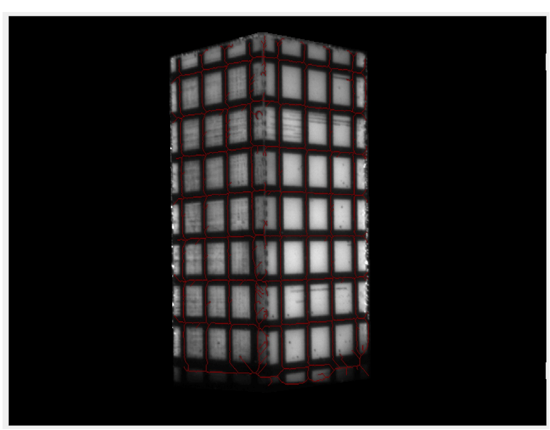


For Connectivity under Skeletonization, choose '8-connected'. It is found to be better than '4-connected'. Click 'Run' to run the skeletonization. As it runs, ensure that there are no errors in the Command Window of Matlab. A dialog box will pop up and disappear when skeletonization is finished.

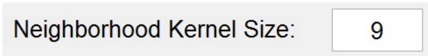




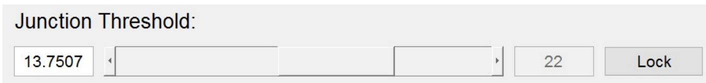
You should now see the skeleton of the cube in red.



The Junction Assignment Settings should be enabled now. You can put other numbers for the Neighborhood Kernel Size, or leave it at 9.



The Junction Threshold puts points on the cube based on a computer algorithm. It will try to place them at the junctions, but is often inaccurate. You can drag the slider to start off, and then press ‘Lock’ to be able to manually add/remove points.

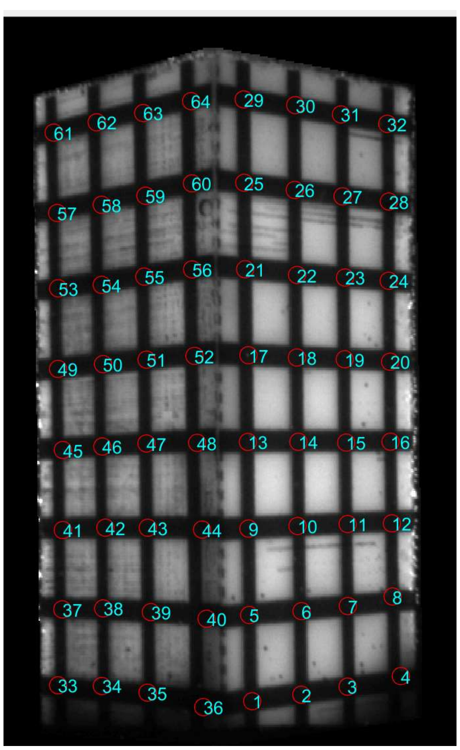


The Clean-Up and Assignment Tools should now be enabled.

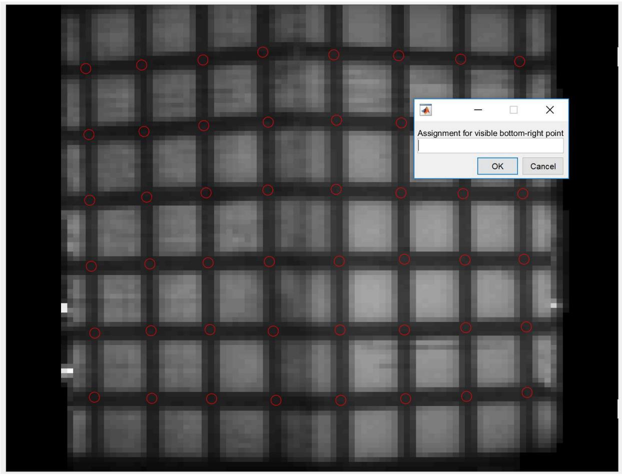
You can add points by clicking the ‘Add’ button and clicking the places on the image where you want to drop points. The button should turn green and the other buttons will become disabled. When finished adding, press ‘Enter’ or ‘Return’ on the keyboard to untoggle.

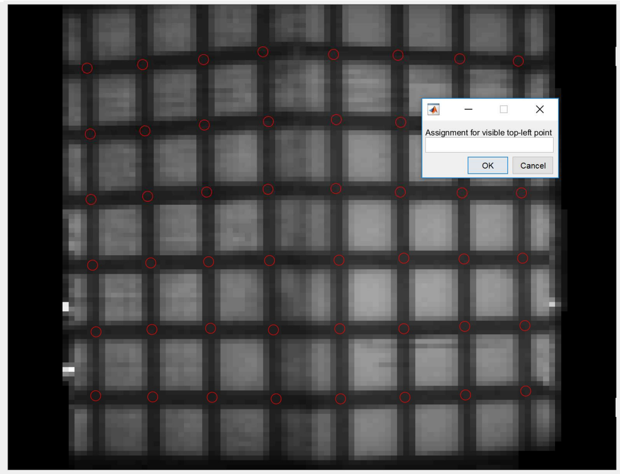
You can remove points by clicking the ‘Remove’ button and clicking the points on the image you wish to remove. The button should turn red, and other buttons will become disabled. When finished, press ‘Enter’ or ‘Return’ on the keyboard to untoggle.

Ensure that all junctions have a point placed on them. Press ‘Assign’ to assign numbers to the junctions. If you are calibrating the geometry camera, this will assign numbers from 1-64 automatically, like such:

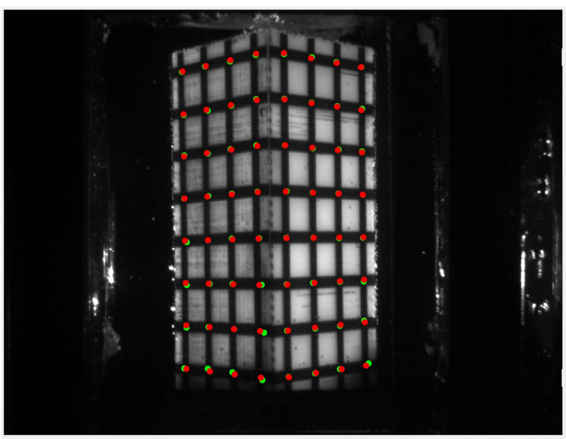


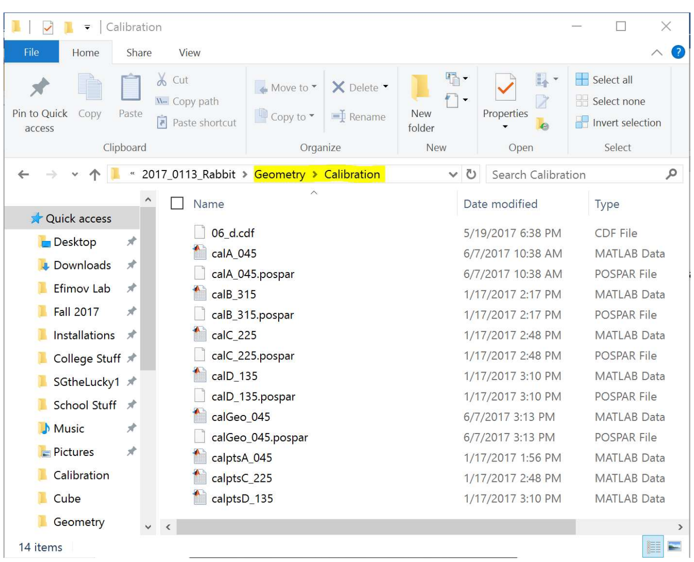
If you are calibrating cameras with a partial view of the cube, the program will show a figure of the cube above and prompt you to enter the value for the bottom-right value and top-left value. Use the reference grid in the figure when putting in the values.





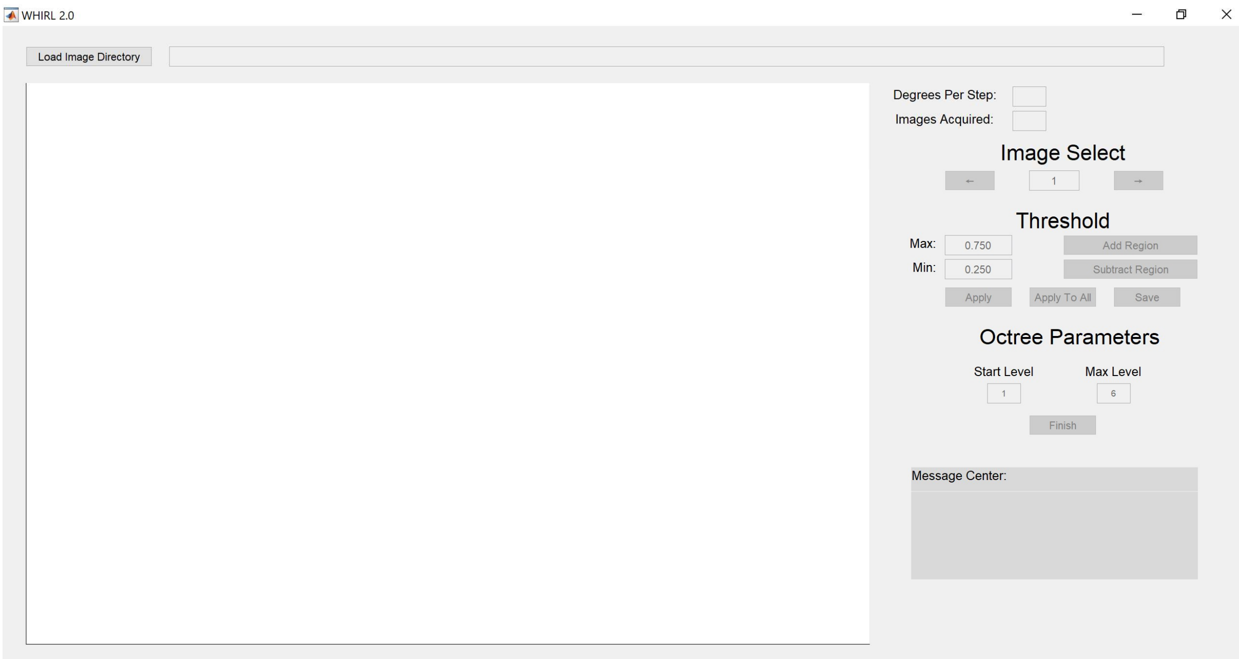
One the numbers are assigned, you can press ‘Calibrate’ to calibrate the camera. The calibration file is saved to the ‘Geometry/Calibration’ folder.



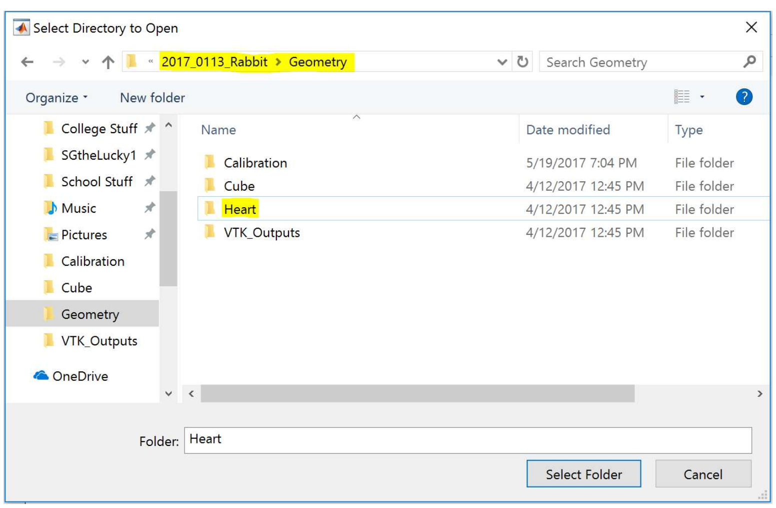


WHIRL – Silhouette Identification

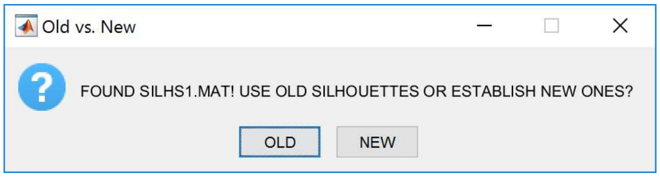
WHIRL is a program used to identify silhouettes of the heart. The images will need to be renumbered to include a leading 0 for the first nine so the order can be maintained. Open 'renameTiff.m' and run it. Select the first picture, and the program will renumber the images properly. Open 'WHIRL2.mat' and run the program by clicking the green arrow in the 'Editor' tab. You should see this screen.



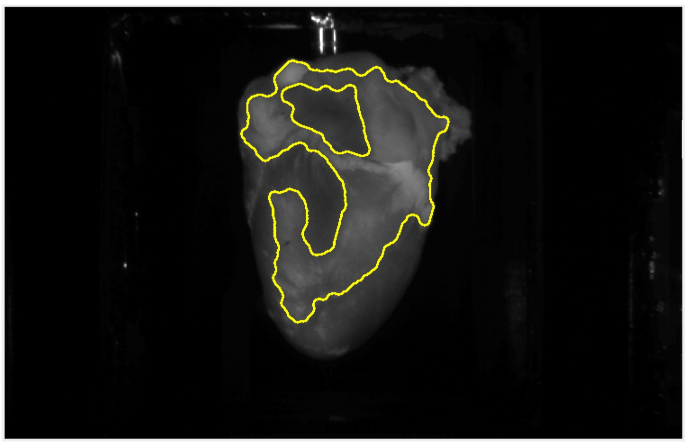
Click 'Image Directory' in the top left and select the folder with all the heart images. For the sample data, this is in '2017_0113_Rabbit/Geometry/Heart'.

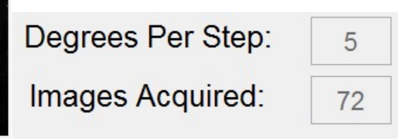


If you have already used WHIRL, you might see a pop-up that asks whether you want to use old silhouettes saved from a file or establish new ones. If 'silhs1.mat' is not on your computer, then this will not come up.



You should now see the first image of the heart, as well as the Degrees Per Step and the Images Acquired. These values cannot be changed in the program itself. The Image Select, Threshold, Threshold All Images, Threshold, and Octree Parameter tools should be enabled.



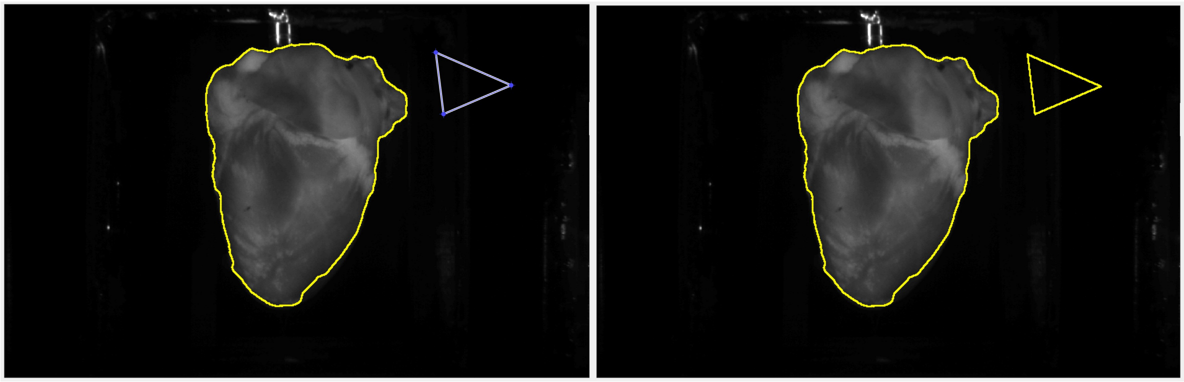


You can move between images by clicking the arrows, typing in an image number, or using the left and right arrows on your keyboard. Note that you might have to click the image to put it in focus before it can recognize the keyboard strokes.

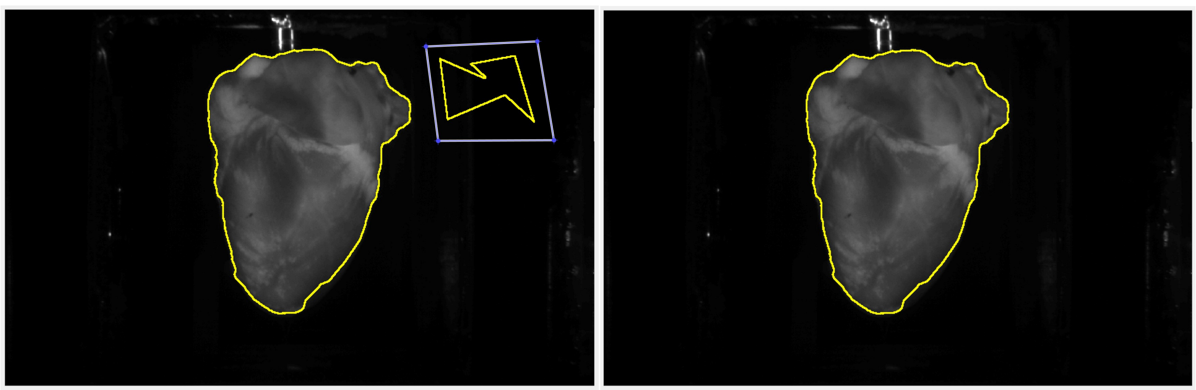
You can change the threshold values by typing in your desired range and clicking 'Apply'. Unless you loaded the old silhouettes, this threshold will apply for all the images.

You can load all the images and compute all the corresponding silhouettes at once by clicking on the "Apply To All" button. It uses top and botom thresholds specified by the interface. You can click on the 'Save' button to save silhouetes as 'silhs1.mat' file in 'Geometry' folder.

In addition, you can add/subtract regions manually. To add a region, click 'Add Region'. The button will turn green. On the image, drop points on the area you wish to add. Once all the points are connected, double-click inside the region to add.



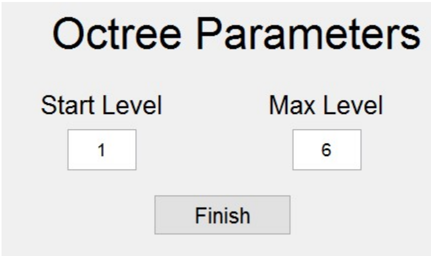
To remove a region, click ‘Subtract Region’. The button should turn red. Similar to adding a region, place points around the region you wish to remove, and double-click inside the region once the points are connected.



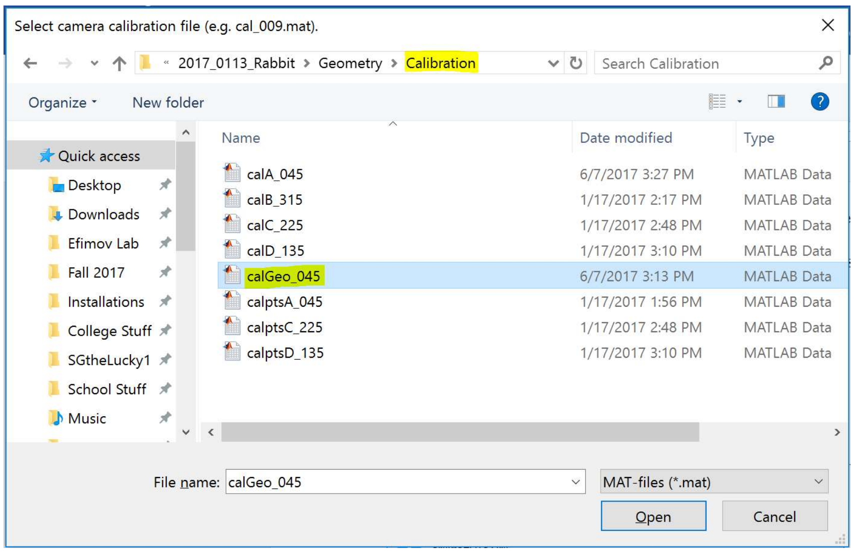
If you accidently click the buttons, you can press ‘Backspace’ or ‘Delete’ on the keyboard to cancel. You can ensure the last point touches the first if you see a black circle as your cursor instead of the cross hair, or if you right-click.

You can also remove the background of an image by clicking the ‘Remove Background’ button. Similar to adding and subtracting regions, you trace around the region you want to keep and double-click the inside to remove everything outside the region.

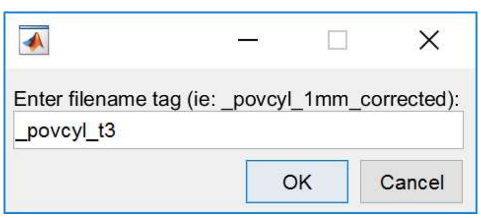
Once you have gone through every picture and are satisfisfied, you can create the octree. Although having a bigger number for the max level is ideal, it takes a lot of time to finish. Thus, you can leave the start and max levels as shown. Click 'Finish'.



You will next be prompted to select the calibration file. This will be in the 'Calibration' folder. You would select the calibration file corresponding to the camera used for the pictures. In this case, we used the geometry camera, so we will load 'calGeo_045.mat'. These files were generated after clicking 'Calibrate' in FIT. Make sure you do not click the files with 'calpts…'.



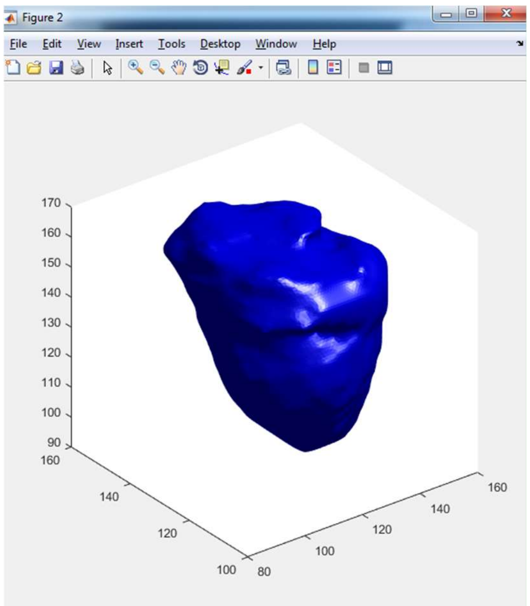
Next, you will be asked to enter a filename tag for saving. Having an underscore at the beginning is preferred, but not required. Click 'OK'.



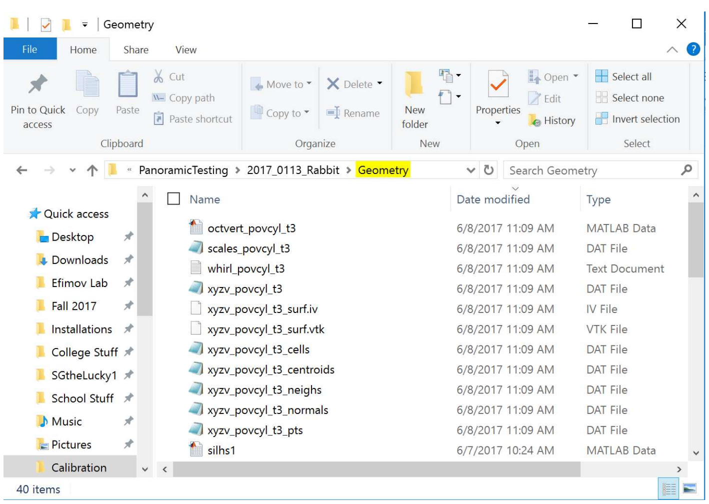
This starts octree algorithm and the following surface smoothing procedure. The smoothing procedure uses cpp-functions compiled inside of Matlab by Mex on the fly. We used cpp module "Smooth Triangulated Mesh" (version 1.1) by Dirk-Jan Kroon available via the following link: https://www.mathworks.com/matlabcentral/fileexchange/26710-smooth-triangulated-mesh

This module is based on the theory described in works of Mathieu Desbrun et al. "Implicit Faring of Irregular Meshes using Diffusion and Curvature Flow" and Alexander Belyaev. "Curvature Estimation".

Once the surface is calcuted, it is depicted and saved to 'Geometry' folder as 'your_tag_'surf.vtk file. You can reopen the surface later with any viewer with vtk reader, i.e. ParaView.

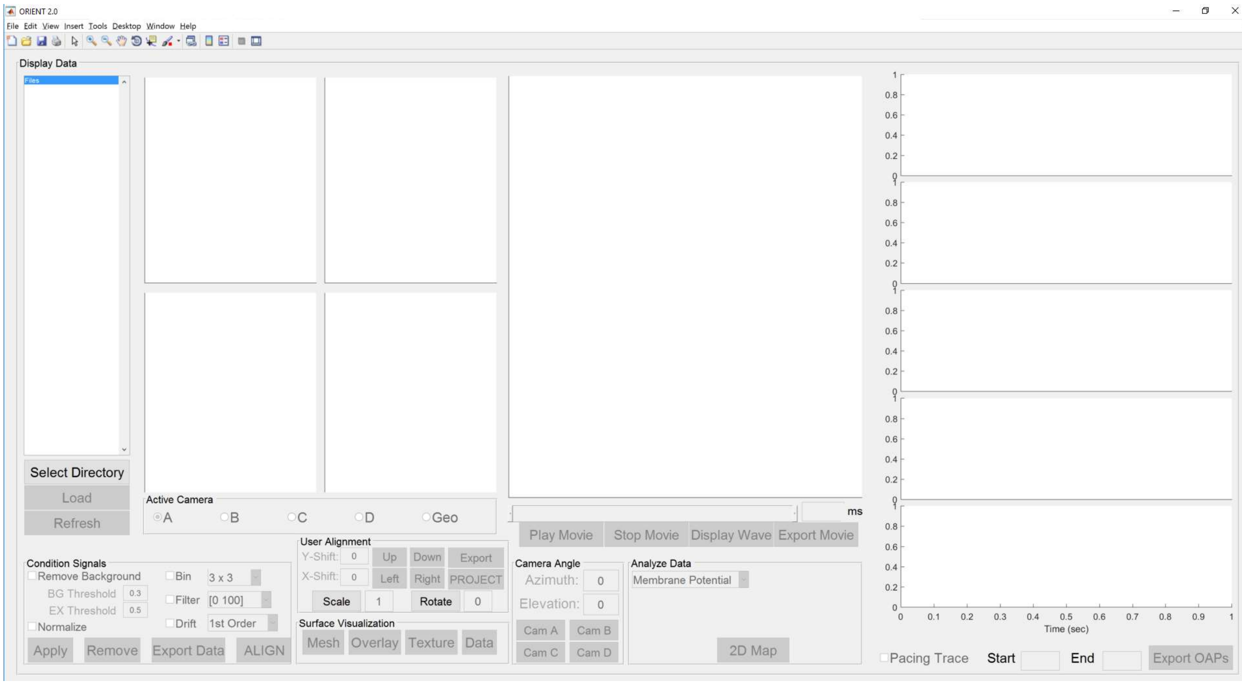


Data files used for ORIENT are created in the 'Geometry' folder.

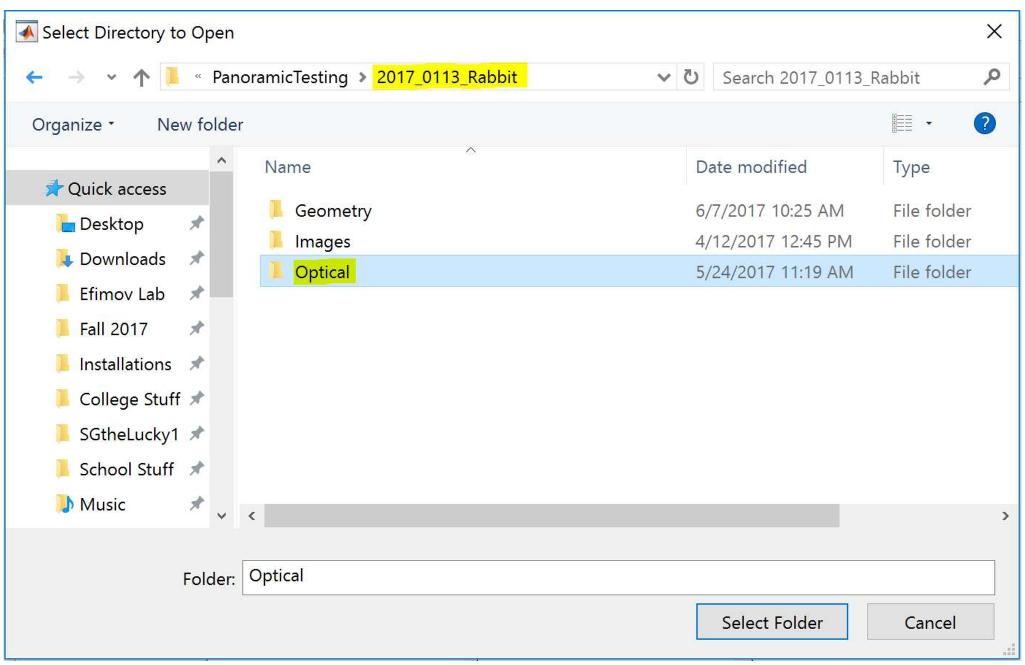


ORIENT – Optical Mapping

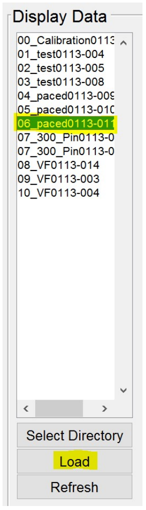
ORIENT is a program used to visualize signals on the 3D visualization of the heart. Open 'ORIENT_shu4' and run the program by clicking the green 'Run' arrow in the Editor view. You should see this screen.



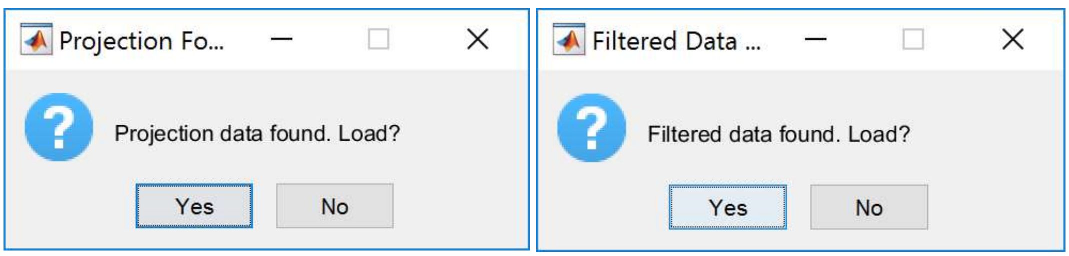
Click ‘Select Directory’ and open the folder with all the optical data. For the sample data, this is ‘2017_0113_Rabbit/Optical’.



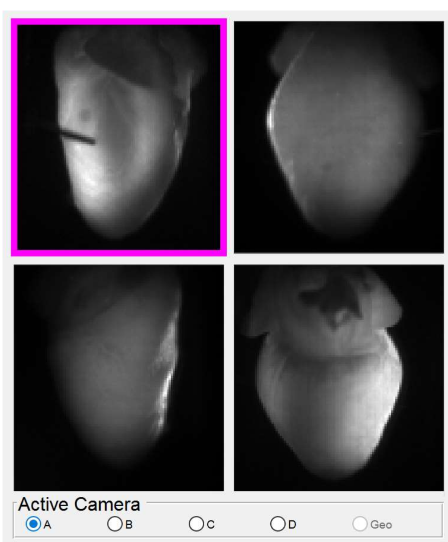
The filenames should populate in the white space. Select the filename tag you want to load, and click ‘Load’. For the sample data, use ‘06_paced0113-011’.



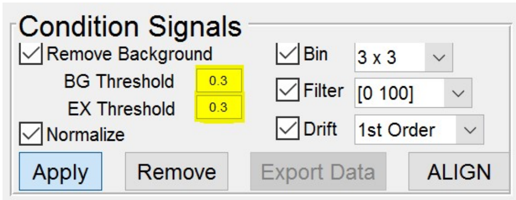
If you have used ORIENT before, two dialogs will pop up asking if you want to load certain things. The first asks if you want to load projection data, and the second asks if you want to load filtered data. You will learn how you can save these things later in this section.



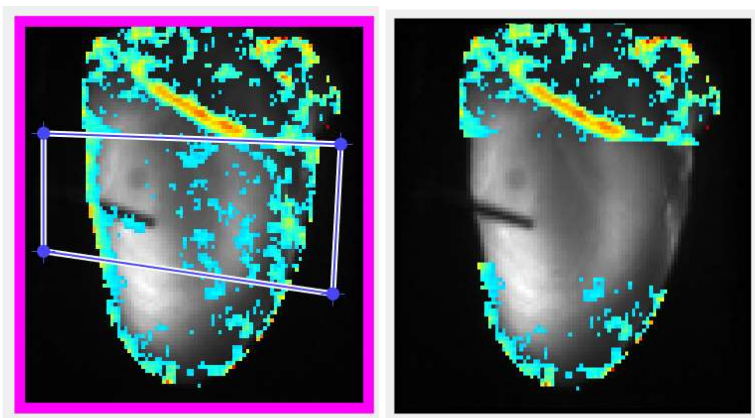
If this is your first time using ORIENT, then the 4 frames will be populated with the four images from the 4 optical cameras. You can select the active camera by click the radio buttons underneath the images.



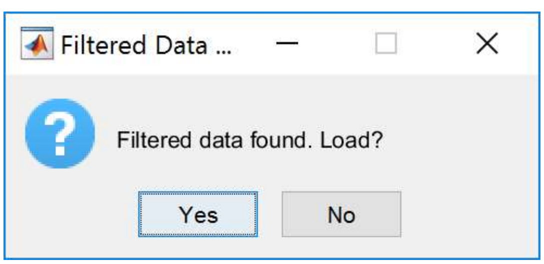
In addition, the Condition Signals tools should be enabled. Check all of the boxes. You might want to make sure the threshold for the background is small enough to get data. Click 'Apply'.



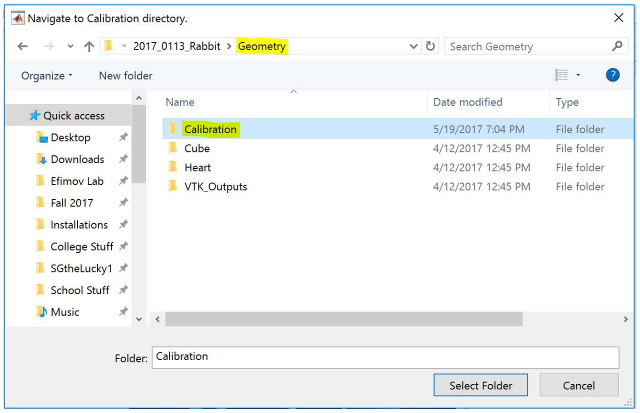
The ‘Remove’ button allows you to remove data for parts of the heart that you choose. To use this, click the remove button, and place points around the region **in the active camera** that you wish to remove. You can ensure the first and last points connect if you see a black circle as your cursor instead of the cross hair, or you can right-click. To cancel, hit ‘Backspace’ or ‘Delete’ on the keyboard.



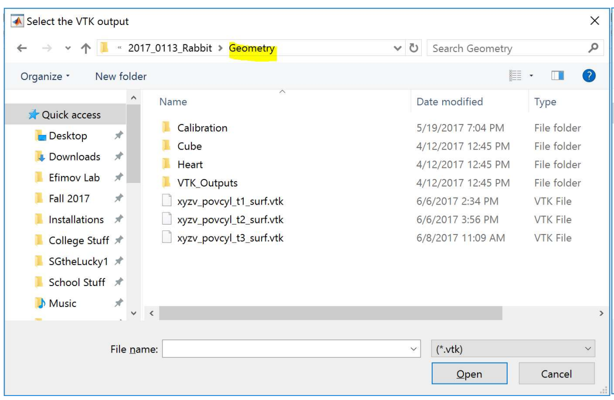
If you do not want to have to go through signal conditioning again, you can click ‘Export Data’. The next time you choose the same filename tag, when a dialog asks if you want to load filtered data, you can press ‘Yes’.

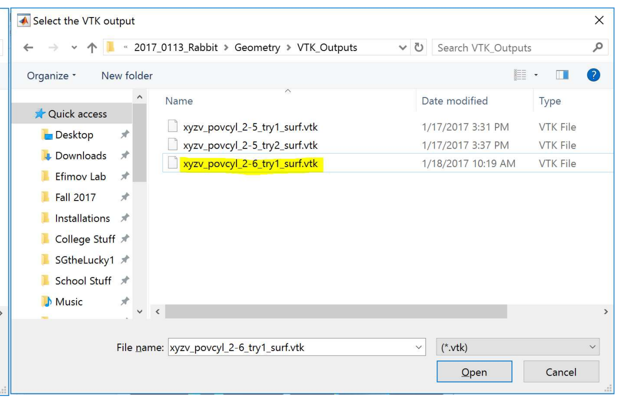


Click ‘Align’. This will prompt you to select the ‘Calibration’ folder. If you recall, it is ‘Geometry/Calibration’.

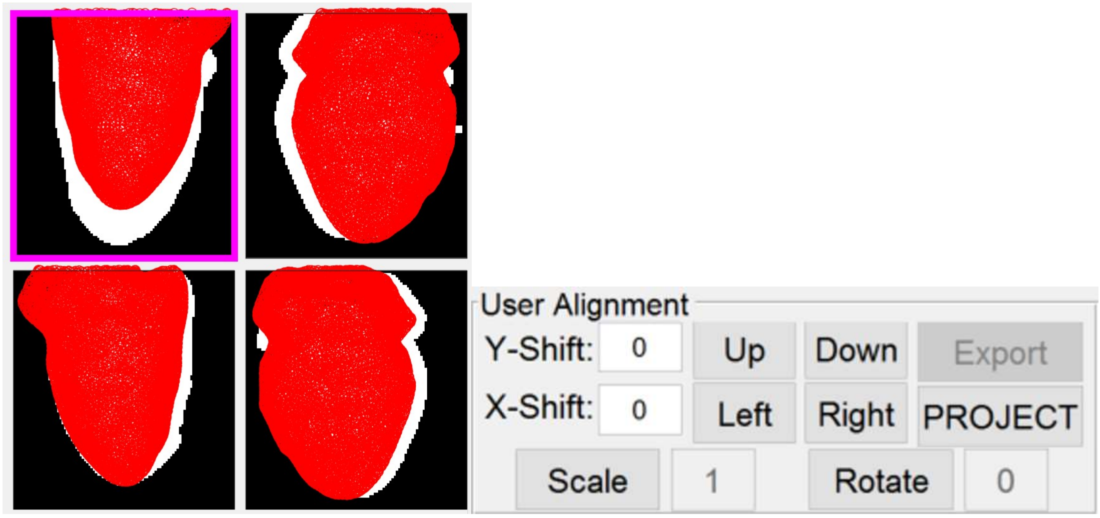


It will next ask you to choose the VTK output. This was part of the files saved at the end of WHIRL. For the sake of testing, go into the VTK_Outputs folder and choose 'xyzv_povcyl_2-6_try1_surf.vtk'.

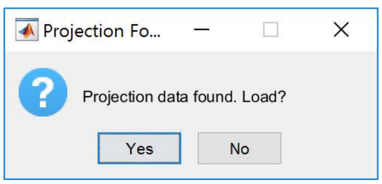




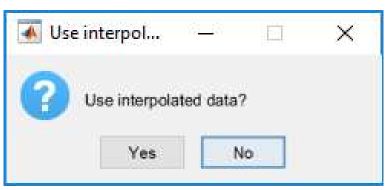
You should see the red and white images of the heart in the camera windows. The User Alignment tools should also be enabled. For each camera, you can move the red mask to fit the white shadow by clicking the buttons, typing numbers, or by using the arrow keys on the keyboard. You can also scale and rotate the red images to fit the white silhouettes. Scaling is a percent scale, so a scale of 1 means 100%, or just the original image. Note that you have to switch the active cameras. You might have to click on the image for it to focus so you can use the keyboard keys.



Once you are done aligning, click ‘PROJECT’. Ensure that there are no errors in the Matlab command window while it runs. At the end, you should see the 3D geometry of the heart with the membrane potentials imposed on it. You can export this projection data by clicking the ‘Export’ button. That way, when the dialog asks if you want to load projection data, you can click ‘Yes’ and it will skip all the way to this point.

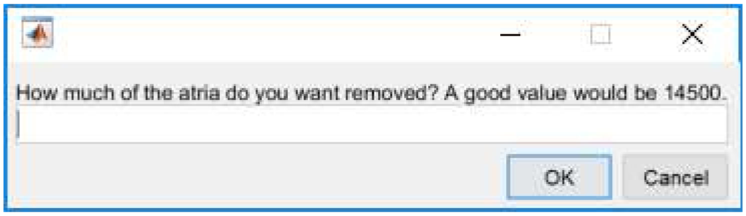


During the projection, you may be asked if you want to interpolate the missing data.



If you click ‘Yes’, the program will start calculating the interpolations. This may take some time, so a dialog box pops up and deletes after calculations are done.

You will be asked to input the index corresponding to how much of the atrial data you want removed. You will have to play around with this number to get the right one.

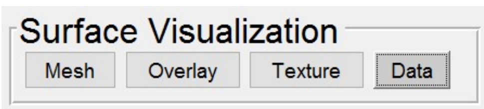


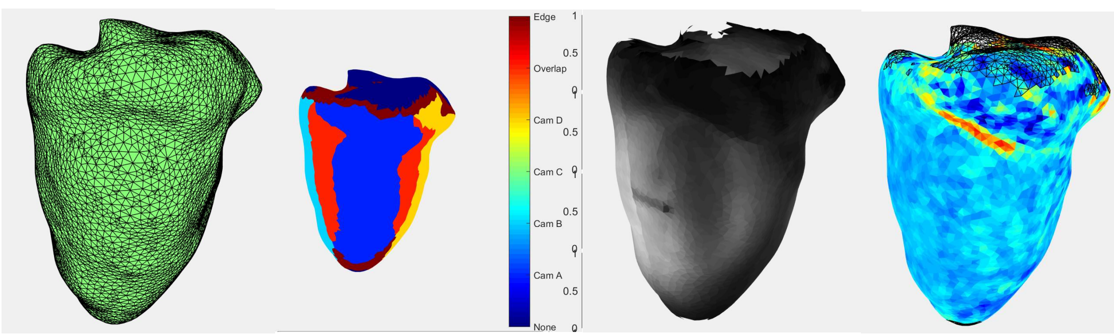
If you clicked ‘No’, the original data will be projected.

After some time, you should see the projection in the big white screen with your data (interpolated or not).

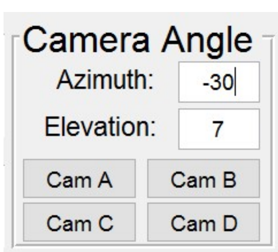
The Surface Visualization, Camera Angle, and Analyze Data tools should be enabled.

You can visualize Mesh, Overlay, Texture, and Data by clicking the respective buttons. The images are in the respective order according to the buttons.

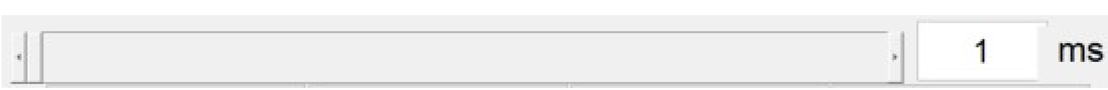




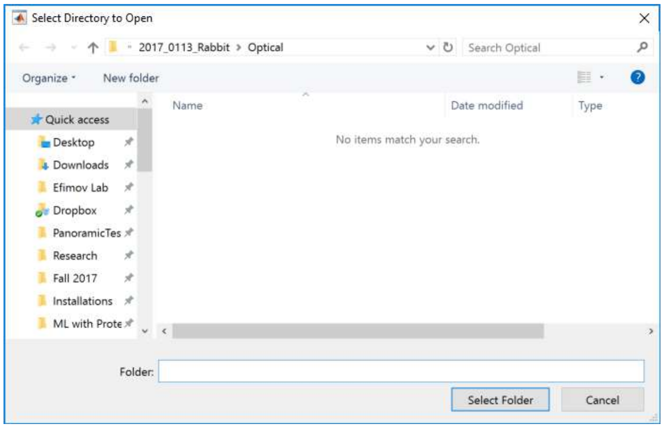
You can look at different angles of the 3D visualization by dragging around the heart. Or you click the camera corresponding to the view you want to see, and change the values for Azimuth and Elevation. Hit ‘Enter’ or ‘Return’ after typing in values to see the change in view.



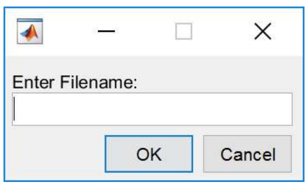
For time-changing data like membrane potential and phase, you can see the movie of how they move throughout the heart over time. Click ‘Play Movie’ to see the movie. The ‘Stop Movie’ button is not effective, so you might have to let the movie run in entirety. You can drag the slider to see signals at different times, or you can type in a millisecond time into the box.



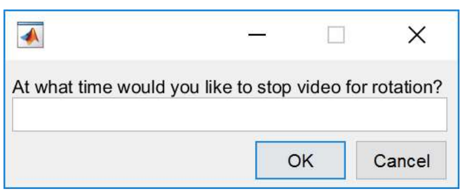
You can also export a movie into a '.avi' file. Click one of the camera views in the Camera Angle box, and click 'Export Video'. You will be asked where you want to save the movie.



After specifying the location, you'll be asked to input a filename.

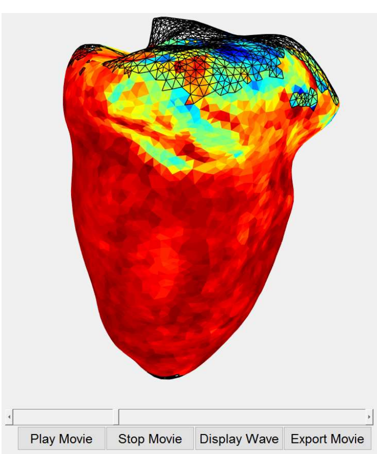


You will be asked at which time you want the heart rotated. Time will stop, and the heart will rotate all 360 degrees before resuming.

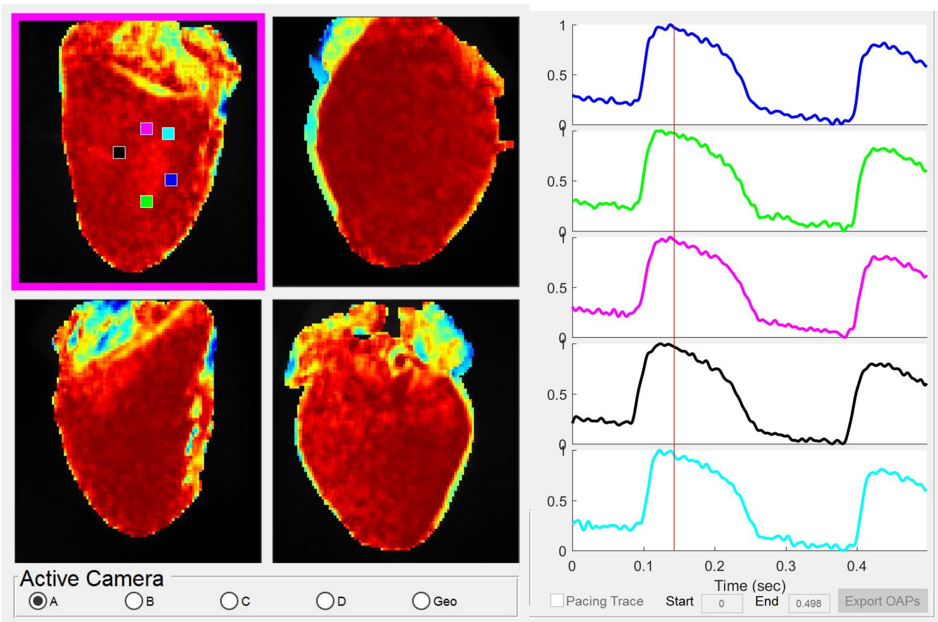


If you don't want the heart to rotate, you can click 'Cancel'.

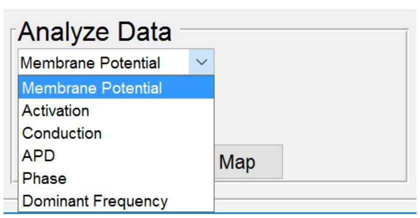
You will have to wait as the movie will play and record simultaneously on the 3D mesh.



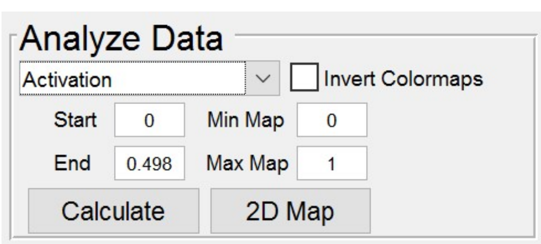
You can see the action potentials at a specific point in the heart using the 'Display Wave' button. Click 'Display Wave' and click a point on the active camera image. If you click a point on a frame other than the active frame, it will plot the point with the same location on the active frame. The screens on the right should update with the point you displayed. Note that you can only display a maximum of 5 points per active camera at a time.



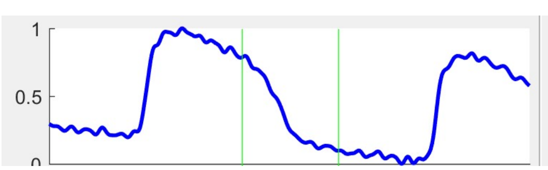
You can create Activation maps, Conduction Velocity maps, APD maps, Phase maps, and Dominant Frequency maps using the Analyze Data tools.



To view Activation maps, select 'Activation' from the drop-down. The section will update to look like this. You can edit the times and press 'Enter' or 'Return' to update.

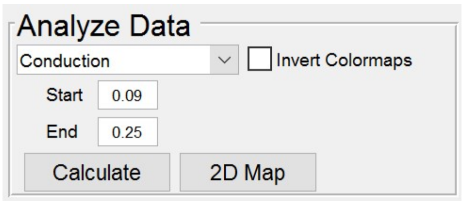


You can look at the signal wave screens to see the range. They are represented by green lines.

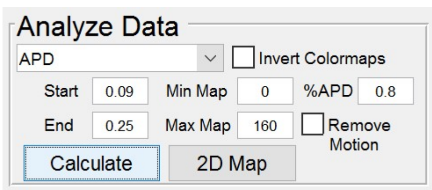


Once you get the desired time range, click ‘Calculate’ to see the activation map imposed on the images as well as the 3D visualization.

To view the Conduction Velocity, select ‘Conduction Velocity’ from the drop down and click ‘Calculate’ after setting the times. Highlight a rectangular area on the 3D geometry A figure should pop up with the velocities, and statistics should be printed out in the Command Window of Matlab.



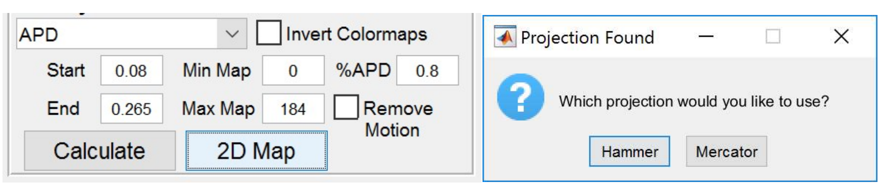
Getting the Action Potential Duration map is the same as getting the activation map. Select ‘APD’ in the dropdown, set the values, and press ‘Calculate’.

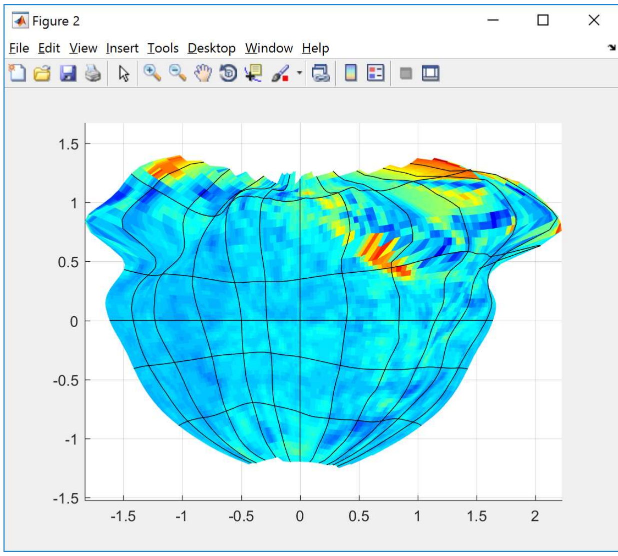


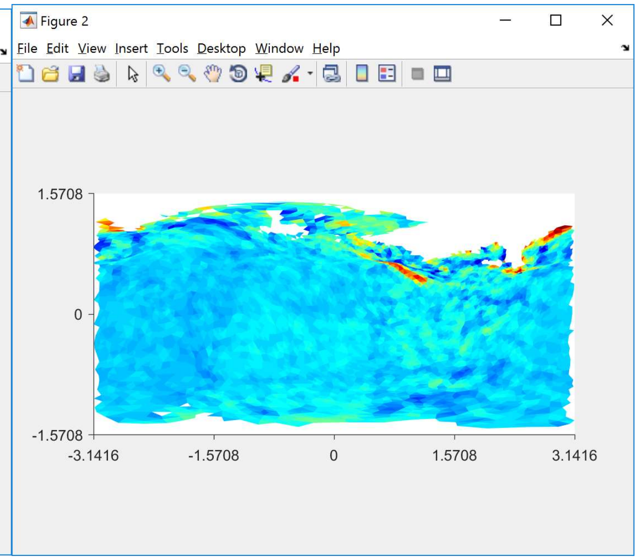
For Membrane Potential, Phase, and Dominant Frequency, you just have to select the map in the dropdown and press ‘Calculate’.

If there is no color in a particular region, this means that the value is less than or equal to 0. The black outline represents the 3D skeleton.

You can also project with a Hammer or Mercator projection. After pressing ‘Calculate’, you can click ‘2D Map’. Ensure there are no errors in the Command Window during the process. Eventually, there will be a dialog box that asks which projection you want. A figure will pop up with whichever projection you designated.







If you have any questions, run into any bugs, or have new ideas, feel free to email sgupta2020@gwu.edu.