
THINKING ABOUT MODELS: CT (Computed Tomography) Exploration of the Human Heart

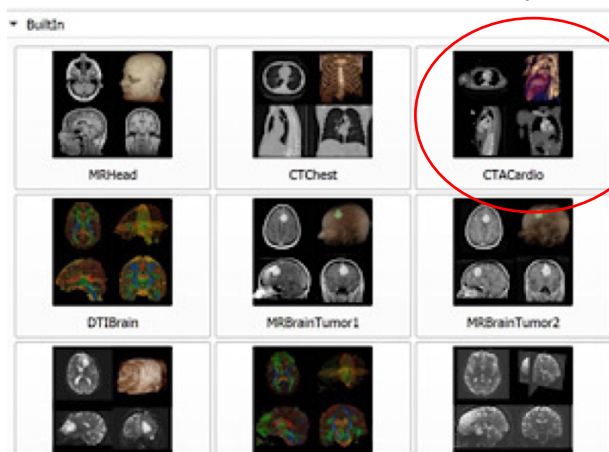
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Overview and Volume rendering

1. Open Slicer if not already open.
2. Under “Welcome” select “Download Sample Data.”



3. Choose “CTA Cardio.” This is an anonymized CT scan of a male patient’s torso.



Once the data opens, make sure your view is “Four Up.”

4. Once the file is loaded, you should see images in the red, green and yellow fields (cross section, frontal section and saggital section, respectively). You can change the contrast on the images by clicking on an image while you drag your cursor across it. If you scroll over a window it will flip through the **slices** (one layer of voxels) from that perspective.

Play with sliders on each to get a feel for the data set and how a body looks. Identify the major organs- heart, lungs, liver, kidneys, etc.

5. Within the window, go to Modules/volume rendering. Select volume: **CTACardio**. Click on the closed eye. The blue square should now display a 3D image of the torso. As discussed in the introduction, this will just be a black block at first.

6. Go to Display/preset. Choose **CT-Cardiac3**. This is your lookup table. We are choosing a lookup table that works for this dataset, but if you want to play with it I can show you how!

7. Play around to get a feel for the 3D view of the torso. The controls you need

Rotate: Click and drag

Zoom in and out: control click and drag or two finger drag.

Pan image: Shift-click-drag

Rotate: Command-click-drag

To see a slice on the 3d image: go to that field (red, yellow or green), and in the upper left, hover over the tack icon and then click on the icon that looks like a closed eye. Move the slider back and forth to see how it relates to the 3D view.

Part 1 3D Cropping

1. Go to Display/crop: click **enable**. Click the icon of the closed eye to “Display ROI”. This means your Region of Interest will show up.

2. A bounding box will appear in the red, green and yellow views (this may take a minute), and each should have large dots in the middle of each side. Click and drag these dots to restrict the Region of Interest; you should see the 3D view change as you do this.

3. Change the bounding boxes in all three views to optimize view of heart; that is, so you see the heart but not much else. Scroll through the slices in each view to find the heart’s maximum dimension in each direction and set the edges of the bounding box to that dimension. What difficulties did you have doing this?

4. Be able to explain in your own words how the computer is generating the 3D image from the dataset. I.e. how does volume rendering work?

5. Take a screenshot of your model, and then go to File/CloseScene. There is no need to save your work.

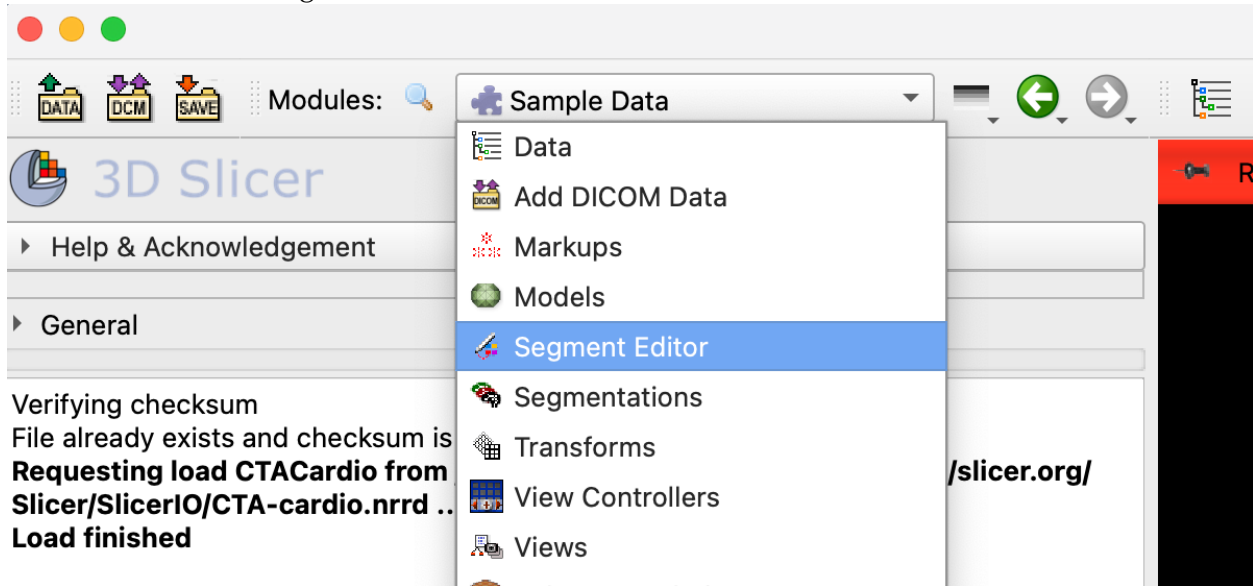
Part 2 Segmenting

Another option for creating a model is segmentation, where we divide the dataset into different regions (**segments**) that the computer can display in 3D. Each segment is typically an organ or another structure of interest. Think of this as a “scientist coloring book”: you

are going to go into slices of the data set and paint voxels with an identifier to tell the computer to which segment they belong.

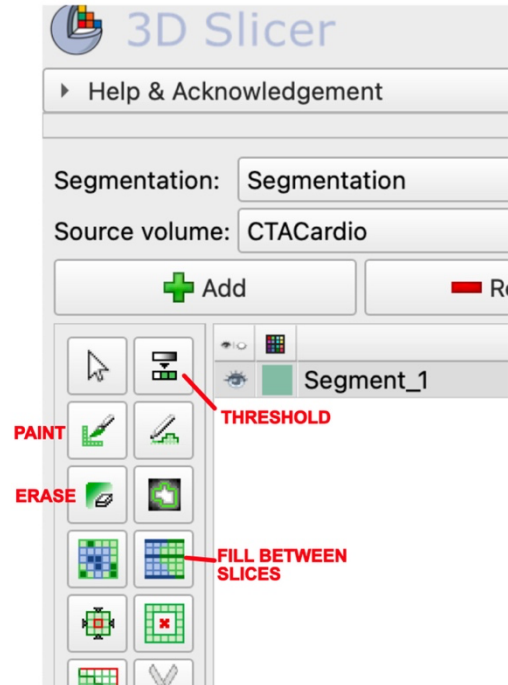
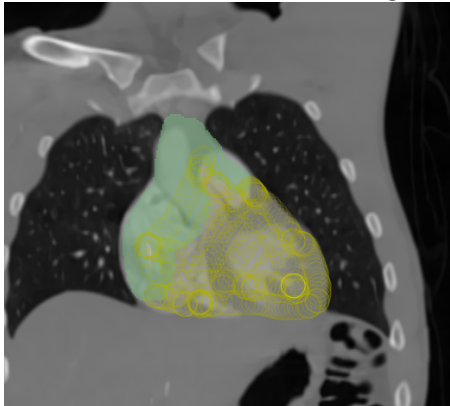
This would be very tedious to do manually for every voxel. Instead, programs have various algorithms to project your painting onto other slices to complete the structure. It is never perfect, and one must go back and correct the projections, but it is a huge time saver. We will paint some slices, and then ask the computer to fill between the slices.

1. Reopen the CTA Cardio sample data, as explained in steps 1-3 above.
2. Go to Modules: Segmentation Editor.



3. In the side panel that opens, choose Add (highlighted with a green plus sign). This tells the program you wish to add a new segment (i.e. labeled set of voxels).

4. You will now paint a slice of the heart, to tell the program which voxels belong to this organ. Click on the Paint tool. Now go to a view on the right (the green view may be easiest) and click-drag the mouse around. You should see an area get colored in green when you release.
5. If you paint an area that is not part of the heart, you can use the Erase tool to remove that region. Note that for both Paint and Erase, you can change the brush diameter to be larger or smaller.



6. You can double click in the view to only display that view and therefore zoom in. If you want to get back to the Four Up view, double click again.
7. Go 15-20 slices further in the stack, in the same view (you can use the slider or the arrow keys), and repeat.
8. Repeat instruction 7) several times, until you reach the end of the heart.
9. Now go back to the middle of the heart where you originally painted. Use the slider or arrow keys to go in the other direction through the stack, painting a view every 15-20 slices.
10. Once you have painted views throughout the heart in both directions, click on the Grow from Seeds tool. Click Initialize. You should see the slices get filled in when you look at the other views (red or yellow).
11. Click Apply.
12. See what you created! Click on the Show 3D button near the top of the left side.
13. Use the 3D manipulation tools explained in part 1 to move the 3D model around. How does this differ from your previous model of the heart?
14. How might you add another organ? Hint: you would start by adding another segment.

Part 3 (Optional) Grow from Seeds Protocol

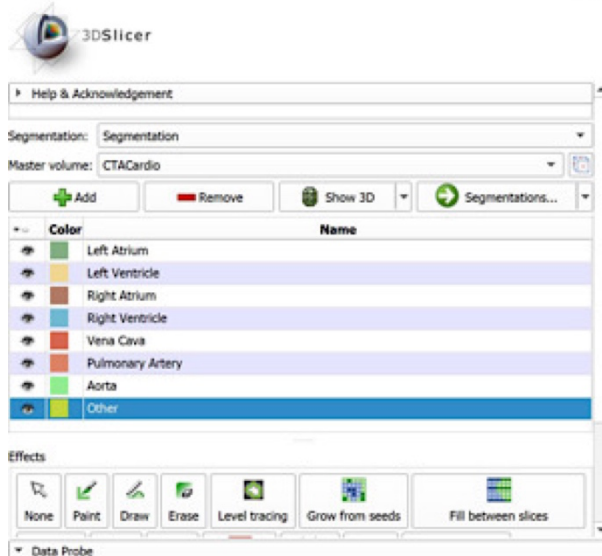
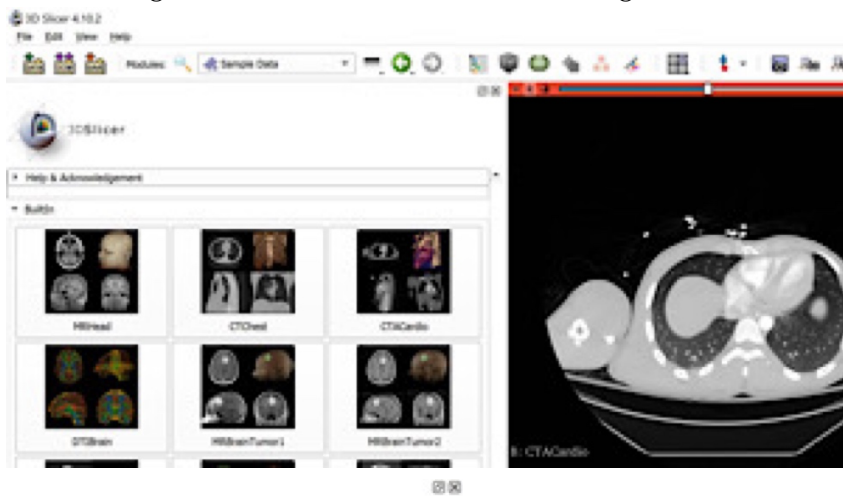
This protocol is based off of Perk Lab Research's YouTube video:

<https://www.youtube.com/watch?v=BjolexlvTGo>. This protocol goes through the steps in the video starting at time 2:06, if you wish to see how someone does this.

Trying to manually segment different regions of the heart could be troublesome: it would take longer, and the computer might sometimes get confused about which slices it was trying to build between. A different algorithm to segment is called Grow from Seeds. That is, we “seed” the segment from painting some slices; the computer then grows the segment out from those seeds until it begins hitting very different greyscale values.

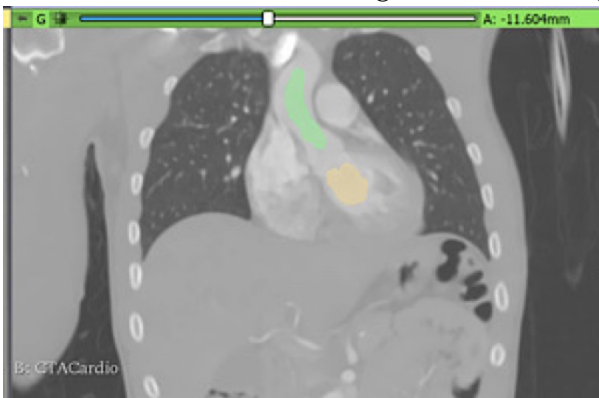
1. Open Slicer if not already open. Go to File/download sample data. Choose the file “**CTA cardio**”.
2. Under “Welcome” select “Download Sample Data.” Choose “CTA Cardio.”
3. In the menu bar under Modules, choose Segment Editor
4. Press “Add” for each part of the heart and name accordingly. The parts of the heart that should be included are the left atrium, left ventricle, right atrium, right ventricle, vena cava, pulmonary artery, and aorta. Also add a segment title “other.” Make the “other” segment a bright color to make it easily distinguishable from the parts of the heart. “other.” Change the color of “other” to be distinguishable from the other

segments.



- 5.

6. Click on a segment and under View select "Paint" (note that it is not labeled with text in the new version, but see the image above to see what the paint icon looks like). Change the brush size to 1 or 2%, and paint each of the structures in the scan as below. If the brush does not color all of the image but only lighter or darker parts, uncheck "editable intensity range"
7. To scroll through slides, use the red, yellow, or green bars above each CT or use your mouse. The more images you paint the structures in, the better the likelihood of having less editing afterwards will be, but details of the minimums are stated below.
8. Continue for each of the segments (heart regions) listed



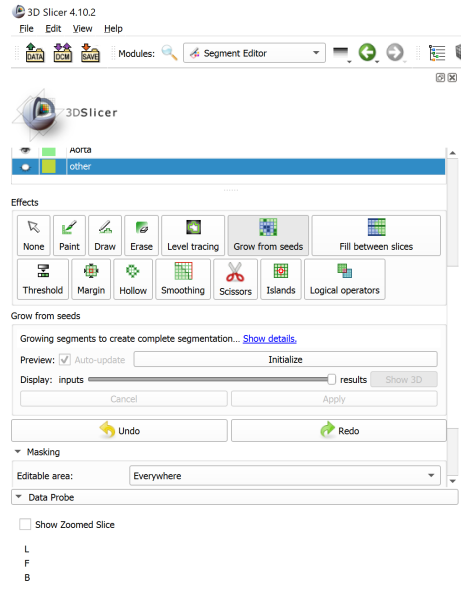
9. The aorta should be above the left ventricle. The pulmonary artery should be to the left of the aorta. To find the right ventricle, scroll to find a more anterior slide and to find the left atrium, scroll to find a more posterior slide. To find the vena cava, scroll to find a more posterior slide.
10. Lastly, select "other" and paint around the components you've already painted at



least twice in each window.

11. Once you've completed painting each section, under Effects select "Grow from Seeds." Click the button that says "Initialize" and the painted areas should expand to encapsulate the features you painted in every view they appear in. If there is a mistake that you see while scrolling through the images, fix it using paint or the eraser and it will update every image with that mistake automatically.

12. Next, under Grow from Seeds, click “Show 3D” and “Apply.” This will bring up the 3D model you created in the 3D window. You may also go back and edit with



paint and the eraser in this phase if you notice another mistake.

13. Save your work.