# Application Note: Converting data into a 3D print

3D printing is a technique that is very compatible with working with CT data. However, you will need to convert the grayscale image to a binary image, and then further convert the volumetric data (made of cubes/voxels) into a surface file (made of flat triangles/polygons), in order to create a printable object.

There are so many different styles of 3D printer that the recommendations below are very general. I recommend that you discuss your print requirements (layout, resolution, file size, file format, etc.) with whoever is running the printer, or review the requirements in the manual if you are running it yourself.

1) Open Avizo and open your data, adding resolution information if needed. View it with Ortho Slice and/or Volume Rendering to confirm the region of interest you want to look at. In the following example, we will be preparing a 3D print of the mouse's skull.
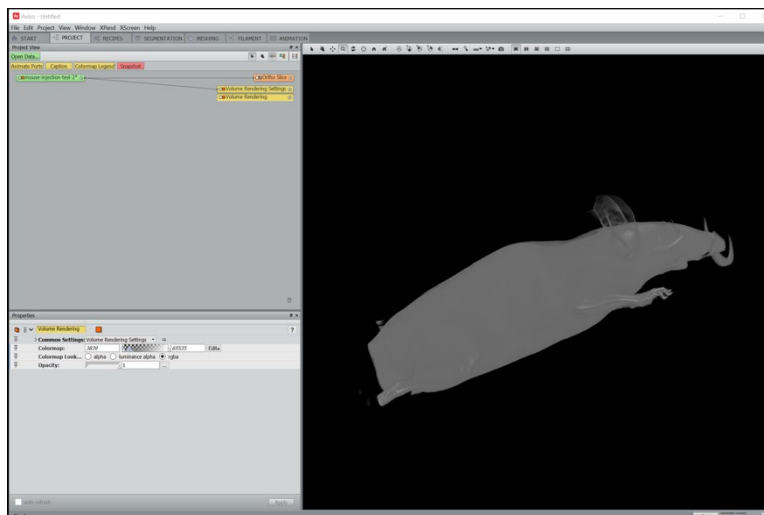
2) Right click on object with the object filename, go to Image Segmentation, and Edit Label Field. You will now be in the Segmentation tab:
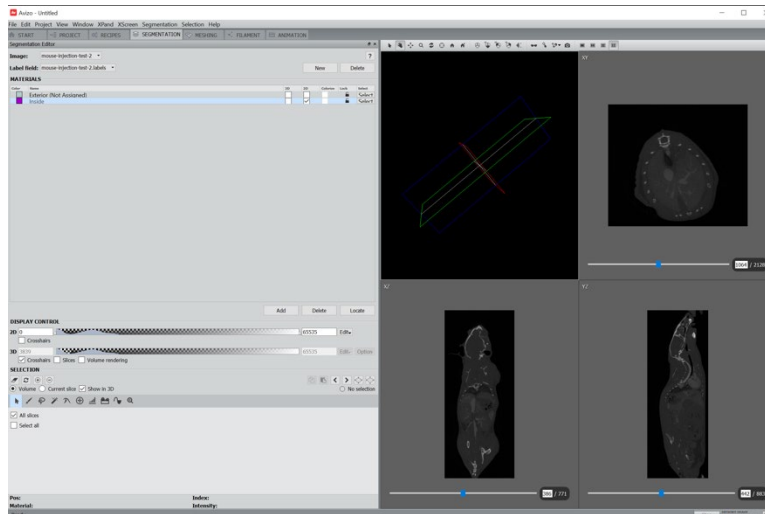
Select the volume you wish to print, using the segmentation tools described in the main Avizo training manual. Below, the skeleton has been segmented from the soft tissue and all the other bones have been manually deleted from the label.
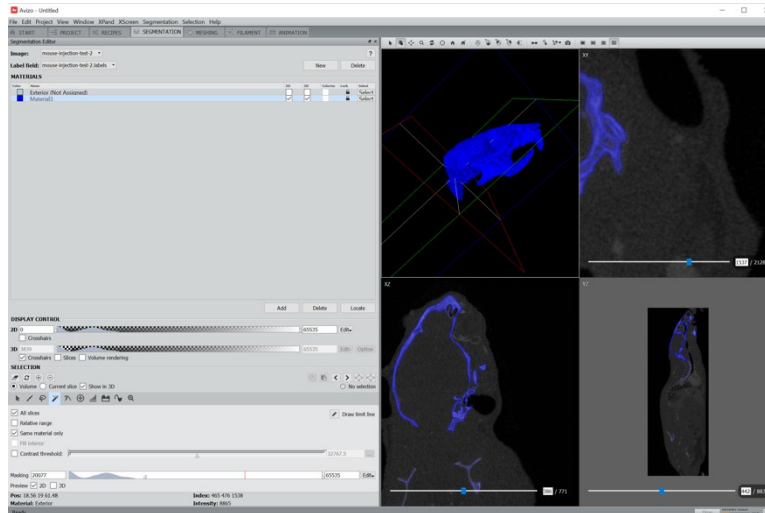

Some things to note as you segment your data:

-Turning the voxel data into surface data will reduce some surface detail, and most typical 3D printers print at a lower resolution than is available in the CT scan. If your desired print involves a lot of fine surface texture, some of it may be lost.

-If you are planning a multiple color print, you can select separate regions and give them each a separate label. For a single print, you will want to end up with a single

label. I'd recommend discussing the requirements for a multicolor print with the tool manager of the 3D printer you are using, or in the manual for the 3D printer you are using. If you are not doing a multiple color print, make sure you only have one label field before creating the surface file.

When the area you want to print has been selected, go back to the Project tab. Create a new volume rendering for the .labels object, or connect an existing volume rendering to the .labels data object. The skull is being visualized in the screenshot below.
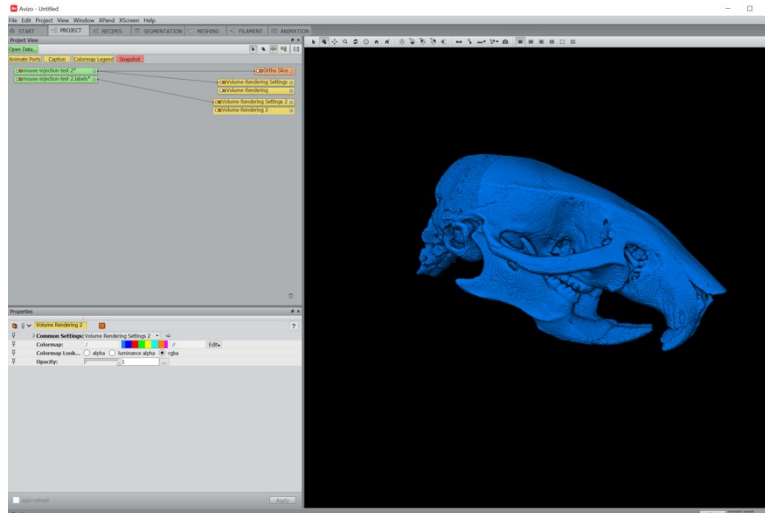

Clean up the dataset if needed. Some tips:

-It's a good idea to fill any unnecessary holes in this selection; this will improve the surface rendering and 3D print later. If there are gaps inside the print that you want to fill, you can right click on the .labels object, select "Fill Holes", and click Apply to try it (a new data object will be created labeled "[filename].filled". Try it in xy first rather than 3D, because it's faster and is often sufficient. The screenshots below show a slice of the selected data before and after the Fill Holes function was applied. This particular print is not set up to show the inside of the skull, so filling it is preferable.
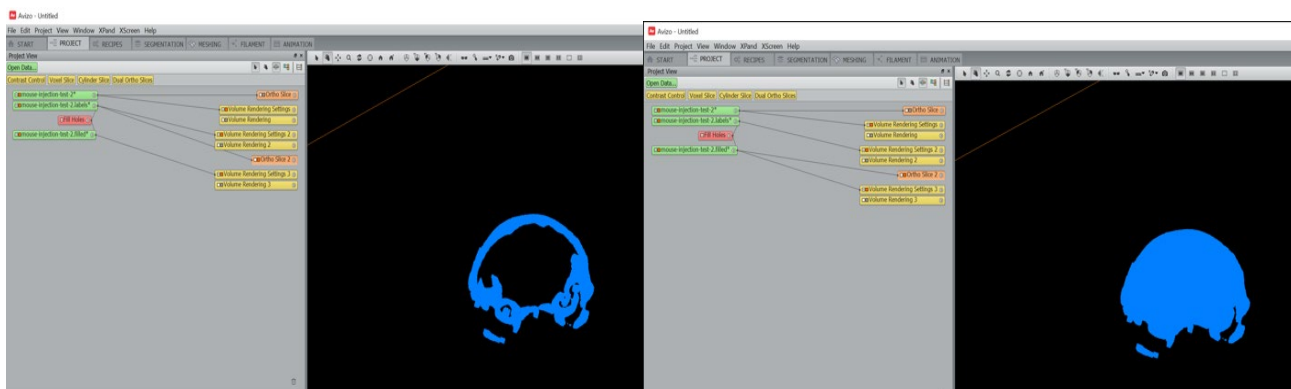
-If there are small floating selected voxels that you want to remove, right click on the .labels object and select "Remove Small Spots". Choose the maximum voxel size that should be kept and click Apply to see how it looks. A new data object will be created labeled "[filename].filtered". Your final object is probably tens of thousands of pixels in size, so don't be afraid to put a fairly large number (>1000) into the filter to get rid of any unwanted, unattached pieces.

Right click on the object containing the dataset you'd like to use for your final print, and select "Generate Surface".
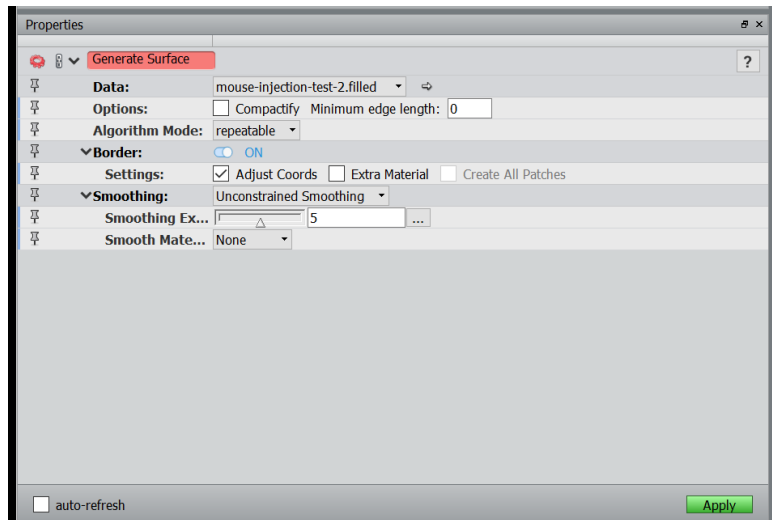

The default values are a perfectly reasonable place to start. Click Apply to create a surface.

This will generate a new object called "filename.surf". Right click on this object and select "Surface View" to show the surface you've created from your segmented data. The images below show the segmented volumetric data (left) and the newly created surface (right):
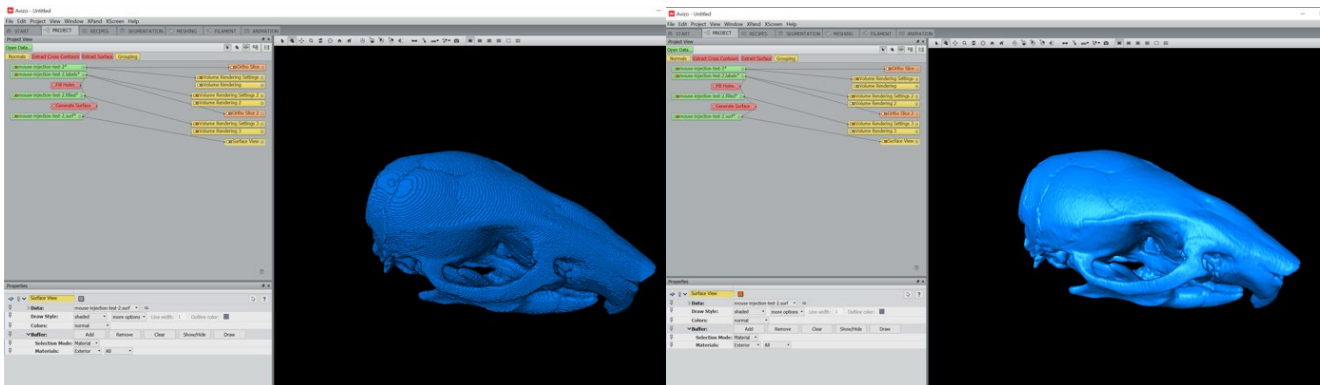
If you zoom in on the surface view, you'll see how it's different than the voxel-based data—it's a surface composed of triangles, as opposed to a volume composed of cubes. Below, the left image shows the voxel-based data and the right image shows the surface file of the same selected data:
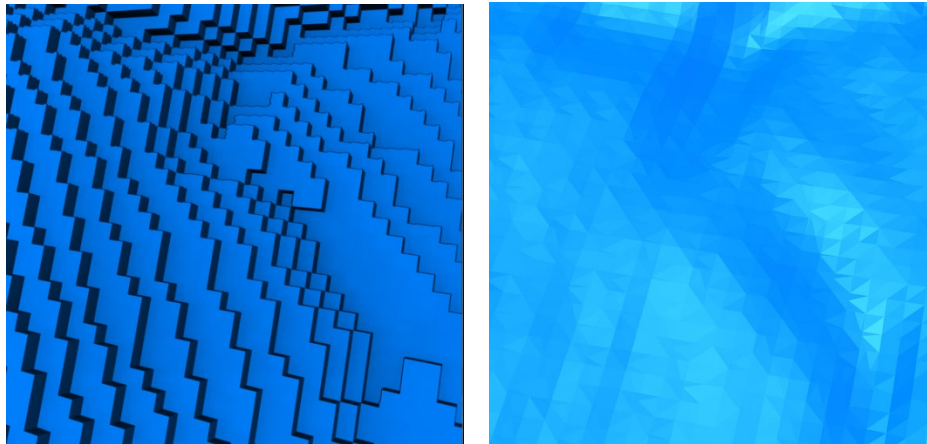

At this stage there may be elements that you want to change—for example, if desired surface roughness has been lost, or conversely, if the surface looks less smooth than it should. After any of these steps, you can perform another iteration of segmentation, either of the previously segmented file, or of one of the new filled or filtered objects. You can also redo any of the functions, changing values, etc. Just keep in mind that if you change something upstream, you will need to click apply on all of the downstream functions in order to get a re-made surface based on the updated information.

The surface that has been created displays a lot of fine detail, resulting in a large file that most 3D printers won't be able to print. The file size can be reduced by simplifying the data. To simplify the data, click on the "simplification editor" button (the square icon with red and black triangles inside) in the surface file's properties window, as shown below.
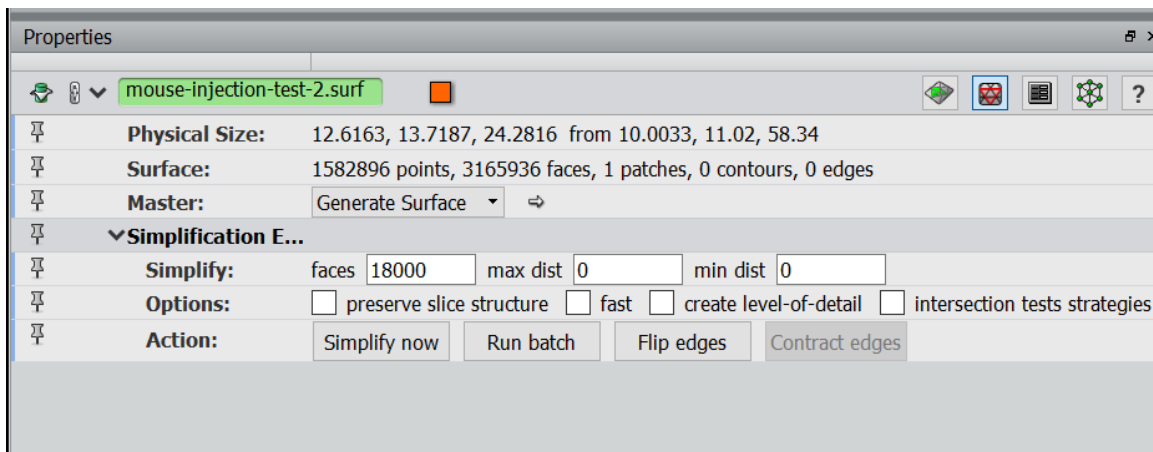
In this example, there are about 3.16 million faces on the existing surface file (this information is listed next to "Surface:"). To further simplify the surface and shrink the file size, we can type any number smaller than 3,165,936 into the box next to Simplify, and click Simplify Now. If you oversimplify and want to get back to the original surface file, click on the Generate Surface object and click Apply in the Properties window again to recalculate the surface, which will get you back to the original file.

If I am about to use an unfamiliar 3D printer for the first time, I usually save surface files of several file sizes (by simplifying to various numbers of surfaces) to compare printability and speed. The images below represent a skull formed from 3 million, 100,000, 10,000, and 2000 facets, respectively. Reducing the number of facets reduces the file size and also reduces surface texture.
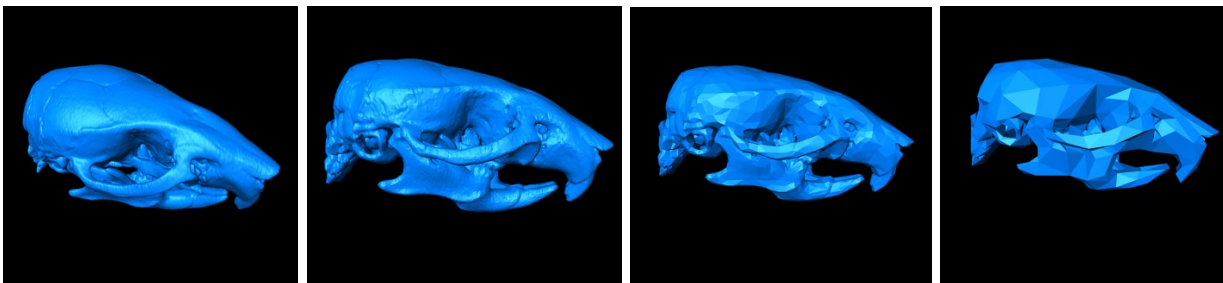
Click on the surface object (will end with the extension .surf) and export the data in a file format that will work for the 3D printer you plan to use. If you're not sure, try .stl.

Additional application note: Changing the smoothness of a surface

Click on the Generate Surface Object and view the options in the Properties window.
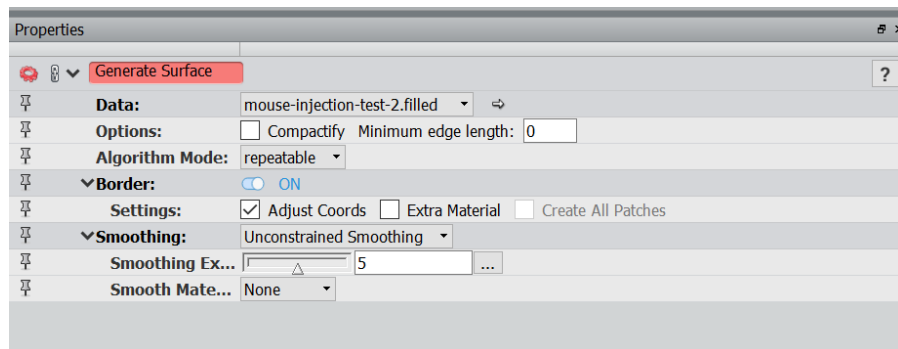
Everything shown above is set to the defaults. Under Smoothing, "Smoothing Extent" refers to how closely the surface that Avizo generates will align with the selected voxels. For a low number, and very little smoothing will be done, and for a high number, a lot of smoothing will occur. The two extremes are shown below, for smoothing values of 1 (left) and 8 (right) on the top of the mouse's skull.

On the left, we see crisp edges of a real feature (the sutures on top of the skull, which are normal features.) However, we also see a lot of "terraces" formed by the surface trying to adhere closely to the individual voxels. These are not real features, but an artifact of the resolution at which we have scanned the skull. A high-resolution 3D print of this area may miscommunicate the actual smoothness of the skull.

On the right, the increased smoothing means that the terracing artifact is mostly gone. However, the sutures, which are somewhat narrow indentations, have also lost a lot of their depth. If there are sharp features that need to be preserved in your 3D print, setting the smoothing extent to a lower number will display them more clearly. Setting the smoothness value too high can also lead to voids in areas where the selected material is only a few pixels thick.

I'd recommend trying files with a few different smoothing extents and then zooming in to see what value gets you the effect you're hoping for.