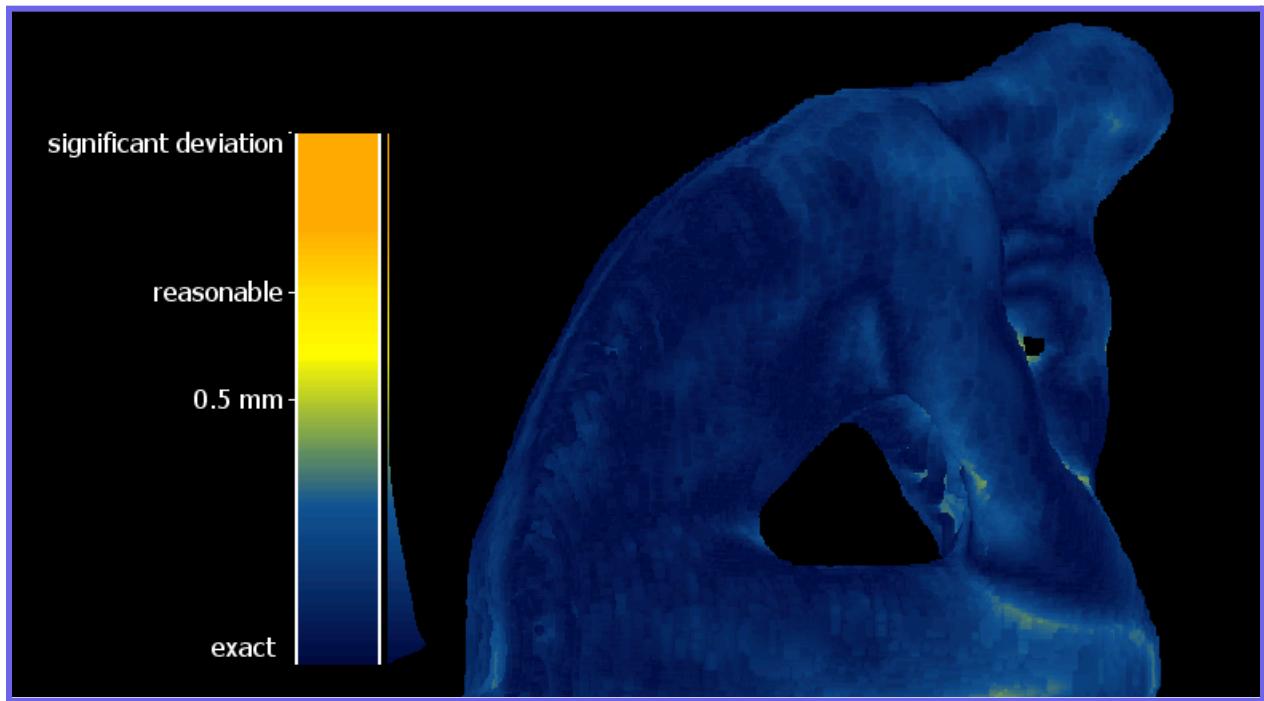


MicroCT to STL using ImageJ

For input into CloudCompare, Meshlab, or similar program for stl comparison

Workflow Prepared by Mack Sowers

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Overview

Use [ImageJ](#) not [Fiji](#) until the end; ImageJ is faster but doesn't have the 3D viewer app.

1. whole scan prior to separating samples.
 - a. If you will be comparing multiple samples from the same scan, you'll want the operations to match.
2. Isolate sample that is target for stl.

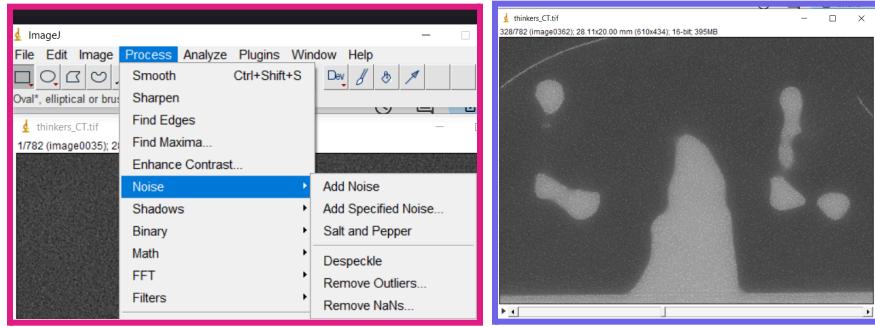
-
- 3. Remove stray objects from frames; eg tape and neighboring samples.
 - 4. Bicubic interpolation to decrease voxelation
 - a. If the object is turned into an stl with the voxel size inherent from the CTscan it will look very boxy and voxelized.
 - 5. Make binary (stls are binary, and subsequent steps require it regardless).
 - 6. Outline (This reduces voxelation appearance further since only the outside edges will be visible- imagine instead of a staircase you have a ladder)
 - 7. Open file in FIJI, make stl

Detailed Steps:

ImageJ log included at end of document; can be personalized to create MACRO. You can create your own record Plugins > MACRO > record

Step 1: De-Noise file.

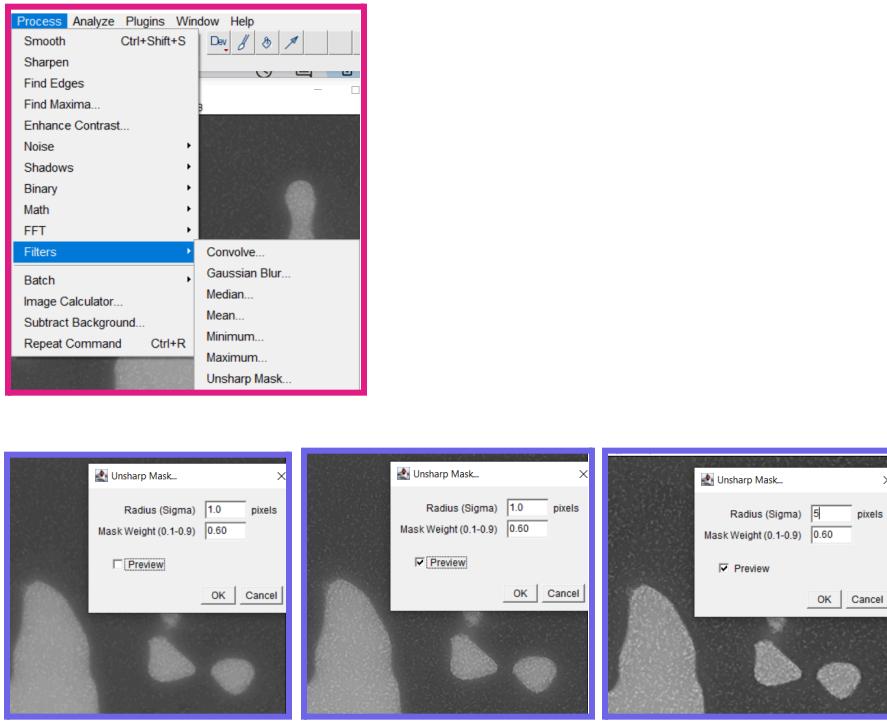
- 1. Open DICOMS as file > import image stack
- 2. Save image stack as .tif and descriptive file name
- 3. Move forward in the stack so an object slice is visible; there is a slider at the bottom of the window.
- 4. Remove Dark Outliers
 - a. Choose radius and threshold by eye, avoid blurring objects. Record parameter values.



5. Despeckle

- There are no parameters to adjust here. It's very fast at millions of pixels a second rather than hundreds.

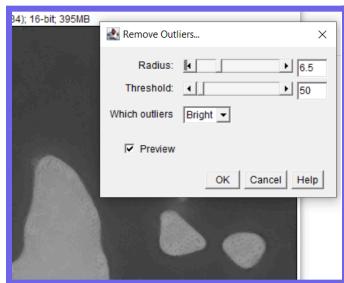
6. Unsharp Mask



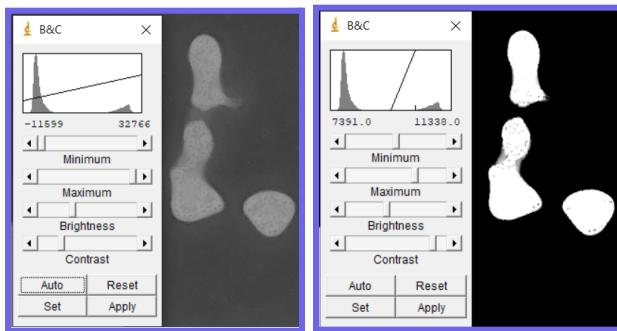
- This helps undo the blurring caused both by the CTscan reconstruction and the despeckle process
- Parameters sigma and mask weight can be adjusted.

- c. Also very fast at 100 pixels/sec

7. Remove Bright Outliers



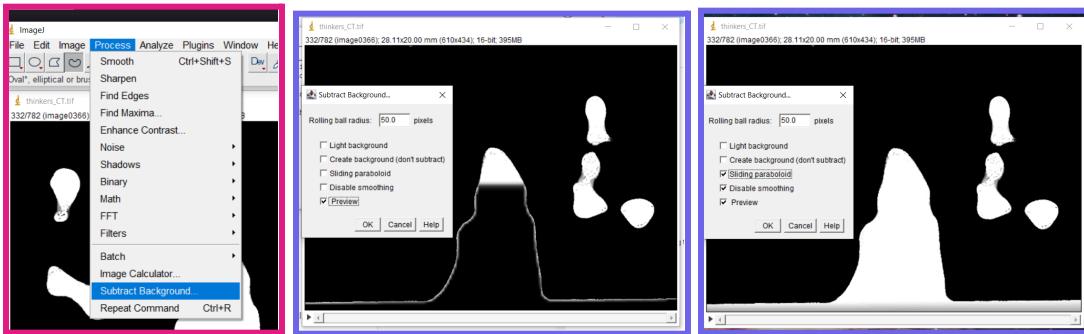
- a. Slower at 7.9million pixels/sec
 - b. Adjust radius and threshold such that you do not overcompensate and introduce new dark spots.
8. Choose a frame that has fine detail in order to preserve detail.
9. Adjust brightness and Contrast in preparation to remove the background.



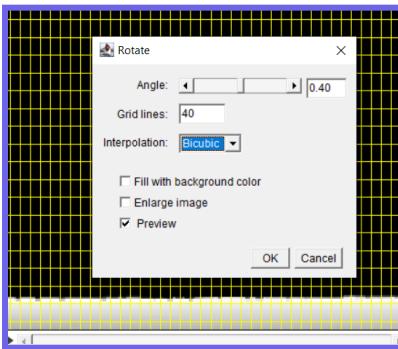
- a. The record function doesn't note these values, so you may want to take a screenshot for repeatability.

Step 2: Prepare for Binary Format

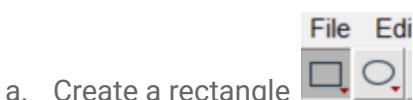
10. Remove Background



- a. Adjust rolling ball radius or choose sliding paraboloid to ensure only the background is removed.
11. Align floor to grid at any time if needed for further cropping; floor should also be removed prior to generating stl.



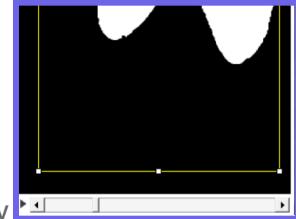
- a. image>transform>rotate
12. If working in a file of multiple samples, crop out one sample by locating the outer edges in the x and y direction



- a. Create a rectangle



- b. use the slider to locate extremes

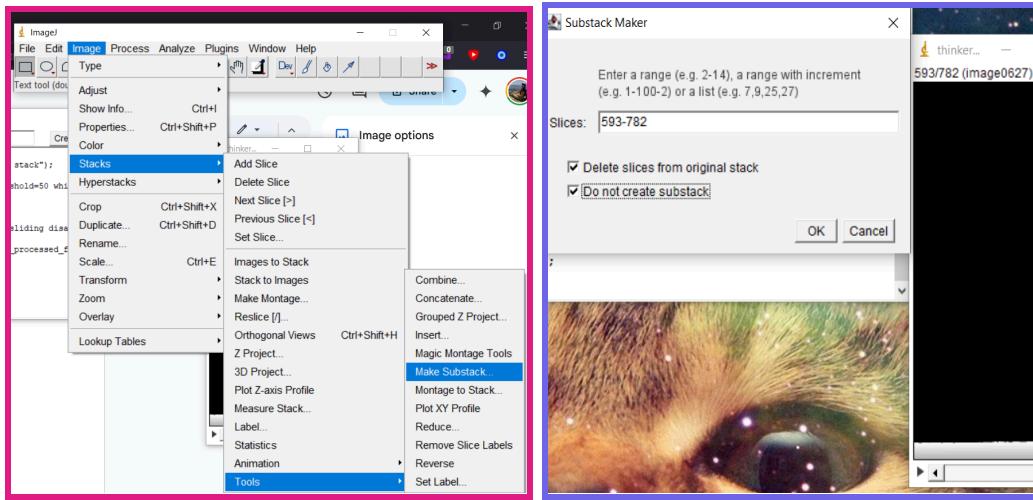


c. Adjust the size of the rectangle iteratively



d. image>crop

13. Locate frames in z direction which do not contain object, delete them from stack.

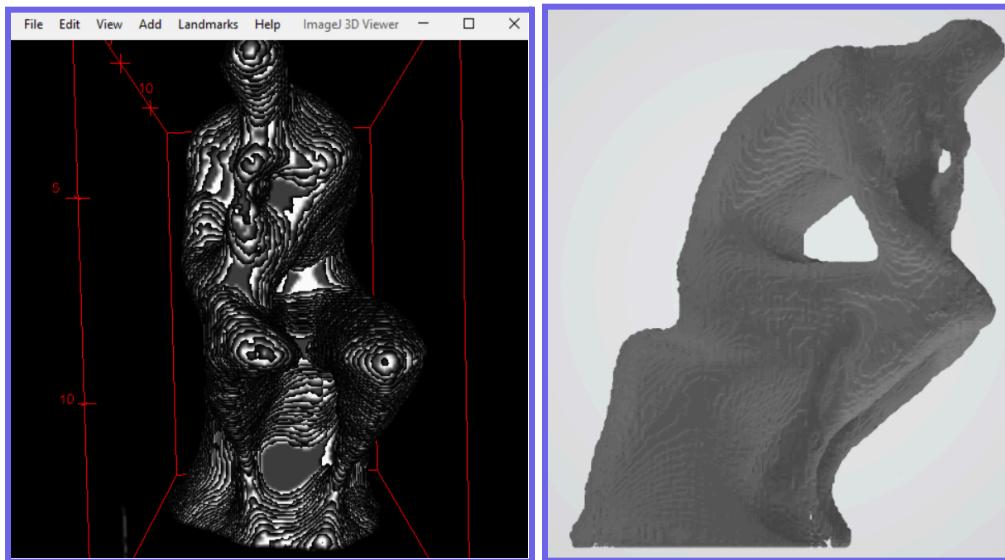


14. Save files with descriptive names, especially before moving on to next steps which could crash the program. You are in charge of creating version control here.

```
thinkers_CT
thinkers_removedarkoutliers
thinkers_removedarkoutliers_despeckle
thinkers_removedarkoutliers_despeckle_unsharpmask
thinkers_removedarkoutliers_despeckle_unsharpmask_removebrightoutliers
thinkers_removedarkoutliers_despeckle_unsharpmask_removebrightoutliers_BandC
thinkers_removedarkoutliers_despeckle_unsharpmask_removebrightoutliers_BandC_removedbackgroundrollingballradius222
```

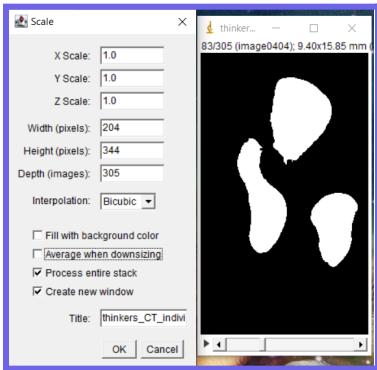
Step 3: Interpolation

Depending on your scan resolution, the voxelization may be high. Below is the stl from the native resolution (only about 20 pixels per mm) before and after export:

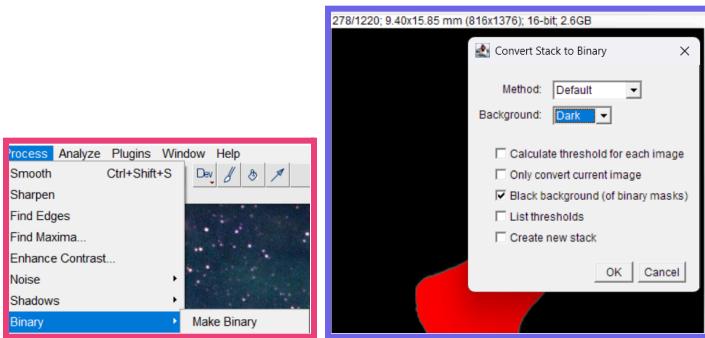


Scaling up using bicubic interpolation before computing binary and exporting stl can help to better resemble the actual surface.

15. Scale to 3 or 4 times size (Ctrl + E)

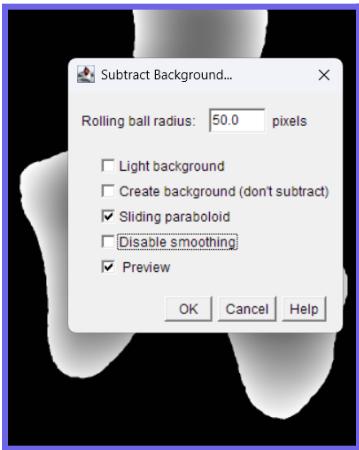


16. Convert to Binary



I deselect the “calculate threshold for each image” as I feel they should all be at the same settings.

17. Subtract Background again



This time you'll need to increase rolling ball radius significantly in order to not subtract from inside object. I chose 500 pixels.

Step 4: Export STL

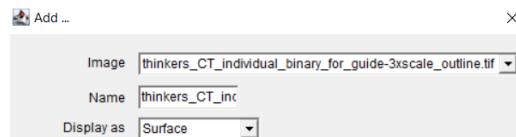
18. Optionally, create Outline before final stl (may help reduce effect of voxelization on distance calculations; only the surface is saved this way, not the lines connecting each surface. Since this doesn't create a closed surface it is not appropriate for other

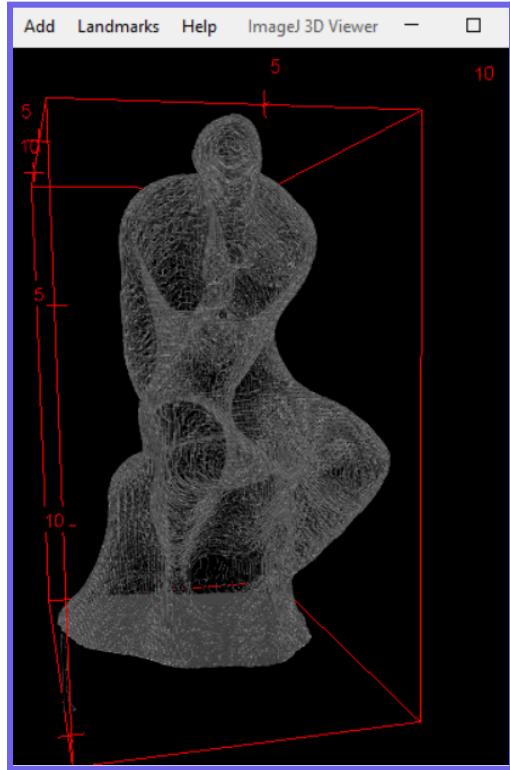
applications. This process is extremely fast.



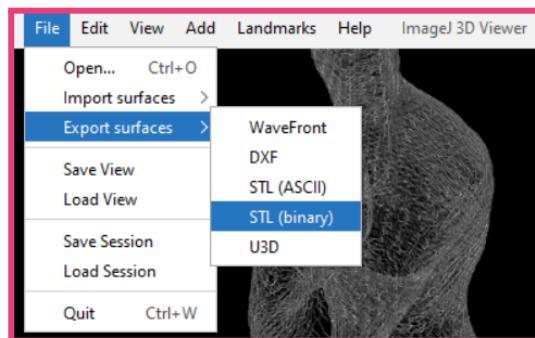
19. Open 3DViewer in FIJI

- a. Not the same as Volume Viewer, which is in basic ImageJ and works very well. Volume Viewer doesn't export STL surfaces. It is good as a preliminary step if you just want to check for stray objects or see the resolution.
- b. Some actions you take could cause the image to no longer have the background removed or to not be binary, so if you have any issues either repeat those commands or load one of your carefully saved previous versions. 3Dviewer isn't as well optimized as volumeviewer so be patient.
- c. Plugins > 3DViewer
- d. Display as Surface. Other parameters can stay as default. Be patient.





e. File > export surface > stl binary



Step 5: Verify and admire

Your STL should now be available for use. Try opening it to be sure.



Record for above process

```
open("C:/Mack/Documents/microCT/thinkers_CT.tif");
run("Remove Outliers...", "radius=16 threshold=50 which=Dark stack");
run("Despeckle", "stack");
run("Unsharp Mask...", "radius=5 mask=0.60 stack");
run("Remove Outliers...", "radius=6.5 threshold=50 which=Bright stack");
//run("Brightness/Contrast...");
run("Apply LUT", "stack");
run("Close");
run("Subtract Background...", "rolling=50 sliding disable stack");
saveAs("Tiff", "C:/Mack/Documents/microCT/thinkers_CT_group_processed_for_guide.tif");
run("Rotate...", "angle=0.40 grid=40 interpolation=Bicubic stack");
//setTool("rectangle");
makeRectangle(380, 0, 207, 431);
run("Crop");
run("Make Substack...", "slices=593-782 delete do_not");
run("Make Substack...", "slices=1-287 delete do_not");
makeRectangle(0, 156, 15, 188);
setBackgroundColor(0, 0, 0);
```

```
run("Clear", "slice");

run("Clear", "slice");

run("Clear", "slice");

selectImage("thinkers_CT_group_processed_for_guide.tif");

saveAs("Tiff", "C:/Mack/Documents/microCT/thinkers_CT_individual_for_guide.tif");

run("Scale...", "x=3 y=3 z=3 width=612 height=1032 depth=915 interpolation=Bicubic process
title=thinkers_CT_individual_for_guide-3xscale.tif");

selectImage("thinkers_CT_individual_for_guide.tif");

close;

selectImage("thinkers_CT_individual_for_guide-3xscale.tif");

saveAs("Tiff", "C:/Mack/Documents/microCT/thinkers_CT_individual_for_guide-3xscale.tif");

run("Make Binary", "background=Dark black");

setOption("BlackBackground", true);

saveAs("Tiff", "C:/Mack/Documents/microCT/thinkers_CT_individual_for_guide-3xscale_binary.tif");

run("Subtract Background...", "rolling=500 disable stack");

saveAs("Tiff", "C:/Mack/Documents/microCT/thinkers_CT_individual_for_guide-3xscale_binary_removed-background.tif");

run("Outline");

//setThreshold(129, 255);

run("Make Binary", "background=Dark black");

run("Outline", "stack");

saveAs("Tiff", "C:/Mack/Documents/microCT/thinkers_CT_individual_for_guide-3xscale_binary_removed-background_outlined.tif");

run("3D Viewer");

call("ij3d.ImageJ3DViewer.setCoordinateSystem", "false");

call("ij3d.ImageJ3DViewer.add", "thinkers_CT_individual_for_guide-4xscale_binary_removed-background_outlined.tif", "None",
"thinkers_CT_individual_for_guide-4xscale_binary_removed-background_outlined.tif", "50", "true", "true", "true", "2", "2");

call("ij3d.ImageJ3DViewer.exportContent", "STL Binary",
"C:/Mack/Documents/microCT/thinkers_CT_individual_for_guide-4xscale_binary_removed-background_outlined.stl");
```