

# ASM CT workshop 2021 – using 3D Slicer to render CT data and create mesh files

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## Converting and downsizing CT image stacks for easier handling in 3D Slicer

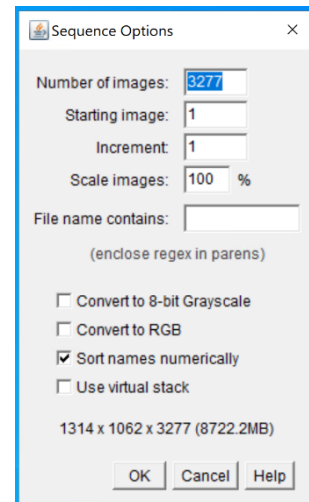
Introduction to ImageJ and Fiji (Fiji is just ImageJ) here: <https://imagej.net/Documentation>

### Import data

*File - Import - Image Sequence...*

- Navigate to folder containing Z stack. Make sure there is nothing else in the folder. Select one of the images in the stack and click OK.
- Here you can reduce the size by converting the stack to 8 bit if you don't need all of your grayscale values. This can be useful for skeletal data sets, but not optimal for soft tissue data sets.
- Note the image dimensions listed at the bottom. This will tell you how big the stack is (this example is 8.7gb)
- At this point you could also reduce the stack size using "Scale Images", but this will change the X and Y size of your images, and not the voxel size of the Z stack, and hence will require some further adjustments to your stack's resolution. Unless your computer lacks the memory required to load the entire dataset

Figure F1. Options when importing image sequence

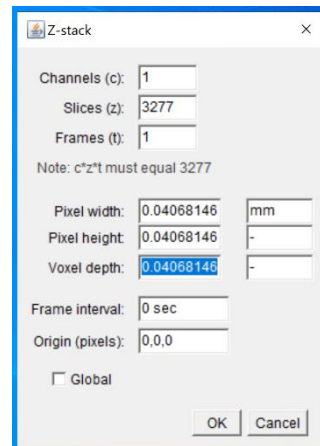


### Specify voxel size

*Image - Properties*

- Find your voxel size in the log file, or on Morphosource (in the same place you downloaded your data from)
- Enter units first
- Then Pixel width, Pixel height, and Voxel depth.

Figure F2. Specifying voxel size



### Reduce stack size

*Image - Stacks - Tools - Reduce*

- Enter the reduction factor you require to downsize your stack appropriately. To reduce by half, enter "2" to reduce to 1/3<sup>rd</sup> of the size, enter "3", etc.

### Save a region of interest only

If you have a large scan and only need a sub-volume of the data set:

- Choose one of the selection tools in the main menu. Usually the rectangle or ellipse tool is best for this part.
- Select an area that encompasses your region of interest (ROI). Scroll through the stack and make sure you have expanded this area to include your entire ROI.

*Image - Crop*

- You will now have a substack of your original volume containing the ROI you just selected.
- If you only need a selection of the slices in your original stack (e.g. if you only need the head and still have part of the rest of the body in your cropped stack), you can make a copy of the stack with only the slices you need.
- Scroll through your stack and identify the slice numbers where your ROI begins and ends (the slice number is shown at the top left corner of your image stack).

#### *Image – Duplicate*

- Make sure the “Duplicate stack” checkbox is selected
- Enter the range of slices you need.

#### **Export as Nrrd file**

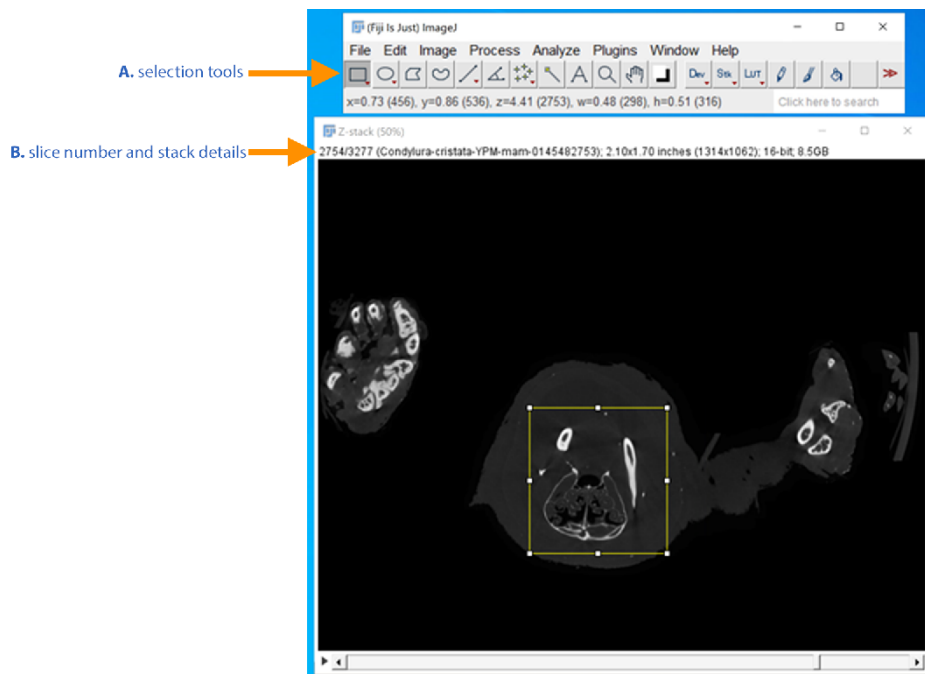
**Nrrd** ("nearly raw raster data") is a library and file format for the representation and processing of n-dimensional raster data. It is intended to support scientific visualization and image processing applications.

3D slicer functions more smoothly when you load data in this format.

#### *File – Save As – Nrrd*

- Enter file name and save in a different location than your original stack. Nrrd will save as a single file instead of a series of images and can be loaded into 3D slicer as one file, rather than a directory.

*Figure F3. Selection tools and stack details*



# Using 3D slicer to render CT data and save mesh files

Download 3D Slicer from: <https://download.slicer.org/>

## *The general idea*

Once you load in a dataset, you will switch between “modules” that each have different capabilities. Your module of choice will depend on the task you want to achieve...

Note: Slicer was created to work with medical data. Instead of “XYZ”, the coordinate system, “RAS,” is short for the human anatomical coordinate system (R: left toward Right, A: posterior toward Anterior, S: inferior toward Superior).

## Load in data

*Load data - Choose File(s) to add*

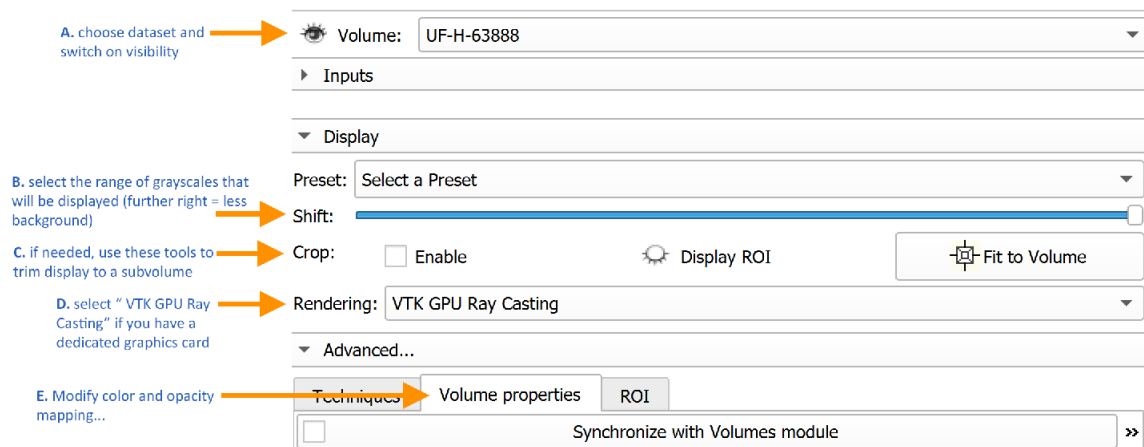
- Navigate to the location of the Nrrd file you just saved and select it. It will appear in the “File” list. It should be listed as a “Volume” under the Description column. Make sure the check box next to it is selected and click OK. Slicer may take a while to load the volume in , depending on the size of the file.
- When the file has been loaded in, you may need to change the voxel dimensions. You can do this using the “Volumes” module under “Volume Information”.
  - o “Image spacing” = voxel size.

## Render data set in 3D

*Choose “Volume Rendering” module*

- Make sure your data set is selected using the drop down box next to “Volume” (Fig. S1 A).
- Click the eye to turn the 3D view on for that volume.
- Use the “Shift” slider bar (Fig. S1 B) to select the range of greyscale values in the scan that will be displayed using Volume rendering.
  - o If you slide it further to the right you will discard some of the lower values (e.g. air and packing material).
- If your computer has a dedicated graphics card, select “VTK GPU Ray Casting” under Rendering options (Fig. S1 D).
- Click “Advanced...”

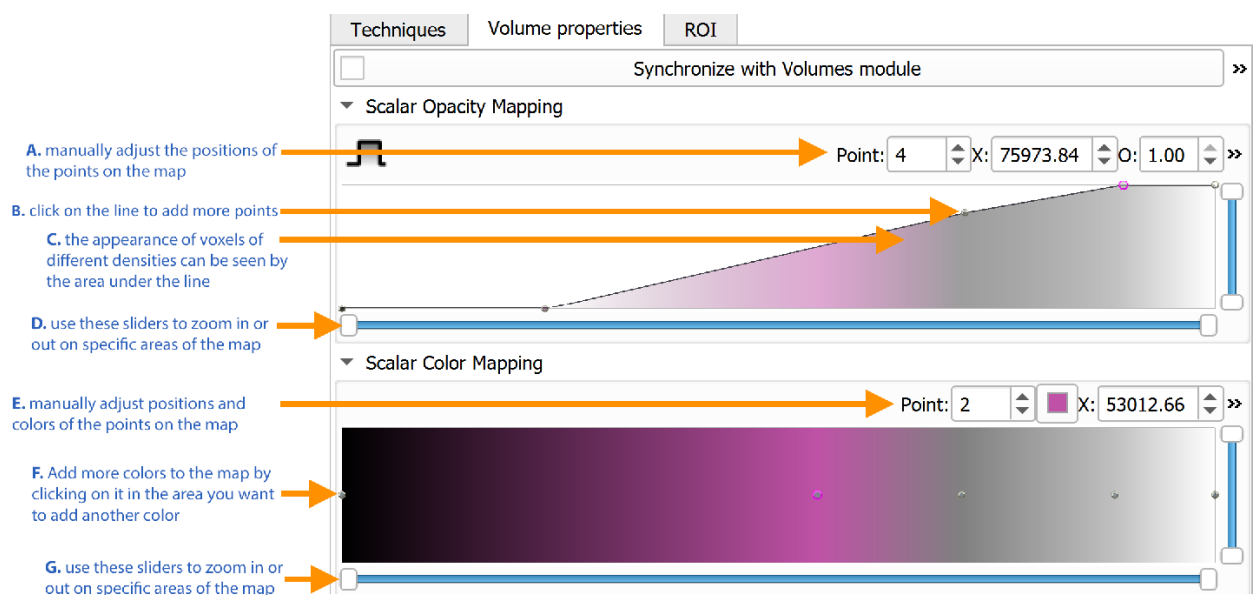
Figure S1. Screenshot from “Volume Rendering” module of volume selection controls.



Under “Volume Properties” tab...

- Use the “Scalar Opacity Mapping” change the opacity of different parts of your scan (Fig. S2 A-C). (You may need to Zoom out using the slider bars at the bottom, see Fig. S2 D)
  - o You can add points to the curve by clicking on it. You may want to add a point towards the left end of the curve and drag it down to make the soft tissue more transparent (you can also choose opacity by changing the O value at the top of the graph).
- Use the “Scalar Color Mapping” to change the colours of different parts of your scan (Fig. S2 E-F).
  - o Select one of the points and use the options at the top of the graph to change its color. You may want to select one of the points toward the left side of the graph and change its colour, to change the color of the soft tissue in the scan.

Figure S2. Screenshot from “Volume Rendering” module of scalar color and opacity mapping



Under “Techniques” tab

- To smooth out stair step artefacts select “Surface smoothing”

To render a subvolume of your scan

- Under “Display”, check the “enable box next to “Crop”, then switch on the eye for “Display ROI” (Fig. S1 C).
- You will see a white bounding box with colored spheres appear around your volume. Use the colored spheres to adjust the box around your ROI. You can click the “Fit to Volume” button to revert the cropping box back to its original dimensions

## Segmentation

Choose the “Segment Editor” module. You may want to switch your volume rendering off for this part so you can see what you’re segmenting.

**Note:** this module will run **much faster** if you use the “crop volume” module to focus on the area of interest that you would like to segment and create a new volume containing that area.

- Make sure your stack is selected under the drop down menu next to “Master Volume”
- Click the “add” button to add a material into the segmentation list.
- To threshold out the entire skeleton
  - o Scroll down to “effects” and click “Threshold”. You will see selected parts of your volume highlighted in green in the X Y and Z planes.
  - o Use the “Threshold Range” slider bars or the value boxes to adjust the threshold until you have only the dense material selected. Click Apply
  - o Scroll up and, with “segment 1” selected, click the “show 3D” button. The material you just thresholded will appear in the 3D viewer.
- [https://slicer.readthedocs.io/en/latest/user\\_guide/modules/segmenteditor.html](https://slicer.readthedocs.io/en/latest/user_guide/modules/segmenteditor.html)
- For faster segmentation, work with the “show 3D” switched off.

### Exporting a mesh file

*Choose the “Segmentations” module*

- Go to the “Export/import models and labelmaps” menu.
- Choose operation → “Export”, and output type → “Models”.
- Click “Export” and save the file as either an OBJ, PLY, or STL file (whichever suits your needs).

### Taking measurements

*Choose the “Markups” module*

- Make sure the entire structure is visible in the 3D viewer before attempting to measure it.
- Click the “create line markup” button (Fig. S3 A).
- In the 3D viewer, click the two end points that you want to measure between.
- If you can’t get the entire structure in the 3D viewer at once, place the points and then click and drag them into position afterwards.
- See your measurement in the list of nodes (Fig. S3 B).

### Adding landmarks

For more detailed instructions on landmarking, see tutorial by the SlicerMorph team here:

[https://github.com/SlicerMorph/S\\_2020/blob/master/Day\\_2/Markups/Markups.md](https://github.com/SlicerMorph/S_2020/blob/master/Day_2/Markups/Markups.md)

*Choose the “Markups” module*

- Choose the “create fiducial markup” button (Fig. S3 A).
- Click on points of interest in the 3D viewer.
  - o Use the controls in the main toolbar to place landmarks under the same fiducial markup (Fig. S3 E). Scroll down to the “control points” list to see the landmark coordinates listed under that markup (Fig. S3 D).
- To export landmarks, right click on the fiducial markups object in the list of nodes and select the file format you want to export them as an **fcsv** or **json** file.

Figure S3. Screenshot from "Markups" module showing controls used to take measurements and place landmarks.

**A.** buttons to create new markup nodes

**B.** "line markup" node for body length

**C.** "fiducial markup" mode for a set of landmarks

**D.** list of control points for a set of landmarks. View coordinates and add descriptions.

**E.** Controls in the main toolbar to place landmarks (when node is selected) and rotate specimen

The screenshot displays the Markups module interface. At the top, a 'Create:' toolbar contains several icons for creating different types of markup nodes. Below this is a table of existing nodes:

Node	Description
Body length	length: 100.3mm
Femur landmarks	
Humerus landmarks	

Below the node list is a 'Control Points' section with various interaction options and a table of control points:

	Name	Description	R	A	S
1	F1	Medial end of femur	-10.215	-36.457	97.372
2	F2	Lateral end of femur	-23.028	-9.127	77.188

At the bottom, a 3D model of a specimen is shown with landmarks F1 and F2 placed on the femur. A line markup is drawn across the body, labeled 'Body length: 100.3mm'. The main toolbar at the top of the 3D view is highlighted with an orange box, showing icons for placing landmarks and rotating the specimen.