



VGSTUDIO MAX CHEAT SHEET

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Part 1: Loading datasets

Project files

For most datasets on the DIL drive at FLMNH, VGL project files have already been generated as part of the reconstruction process immediately after scanning. These files appear as "VGSTUDIO MAX/VGSTUDIO project file". They can be opened directly in VGStudio without needing to import the datasets, and will reference "VOL" files or TIFF stacks stored in the same location. To open them, open VGStudio and then:

- *File* → *Open* → Navigate to file location on *FLMNH\NaturalHistory\DIL*
- Select VGSTUDIO MAX/VGSTUDIO project file and *open*.

However: if the .vgl file has **not been opened before** (i.e. if the preview icon is blank/shows no image), it is a good idea to import and calibrate the histogram. To do this:

- *File* → *Import* → *.VGL*
- Navigate to the folder with the .vgl file and select it (Voxel sizes should be automatically ingested).
- Click next, then follow the instructions to calibrate the histogram and crop the scan below.

TIFF stacks

In some cases, you may need to import a dataset with no VGSTUDIO project file (e.g. if you've downloaded a TIFF stack from MorphoSource). To import an image stack, open VGStudio and then:

- *File* → *Import* → *Image Stack...*
- Make sure *File type* is set to *TIFF images*, then select either
 - *Files* - and then navigate to folder location and select all the images in your stack OR
 - *Directory* - and then navigate to folder location and specify the file location containing all of the images in your stack.
- Click *Next*.

To specify the voxel size:

- Open the **metadata file** (e.g. **.pca**, **.log**) that accompanies the scan. These files can be opened in Notepad.
- Once opened, check the number for *VoxelSizeX* and *VoxelSizeY*. Copy this number and paste it into the window you have open in VGStudio under *Resolution*, this number should be the same for *X*, *Y* and *Z*. The *units* are usually in millimeters.
- If you have downloaded the dataset from Morphosource, the voxel resolution can be found under file object details: X pixel spacing. In some rare cases, the Z pixel spacing will be a different value to the X and Y pixels, so be sure to check this.

To calibrate the histogram:

- Click *Histogram*, a window will open up with two tabs, *Histogram* and *Calibration*. Select the *Calibration* tab and maximize the window to make it easier to see.
- At the bottom you will see options to map the grayscale values for the *background* and *material*. For a standard skeletal CT scan, you can leave the *background* value at 10,000 and the *material* value at 50,000. For DiceCT scans, you may need to change the *material* value.
- Click *Define background* and draw a small box (click and drag) in an area containing background (e.g. air). Click *Apply*.
- Click the “Define material” button and draw a small box (click and drag) in an area containing the brightest material you are interested in visualizing (e.g. bone/ enamel). Click *Apply*.
- *Hide* this window.

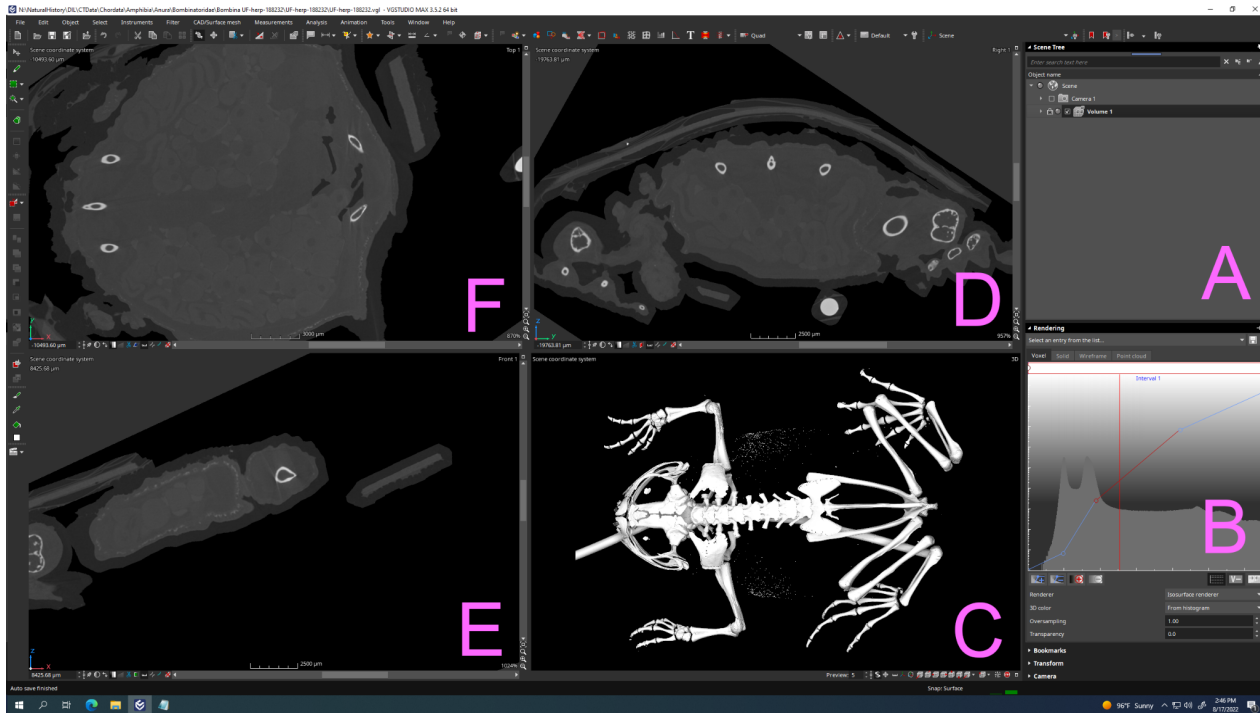
To crop the scan:

- Click *Preview*, a window will open with four tabs, one with a *Preview* slice, and three tabs each for *Top*, *Right*, and *Front* projections.
- Switch between the *Top*, *Right*, and *Front* projections and adjust the bounds of the blue box to crop off the edges or specify a subset of the stack that you would like to work on.
- *Hide* this window.

Click *Finish* to import the image stack.

Part 2: Navigating and rendering datasets

When your scan opens in VGStudio, it will look something like this:



A) **Scene tree:** this is where your objects will appear. Your scan will appear as a *volume*, and *regions of interest*, *clipping planes*, *measurements*, and anything else you create from now on will appear as objects in this window. Use the *scene tree* window to switch between objects while you're editing them. You can also right click on an object to bring up editing options. The Camera function is also listed as an object here and can be used to change the lighting in the 3D viewer window.

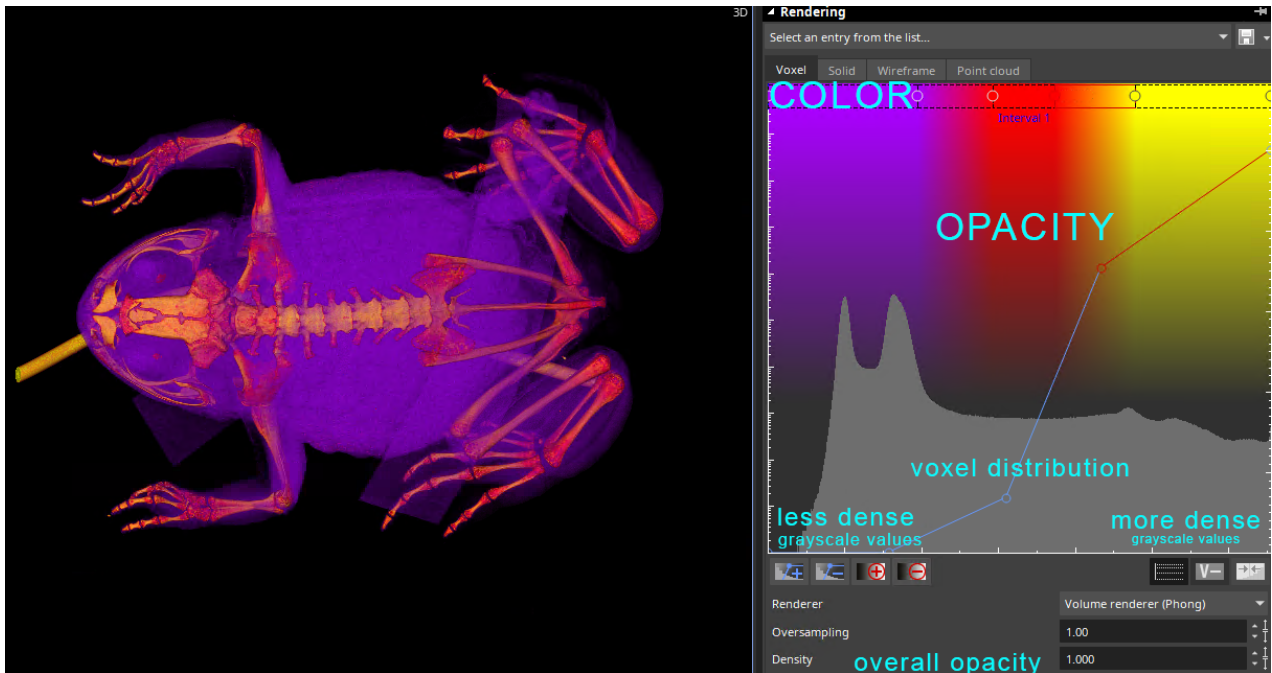
N.B. unlocking the padlock icon next to the objects will removed the lock on the orientation, meaning you can move and reorient the volume/regions of interest on the fly. This is can lead to some problems and its recommended you keep these icons locked and use the registration tools to reorient your data (See section 3).

B) **Rendering:** this is where you control how your objects are rendered in the 3D window (C) and slice windows (D–F). You will see your *histogram* here, which shows you how the grayscale values are distributed for your chosen object.

A few things to remember here:

- You can switch between *renderers* by clicking the dropdown box next to *Renderer*.
- By default, VGStudio will choose the *isosurface renderer*, this is the simplest way to visualize surfaces. You can use this renderer to visualize surfaces based on a single grayscale value threshold, set by moving the *red line* (click and drag) on top of the *histogram* to your chosen grayscale value.
- Other *renderers* commonly used in the lab include *Volume renderer (Phong)* and *X-ray*. While the isosurface renderer is useful for basic editing processes, the *Volume* and *X ray renderers* are

better for creating eye-popping visualizations and a better option for creating figures for publications.











- For both the *Volume* and *X-ray renderers*, you can control the *color* (bar above the histogram) AND *opacity* (values on top of the histogram) of the voxels in your chosen object based on their grayscale value (density)
 - To control *color*, use the *color bar* above the histogram.
 - To add *color handles* - right click on the *color bar* in the location you would like to add a handle and choose “add color handle” (SHORTCUT = click the middle mouse button).
 - To remove *color handles* - right click on the *color bar* in the location you would like to add a handle and choose “remove color handle” (SHORTCUT = click the middle mouse button).
 - To choose *colors* - double click on either a *color handle* (to assign color to a single point), OR the space between two color handles (to color an entire section of the color bar). A *Select color* window will appear that will let you choose a color.
 - To control *opacity*, use the blue line on top of the histogram, it’s called the *opacity curve*.
 - To add *opacity handles* - right click on the *opacity curve* in the location you would like to add a handle and choose *add opacity handle* (SHORTCUT = click the middle mouse button).
 - To remove *opacity handles* - right click on the *opacity curve* in the location you would like to add a handle and choose *remove opacity handle* (SHORTCUT = click the middle mouse button).
 - To control *opacity* - click and drag the *opacity handle* up (to increase opacity), or down (to decrease opacity). You can also drag *opacity handles* left (to assign opacity to less dense voxels) or right (to assign opacity to more dense voxels).

Additional preset renders can be found on the DIL drive

I encourage you to play around with the renderers to achieve the effects you want for your dataset, there is no right or wrong way to do it. Have fun!

C) **3D viewer window**: the 3D rendering of your dataset and other objects in your scene tree will appear here. To turn the visibility on/off for your objects, use the checkboxes next to each object in the scene tree. There are some controls at the bottom right hand side of the window:



-  **Rotate***
 - left click and drag = freely rotate
 - Middle mouse click and drag = rotate in a single plane parallel to the screen
-  **Move***
 - Left click and drag = move object around without rotating (AKA panning)
 - Middle mouse click and drag = zoom in/out
-  **Show scale bar**
 - Toggles the scale bar on/off. This only works if the camera is set to the “Parallel” projection mode. You can change this using the Camera window on the right side of the screen, under the rendering window.
-  **Show tripod**
 - Toggles the tripod on/off. The tripod appears in the bottom left corner and shows where your x, y, and z axes are in your current view.
-  **Show box**
 - Adds a bounding box around your object, including scale.
-  buttons to snap to standard viewing angles
 - In the order they appear = front, back, left, right, top, bottom, front.
-  **Center and focus camera**
 - Brings your visible object to the center of the 3D viewer (handy for when you accidentally pan too far away from your objects!).
-  **Toggle fullscreen state**
 - Makes the 3D viewer window full screen. Each of the slice windows has one of these buttons too, so you can bring any of the viewers into fullscreen state if you need to save images.

* To quickly switch between the rotate and move functions, double-click the middle mouse button.

D) X axis slices

E) Y axis slices

F) Z axis slices


- All of the slice windows have the same controls, you are just moving through your 3D volume in different directions depending on your selected window. To scroll through your slices, select your chosen window and click and drag the  button up/down. You can also use the scroll wheel on the middle mouse button.
- As you scroll through the tomograms, the slice position will show up on the 3D Viewer window as a red, blue or green polygon. You can also click and drag these polygons to quickly navigate through your slices.
- To adjust the brightness/contrast of your slice windows, click the  button. This will bring up a window with controls.

Save images by selecting File → Save image(s) and using the options provided.


Part 3: Registration

The specimens you will be working with are often scanned at awkward angles. Luckily it is easy to reorient the X, Y and Z axes to view your object in the traditional sagittal, transverse and coronal planes. This makes it much easier to navigate and segment structures.

Simple registration

- Select the Simple registration button  in the top bar (or object → register object → simple registration).
- Use the colored axes to rotate the X,Y and Z windows to align the views to your preferred orientation.
- Click and drag on the central square to move the center of rotation to make it easier to modify and click finish when done.
- If the view reverts back to the original orientation, switch the view bar in the right-hand side of the top bar from *volume 1* to *scene*.

Simple 3-2-1 registration


- Select the Simple 3-2-1 registration button  in the top bar (or object → register object → 3-2-1 simple registration).
- Ctrl + click on three points in the 3D viewer window to set the xy plane, then Ctrl + click on 2 points along the central line of your sample to create ZY orientation, then Ctrl + click once in the center of your area of interest to center your object.
- If the view reverts back to the original orientation, switch the view bar in the right-hand side of the top bar from *volume 1* to *scene*.

N.B. re-registering your volume will mean your voxels will no longer appear square in the X,Y and Z windows (this is really only noticeable if you turn off the *interpolation mode* by right clicking on the X,Y or Z window, select *interpolation mode*→*off*).

Part 4: Segmentation

To create figures or 3D meshes for further processing, often we need to segment certain subsets of voxels, representing specific structures from our scans, these are called *regions of interest* (ROIs). VGStudio has many useful tools for creating ROIs.

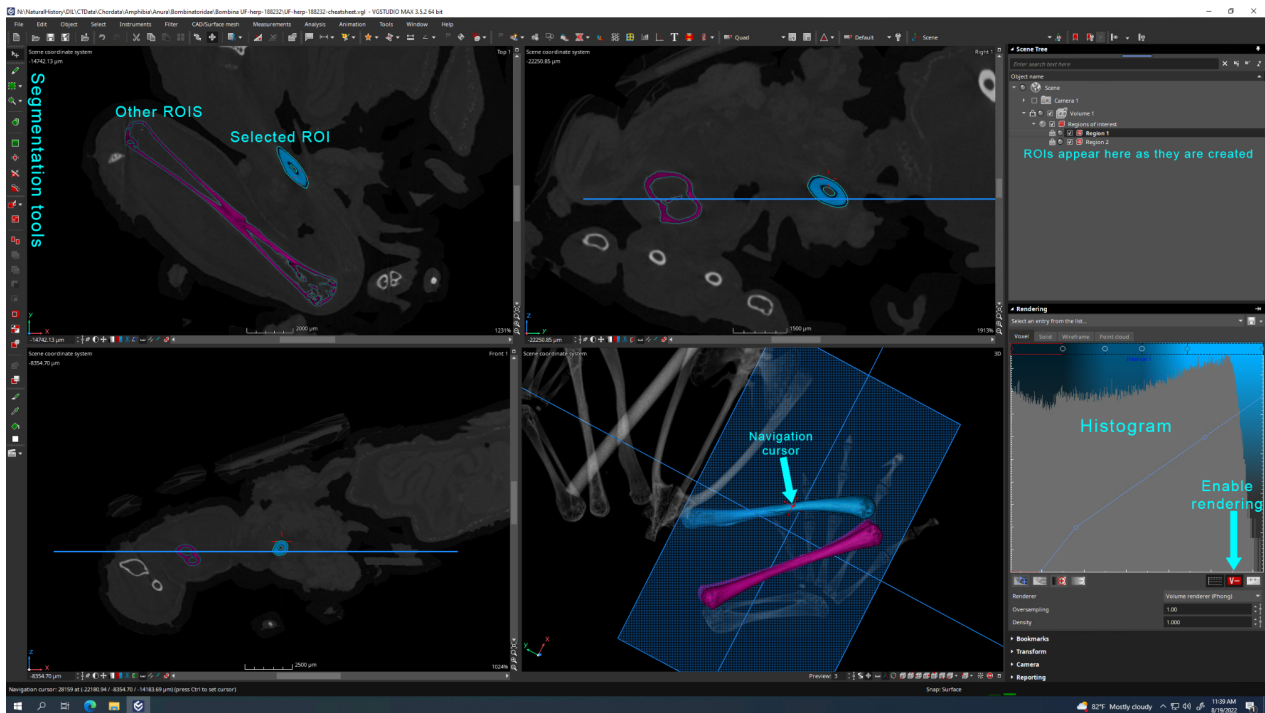
Working with ROIs

- It is useful to first **make your volume invisible** by selecting it in the *scene tree* window, and then changing the *density* to zero (for *phong volume* or *X ray* renderers) or the *transparency* to 100% (for *isosurface* renderer).
- If you still want to see your whole volume while you segment ROIs, you can also **make the opacity very low** (i.e. density of 0.01 or transparency of 95%). This will allow you to see a transparent version of your volume as you segment, though this will increase the render time.
- Once you start segmenting, the ROIs you create will appear in the scene tree, as a list nested under their associated volume.
- To rename your ROIs, slow double click on them in the *Scene tree* and change the *Object name*.
- When they are first created, the rendering for ROIs will be disabled. You will need to change this before you can see them:
 - Once you have created an ROI, make sure it's selected in the scene tree window, and then **click the  button** to enable ROI settings.
 - Your ROI will automatically inherit the rendering settings from its associated volume, so it will be transparent. Change this so the *density* = 1 (for *volume renders*) or *transparency* = 0 (for *isosurface renders*). Your ROI will then appear in the 3D viewer.
- You can independently control the rendering of each ROI as outlined previously by selecting one in the scene tree and using the rendering window. It's important to note however, that you can't change the TYPE of renderer to be different from its associated volume, e.g. if the volume is rendered using the *Volume renderer (Phong)*, then its ROIs can only use that type of renderer and not the *X-ray* or *Isosurface* renderers.
- In the slice windows, selected ROIs will be outlined in bright blue, while other visible ROIs will be outlined in a darker blue. When using the segmentation tools, a preview of what you have selected will be outlined in yellow.
- You can change the display mode in the slice windows by right clicking on one of the slices and then hovering over "Display mode". This gives you options to see the ROI color, opacity, or both, as specified in the rendering window.
- When editing using the segmentation/editing tools, you will often see these buttons:







In the order that they appear:

- Create new ROI (shortcut = ALT + SHIFT + N)
- Replace selected ROI (shortcut = ALT + SHIFT + R)
- Add to selected ROI (shortcut = ALT + SHIFT + A)
- Subtract from selected ROI (shortcut = ALT + SHIFT + S)

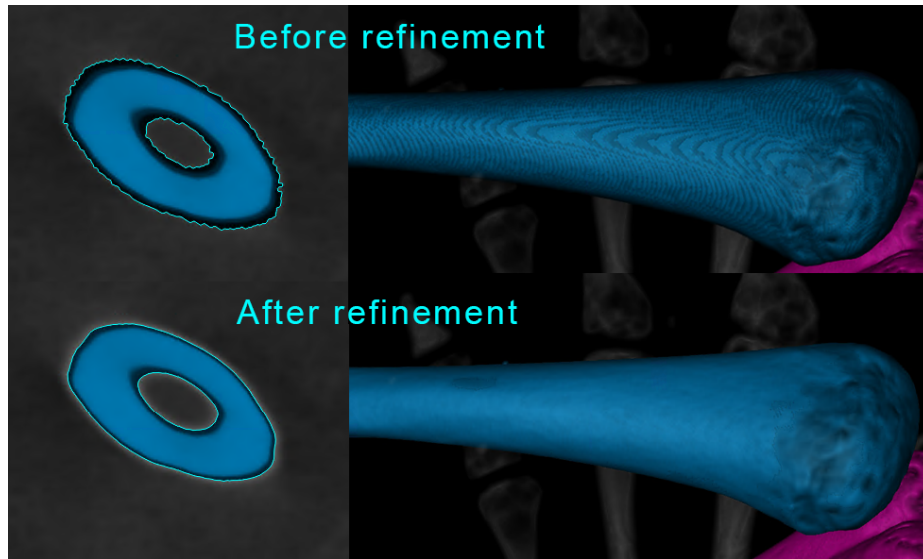




Commonly used segmentation tools

-  **Navigation cursor**
 - When active, hold down CTRL and click anywhere, in one of the slice windows OR in the 3D viewer, and VGStudio will navigate to the location in all of the other windows. You can also click and drag it to move it around.
 - **USEFUL TIP** = when the cursor has been placed, information about that location will be displayed in the bottom left corner of the screen, including grayscale value and coordinates.
-  **Draw**
 - Use this to “paint” your regions of interest in the slice windows. As you draw, material will be added to your selected ROI.
 - Set a *gray value interval* for your brush by checking the “Gray value interval” box, and then typing in values for your chosen interval.
 - **USEFUL TIP** = use the navigation cursor to identify gray values for your desired ROI. You can continue to adjust the *gray value interval* as you work.
 - You can paint in a sphere shape (i.e. multiple slices at once) or you can also paint in a disc shape (i.e. only several slices at once) by checking the “2D disc mode” box.
 - Use the draw window to control the *radius* or your ball/disc, or the *thickness* (disc mode only).
 - The smoothing value allows you to segment below the voxel level. This can be adjusted in the tool window or by holding alt and using the scroll wheel.
 - To create a new ROI using the draw tool, select the Volume in the scene tree and begin segmenting.

-  **Region growing**
 - Selects material based on a tolerance value. The *region growing* tool takes the grayscale value of the voxel you click on and grows the selection outwards, until it hits a boundary that is greater than your specified tolerance value. This tool can be useful for quickly segmenting isolated bones.
 - To use this tool, **single left click on an area**, it will grow outwards indeterminately until it finds a boundary. OR
 - **Click and drag outwards**. This will define a smaller area for the region growing tool to cover, it will stop when it reaches your dragging distance.
 - Play around with using narrow tolerance windows (smaller gray value intervals) or wide tolerance windows (larger gray value intervals).
-  **Polyline 3D**
 - Lets you select material in a polygon using the 3D viewer window. Since you can't set a threshold for this tool, it is only really useful for cropping away pieces you don't want. With the tool active, hold down CTRL and click in the 3D viewer to create the points of a polygon. Selected material will be highlighted in yellow. Use the buttons to this material from your ROI.
 - USEFUL TIP = you can use this tool to easily split apart two objects in one ROI. Simply duplicate your ROI - right click on it in the scene tree and select "copy", and then right clicking again and select "paste" to create a duplicate. Then use the polygon tool to crop away the piece you don't want for each ROI.
-  **Erode/Dilate and Opening/Closing**
 - Change between *Erode/Dilate* and *Opening/Closing* modes using the dropdown box.
 - *Erode/Dilate* expands (positive values) or shrinks (negative values) your ROI. Use the arrows to control the radius (in voxels) of erosion/dilation. (you can only dilate or erode by 9 voxels at a time)
 - *Opening/Closing* closes holes (positive values) or opens holes (negative values) in your ROI. Use the arrows to control the radius (in voxels) of opening/closing. (you can only open or close by 9 voxels at a time)
-  **Refinement**
 - Adjust the borders of the selected ROI using local gray value gradients within the search distance if the gradient is higher than the threshold. This refines the edge of your ROI at a subvoxel level, which is useful for making objects look more realistic after they have

been segmented, removes stair step artifact:



- Adjust the *search distance* to specify the area around the ROI border to be considered for refinement.
- Adjust the *threshold* for the gray value gradient. If the gray value gradient is above this threshold, the ROI border will be adjusted.
-  **Smoothing**
 - Smooths the border of the selected ROI.
 - Specify the smoothing level. The higher the value, the smoother the ROI border.
 - This can also be used to remove isolated single voxels.
-  **Split ROI**
 - Splits the ROI into its disjoint components and creates a new ROI for each of the components.
 - Use the *Minimum volume* box to specify the minimum size (in voxels) of ROI components to be created. You will see the number of components to be created written below. Higher values = fewer components created. Click *OK* when ready.
 - This tool is useful for quickly cleaning up an ROI and getting rid of small floating pieces.
- You can also use the *Rendering* window to quickly create an ROI containing an entire gray value interval. This is useful for segmenting entire skeletons/bodies quickly. To do this:
 - Select your volume in the *scene tree*.
 - Right click on the *histogram* where you would like the interval to begin, and select “split interval”.
 - A *blue line* will appear on your histogram. You can adjust the position of this line by dragging it left/right.
 - Right click on the *histogram*, to the right of the line you just created, select “Create ROI from gray value interval”.
 - Your new ROI will appear in the *scene tree*. Edit as needed.

Part 5: creating and saving meshes

You can use your finished ROIs to create meshes for 3D models or further analyses. There are two major steps for exporting a finished mesh:

Surface refinement

- Once you've finished editing your ROI, right click on it in the *Scene tree* and select *Surface determination*.
- For *approach*, select *Advanced (classic)* for a single ROI, or *Advanced (multi-material)*, for multiple ROIs
- **For Advanced (classic)**
 - *Starting contour = from volume/CAD/mesh/ROI*. Use the drop-down box beneath to select your preferred ROI.
 - Similarly to the *Refinement* tool, you can use the options at the bottom of the window to adjust the *search distance* for creating a surface. You will see a preview of your surface outlined in yellow in the slice windows.
 - USEFUL TIP = if you have already refined the surface of your ROI during the segmentation process, you can use *search distance = 0* and *edge threshold = 1* to use the pre-existing edges of your ROI.
- **For Advanced (multi-material)**
 - Enter the *Number of materials* you want to create
 - *Starting contour = from volume/CAD/mesh/ROI*.
 - Use the drop-down boxes beneath to select your preferred ROIs.
 - Similarly to the *Refinement* tool, you can use the options at the bottom of the window to adjust the *search distance* for creating surfaces. You will see a preview of your surfaces outlined in yellow in the slice windows.
- Once you hit *Finish*, VGStudio will generate your surfaces. This can take a minute or so, be patient!
- If you are not using the *Isosurface renderer*, VGStudio will ask if you want to switch over to the *Isosurface renderer* for the 3D view. You can ignore this and select *No*.
- Once your surfaces have been created, they will appear in your slice windows as a white line.
 - You can toggle this on/off using the button at the bottom of the slice windows.
 - You can also remove the *Surface determination* by right clicking on the ROI in the *Scene tree* and selecting *Remove surface determination*.

Mesh generation

Once your ROI has a surface defined, you can convert it to a mesh:

- Right click on the ROI and select Convert to → *Surface mesh...*
- Make sure *Source* = preferred ROI
- Select an entry from the *Preset selection* list. I usually use *Ray based normal* or *precise*.
- You can further refine settings for your mesh below.
- For complex structures, I recommend you check the *Simplification* box and set a *Maximum number of triangles* appropriate for your project (e.g. usually around 2 million for a Sketchfab model)



- You can also *Colorize* your mesh. If you select this option, VGStudio will use the *rendering* window to assign colors to the points that make up your mesh. **If you want your mesh file to store color information, you will need to save it in PLY format.**
- To add your mesh as an object in your VGStudio *Scene tree*, check *Place in Scene*.
- To export your mesh for further editing/analyses and to use in other programs, check *Export*, and navigate to the file location you would like to save your mesh. Enter a name, and use the drop down box to choose your file format. For most things, you will need either PLY, STL, or OBJ format.
- Once you click *Save*, you can click *OK* (if storing color info make sure you check the box for *Vertex colors*).
- Once you hit *OK*, VGStudio will generate your mesh. This can take a minute or so, be patient!

Part 6: Capturing images

Once you have processed your dataset to a standard that you want to present, you can save the 3D viewer window, and/or the X,Y,Z slice view as an image or as a video.

Set the view to the orientation and settings you would like to capture:

If you would like to add a scale bar to the 3D window:

- Make sure you have the parallel projection mode selected in the camera tool window (if this does not appear on the right side of the screen, view it by selecting *tools*→*camera* in top bar).
- Select the  below the 3D window to toggle the scalebar on or off, or right click on the 3D viewer window then select *scale bar* → *show scale bar*.
- Change the relative size and other features of the scale bar by right clicking on the 3D window, then select *scale bar* → *configure scale bar*.
- You can change the units by clicking on the  button on the right side of the top bar and selecting your preferred unit in the length section.

You can toggle the tripod on/off by right clicking on the 3D window, then selecting *tripod/box*→ *show tripod*, and remove the 3D window text by right clicking on the 3D window, then deselecting *text overlay*→ *default*

If you would like to change the background color



- Right click on the 3D viewer window select *Background color*, then select your preferred setting (Flat/ vertical gradient/ Horizontal gradient/ Radial gradient) and then pick your colors.

Adding shadows to the lighting settings can give the 3D render additional depth, and also implements the ambient occlusion settings for the volumetric phong rendering, which greatly improves the texture renders

- In the Scene tree, open the camera drop-downs to expose the 2 light sources.

- Select each light source and check the enable shadow box. You may need to increase the overall intensity to maintain the image brightness- we suggest an intensity of 100 if you are adding shadows to both light sources.
- This will greatly increase the rendering time, so make sure you only do this immediately prior to saving the images

Save image

- Maximize the window you wish to save by clicking on the  button in the bottom right side of the 3D viewer window. The resolution of the final image is dictated by the size of the window, so if you do not maximize the window, the saved picture will be pixelated.
- Select *File*→*save image(s)*
- In the following window, choose the image resolution size and DPI, then hit save and select your preferred location and file format.
- If you want to save a tomogram, simply navigate to the slice position you need, then maximize the window by clicking on the  button in the bottom right side of the window. Again, select *File*→*save image(s)*, choose the image resolution size and DPI. If you would like to show the relative slice position in the 3D view, check the *slice position indicator* box and adjust the position and relative size. N.B. the 3D inset will appear as it does in the 3D viewer window, so make sure you have oriented it before setting up the tomogram image.