Standard Operating Procedure: SOFIA (Size of Oxidation Feature from Image Analysis)

Requirements:

python3 code editor (64bit of your OS, if applicable):
https://www.anaconda.com/products/individual

Tesseract (64bit Windows, if applicable): https://github.com/UB-Mannheim/tesseract/wiki

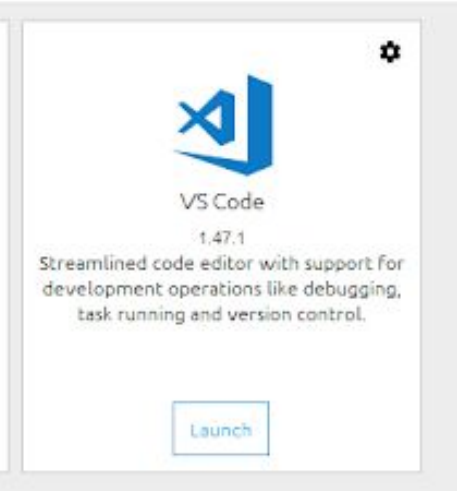
Tesseact (Non-Windows): https://github.com/tesseract-ocr/tessdoc/blob/master/Home.md

ImageJ: https://imagej.nih.gov/ij/download.html

Setting up Python

Run the anaconda installer

1. Run the installer and keep pressing Next or Agree until you can install
2. Run Anaconda Navigator
3. In the Anaconda Navigator menu install VS Code



4. Launch VS Code
5. Install the following one at a time by copying the line and pasting it in the terminal at the bottom of the screen

pip install imutils

pip install pytesseract

pip install opencv-python

pip install pathlib

pip install shapely

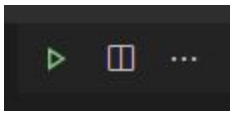
6. After installing the modules, restart VS Code

Setting up Tesseract

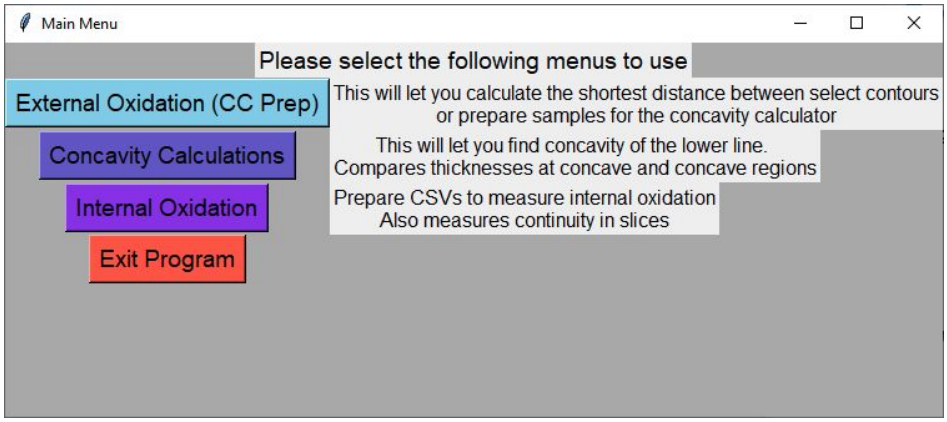
1. Run the Tesseract installer and press Next or Agree until the installation is finished
    - Make sure that it is installing to C:\Program Files\Tesseract-OC

Using the Program (External)

1. Open SOFIA.py in VS Code. You should see code
2. Press the green triangle in the top right corner to run the script



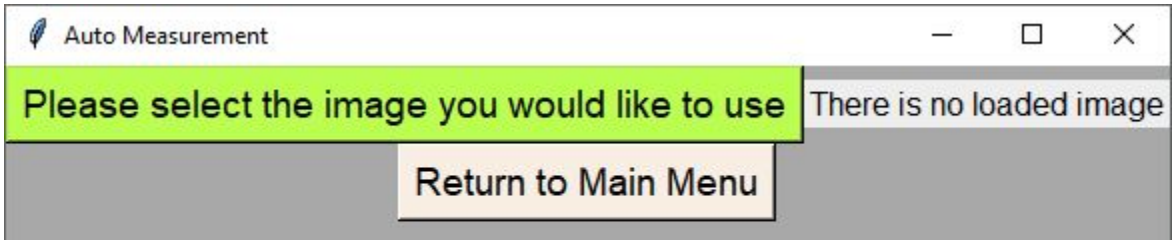
3. When you open the script you should see the following menu. If you get any errors make sure you have the required modules installed



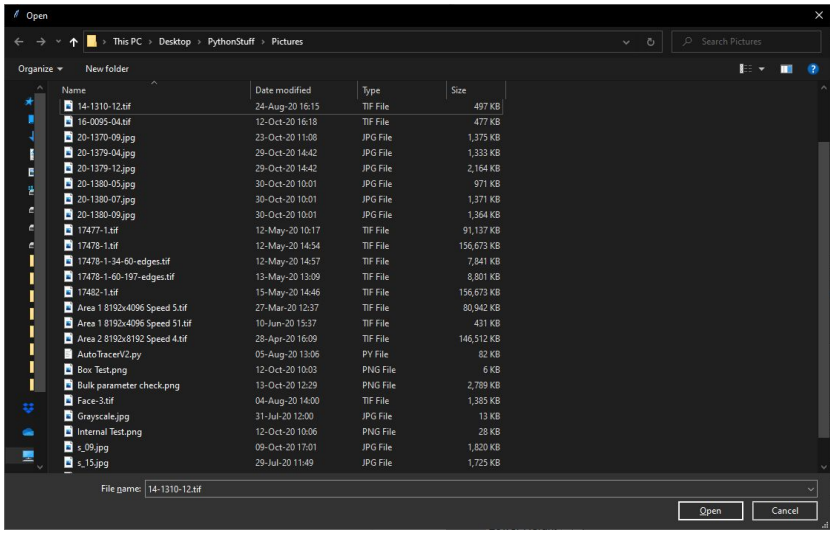
4. External Oxidation is intended for external oxidation and Internal Oxidation is designed for internal oxidation measurements. Concavity is a special module to be used after External Oxidation that is designed to be used with sinusoidal-like scales. In this section

of the guide, we will be following External Oxidation. Start by clicking the labeled button.

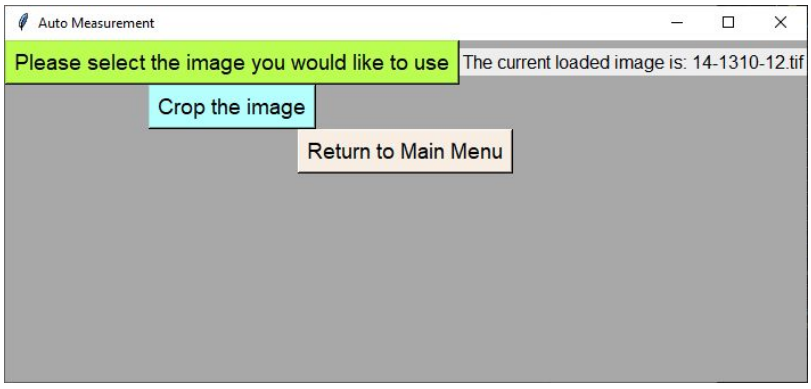
5. Click the green button to select an image to use



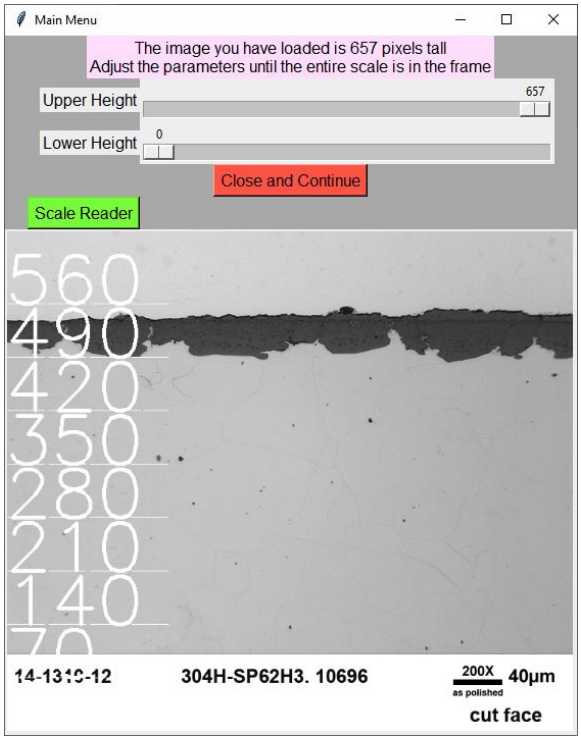
6. This will open a file explorer menu where you can select an image you would like to use.



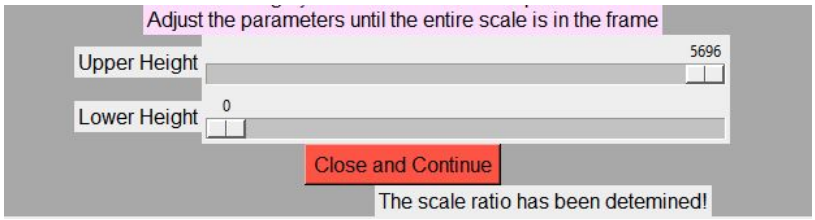
7. The menu will update showing a new option to crop the image and the image you selected will be listed next to the image selection button.



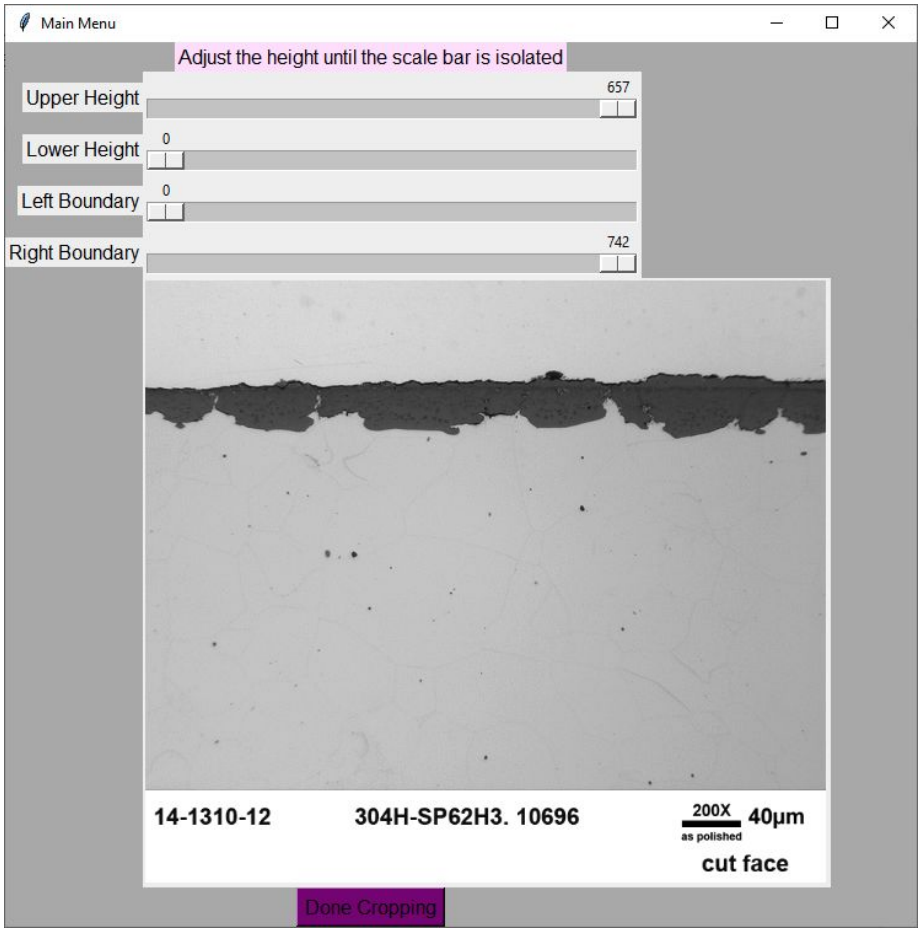
8. Selecting the crop the image button will open up a new menu where you can set the cropping parameters.

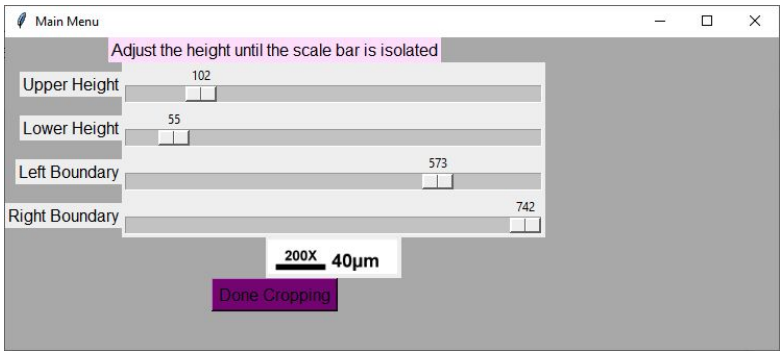


9. This menu will display the image and will give you sliders to adjust the upper and lower heights to isolate the oxidation.
10. Some images will automatically read the scale bar. If this is the case, when you open the crop menu it will display the message “The scale ratio has been determined!” you can skip to step number 16. If the scale was not automatically read, as seen in the image above, there will be a button labeled “Scale Reader” that will help you set the scale.

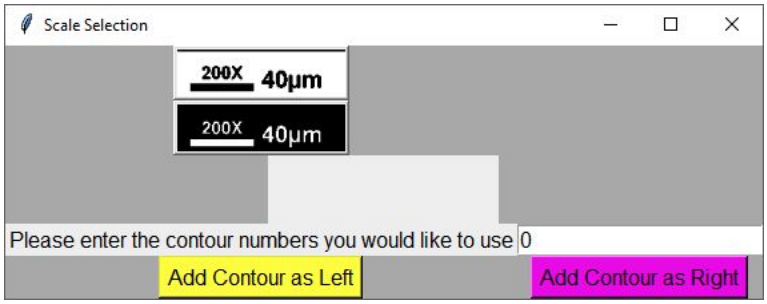


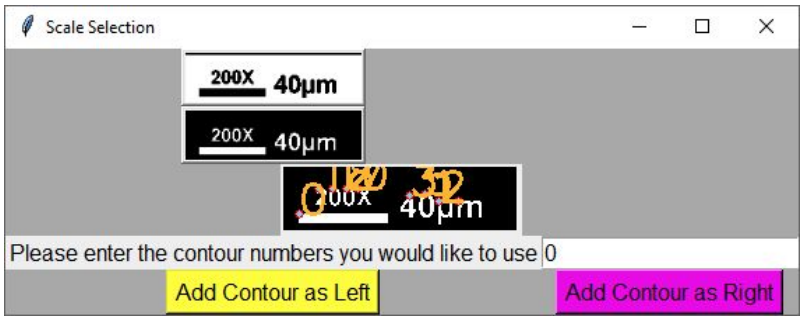
11. Selecting Scale Reader will open a menu very similar to the cropping menu. This contains additional sliders that you should adjust to just show the scale bar.



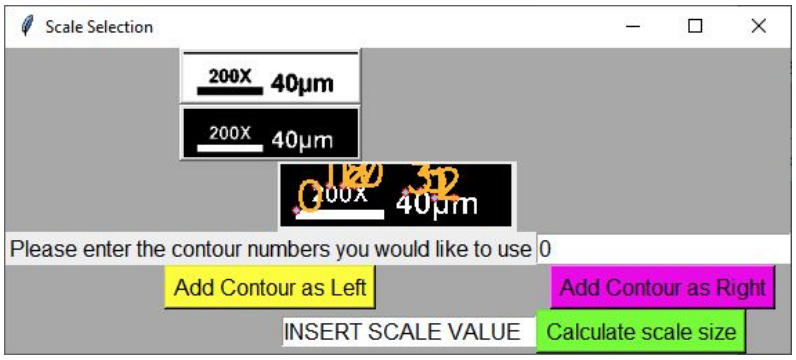


12. When you indicate that you are done cropping another menu will open where you will select which contrast profile has the scale bar in white.

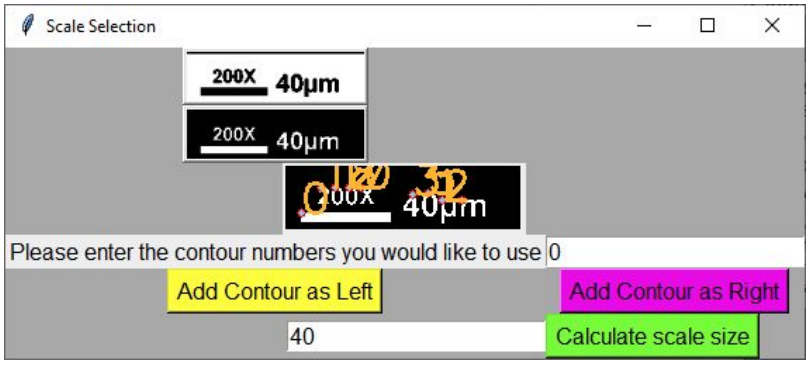


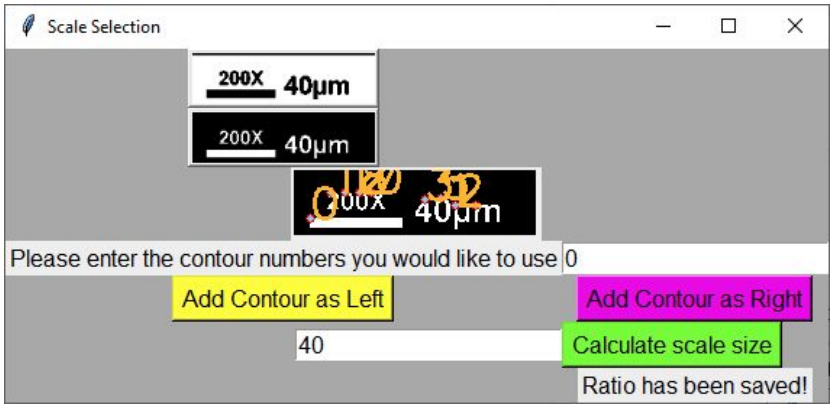


13. When you select a profile the image in the center will show numbers. The numbers indicate the contours and are just used for user reference. You can click on the image near the red and teal dots to select contours. For this scale, we can mark the left and right boundaries of the scale with the same contour. These images show a continuous scale, which is labeled 0, sometimes there will be tick marked scales. For the tick mark scales, indicate the leftmost and rightmost borders by selecting the contours and the respective boundary button.

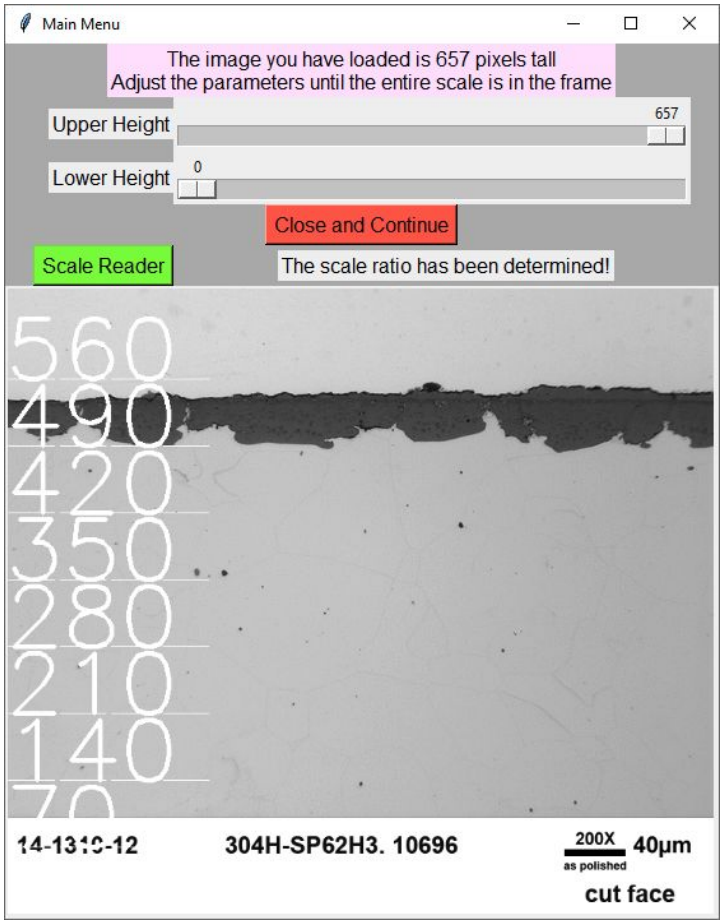


14. After you mark both boundaries an entry box will appear next to the “Calculate Scale Size” button. Replace the text with the size of the scale (in this case it is 40) and press the button.

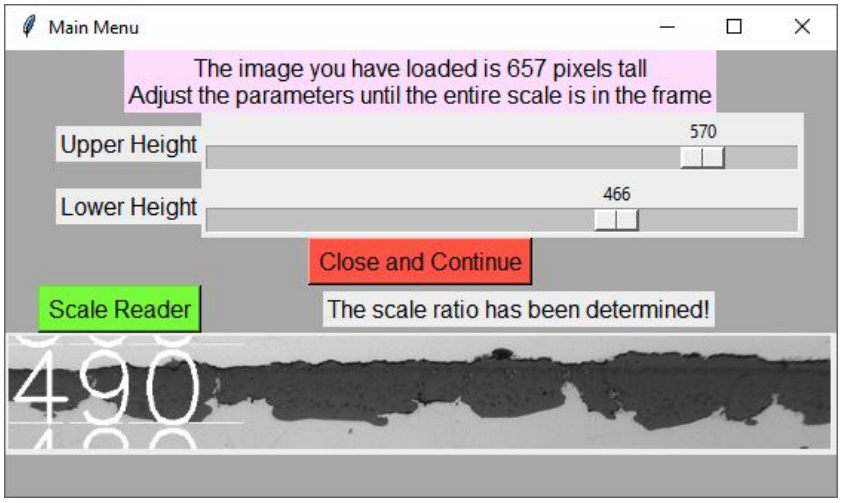




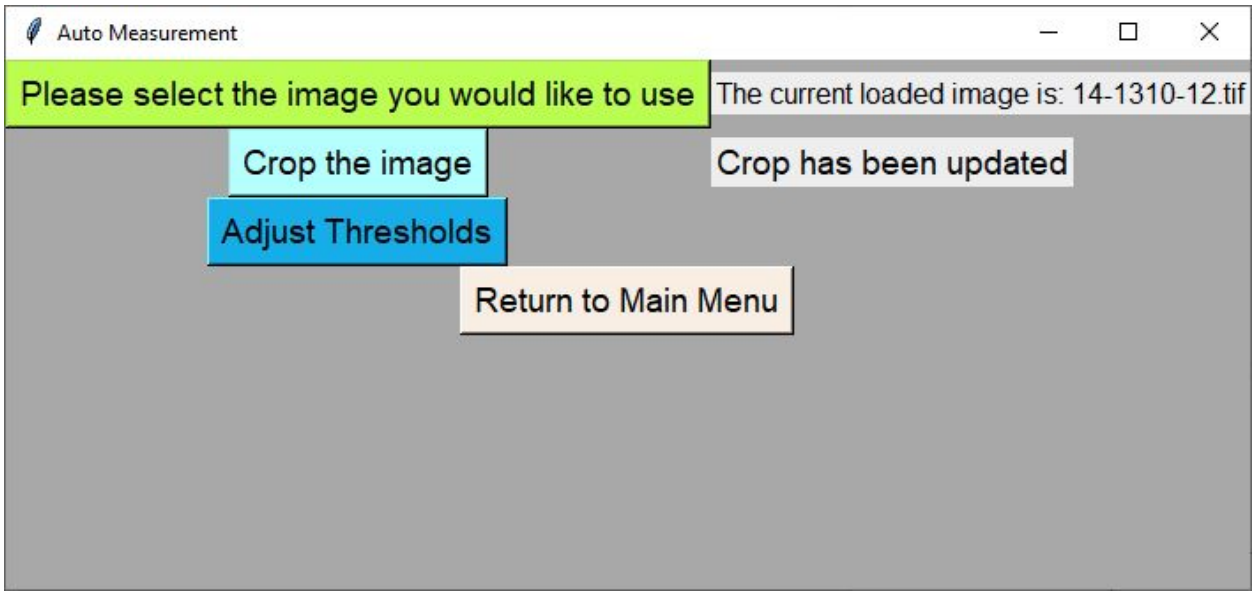
15. Exit out of the two menus that opened for the scale bar and return to the crop menu. On the crop menu, you will see that “The scale has been determined.”



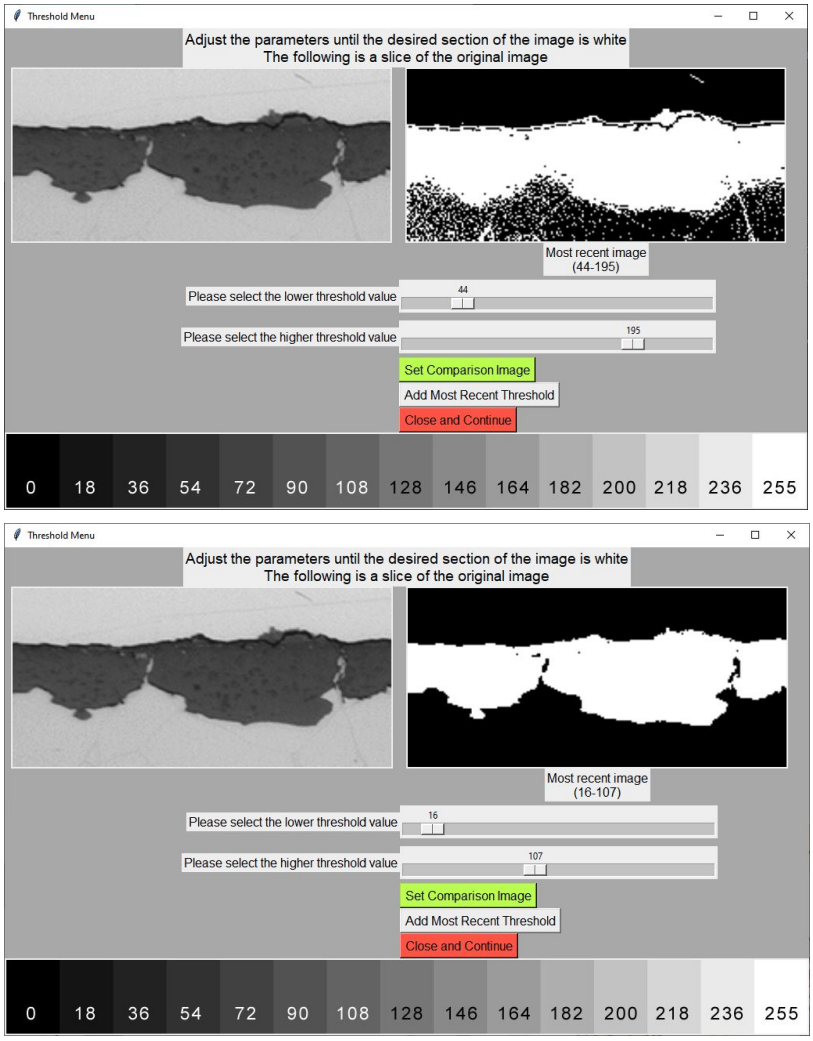
16. Adjust the sliders to isolate the oxide.



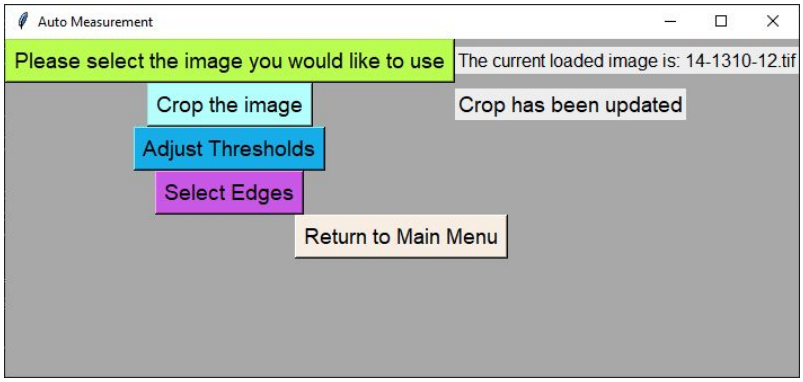
17. When you have finished cropping the image press the “Close and Continue” button. A new option will appear on the main menu.



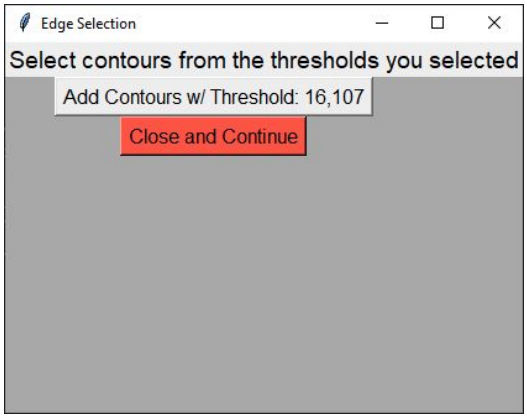
18. Adjust Thresholds will take you to a menu where you can adjust sliders to isolate the regions of interest. The regions of interest should be in white. The following shows a demonstration of the images.



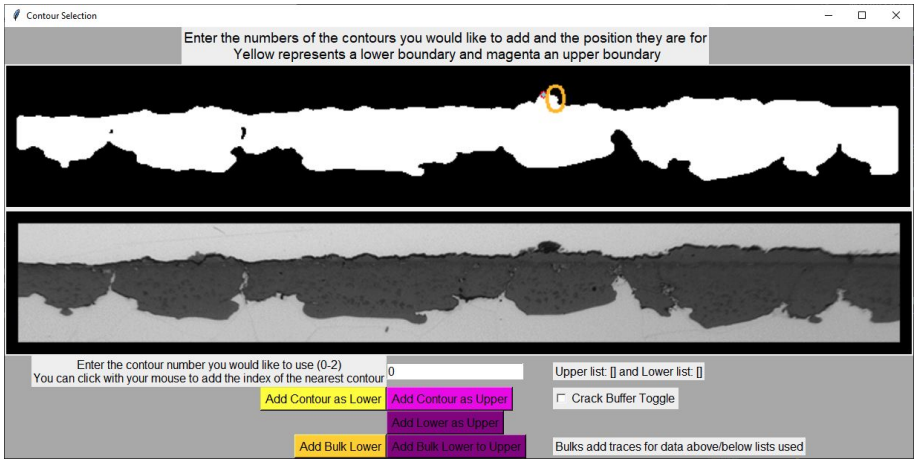
19. You can press “Set Comparison Image” to add a third image to compare two different thresholds. “Add Most Recent Threshold” is used to indicate the threshold set(s) you would like to work with. Pressing that button will add the set to a list of sets you can work with. This will make more sense when we get to the edge selection. When you find the set(s) you want you can press “Close and Continue” and you will find a new button available on the main menu.



20. “Select Edges” will take you to a menu titled “Edge Selection” where you can select the threshold set you want to use.



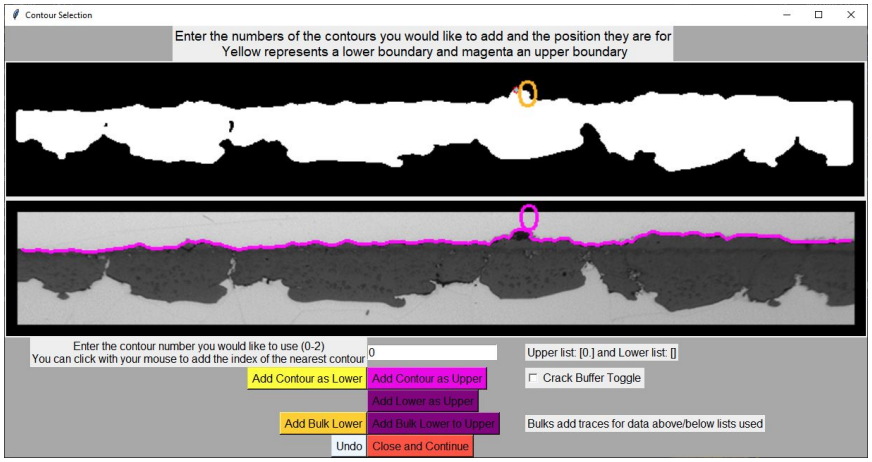
21. Selecting a threshold set will take you to a new menu where you will see the thresholded image and the original image as well as several buttons. On the thresholded image you will see labeled areas similar to those seen when defining the scale bar. You can click on the labels to enter that value into the text box above the buttons. For reference, the ten largest labels are gold with a teal dot in the center of the red point while the rest of the labels are in green without the teal dot. In the case of the following image there is only one labeled area, but some images can contain hundreds.

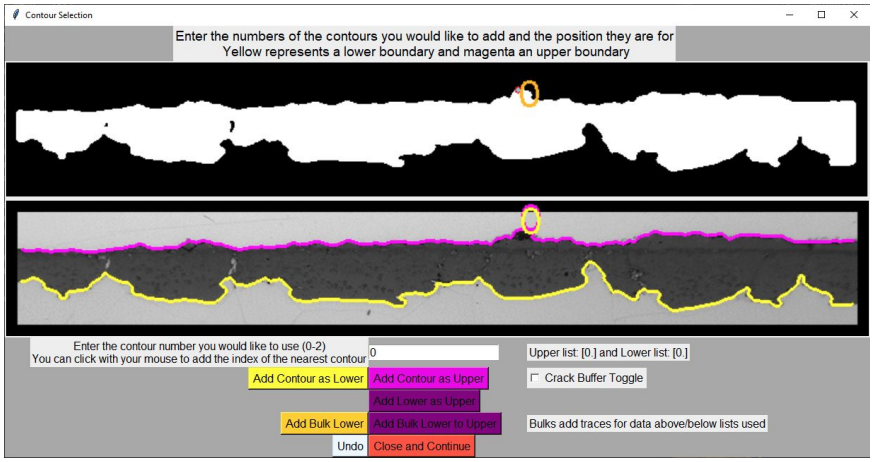


22. The buttons are defined as follows:
    a. “**Add Contour as Lower**”: Takes the bottom side of the selected region and adds it’s points to a list of the lower boundary values.
    b. “**Add Contour as Upper**”: Takes the top side of the selected region and adds it’s points to a list of the upper boundary values.
    c. “**Add Lower as Upper**”: Takes the bottom side of the selection region and adds it’s points to a list of the lower boundary values. (Designed for internal oxidation)
    d. “**Add Bulk Lower**”: Requires an upper boundary to have already been defined. Applies the “Add Contour as Lower” effect to all areas below the upper boundary/boundaries. (Designed for internal oxidation).

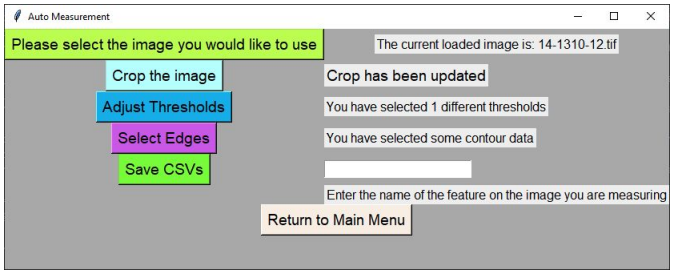
e. “**Add Bulk Lower to Upper**”: Requires a lower boundary to have already been defined. Applies the “Add Lower as Upper” effect to all areas above the lower boundary/boundaries. (Special case usage)

23. There is a checkbox titled “Crack Buffer Toggle,” this is to help reduce the effect of cracks that might make the upper and lower boundaries touch.
24. Select the region you want to use by clicking near it and then press the appropriate button to add the data. After you press the button you will see an undo button appear. It will let you undo your previous action. You cannot undo more than your previous action, so you will have to close out of these menus and reopen the edge selection menu from the main menu. When you add data you will see it added to the original image for reference. Yellow indicates lower boundary while magenta indicates an upper boundary.



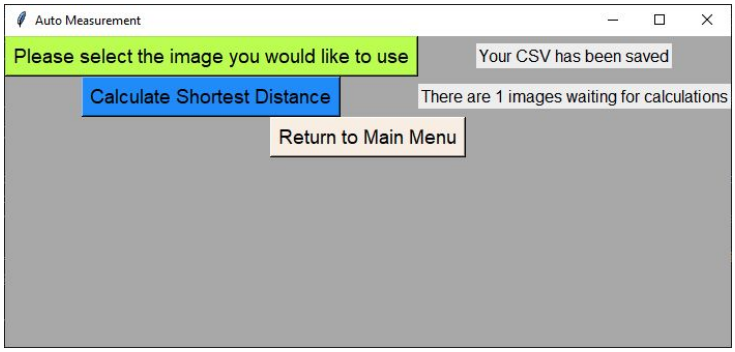


25. When you have finished adding the data press “Close and Continue” to go back to the main menu where you can now save the data using the “Save CSVs” button. Next to the button you have the option to add a name to the data set if you are looking at different regions of the same image.

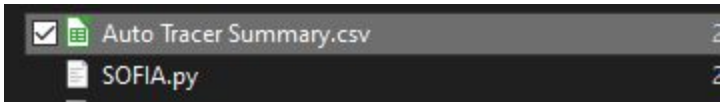


Data Acquisition (External)

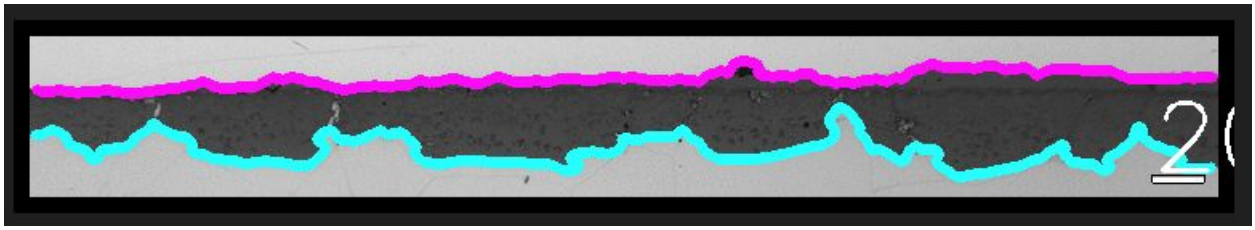
1. When you have saved data you will see a new option on the menu to “Calculate Shortest Distance.” This option can be done in bulk for the external oxidation. When you press the button calculations will be performed.

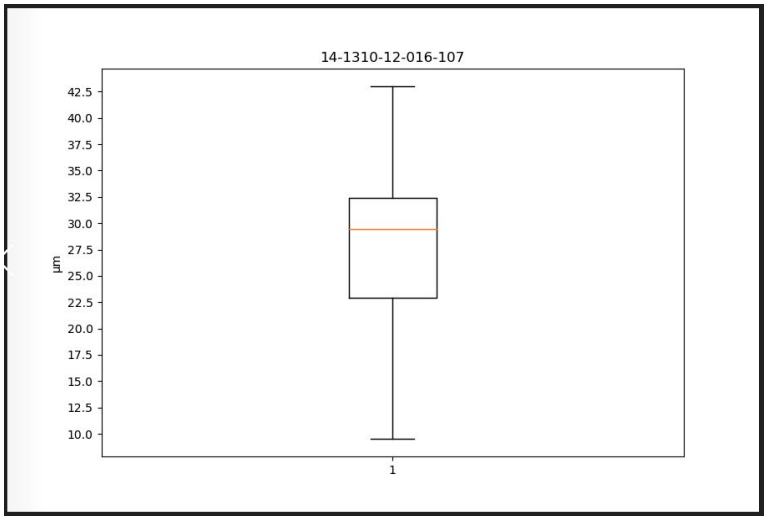


2. When the button disappears that means that the calculations have been finished.
3. The saved data can be found in a few locations. There is a summary csv for quick reference found in the same folder as SOFIA.py titled “Auto Tracer Summary.csv”



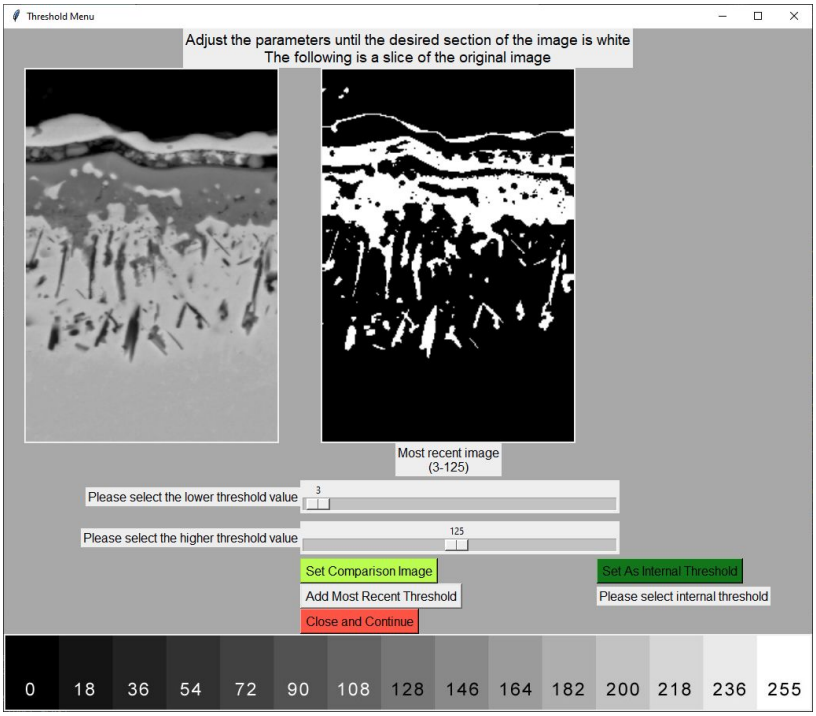
4. Inside this you can find quick reference data like the mean, median, standard deviation, first and third quartiles, and the number of datapoints used in the calculation.
5. In addition to that if you go into a folder labeled “workedcsv” in the same folder you can find folders for all of the images you have worked through. Inside of the folders in there you can find an image showing the traces, a boxplot to show data distribution, as well as three csvs. Two of the csvs are the lower and upper boundary data while the third csv are the results from the shortest distance calculations.



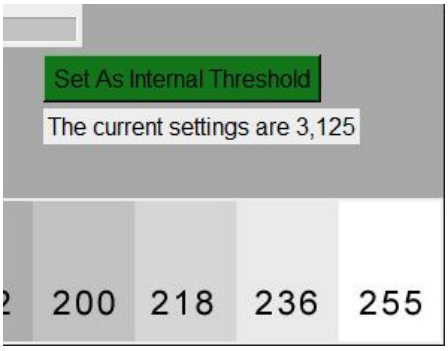


Using the Program (Internal)

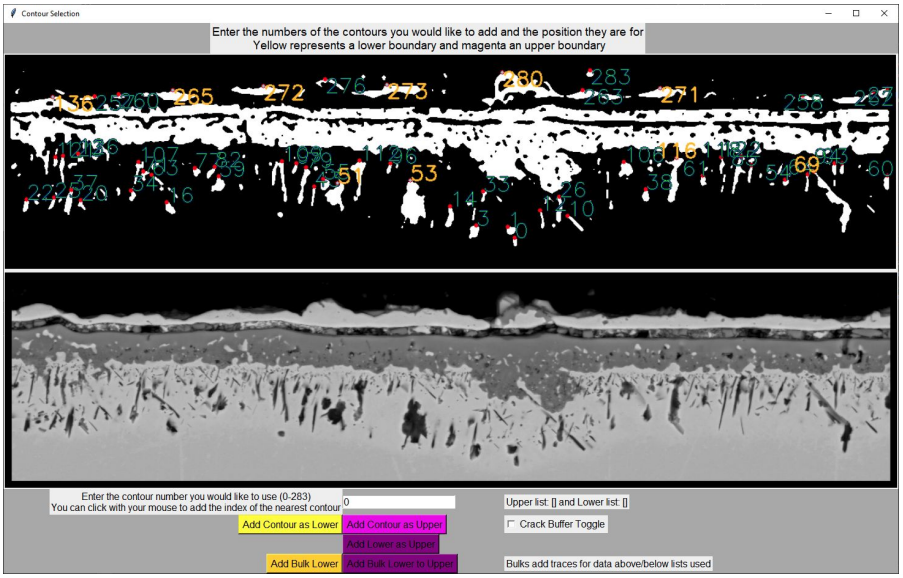
1. This procedure follows similar steps to the External method, up to step 26 as well as the additional step of multiple thresholds as well as declaring the internal threshold.

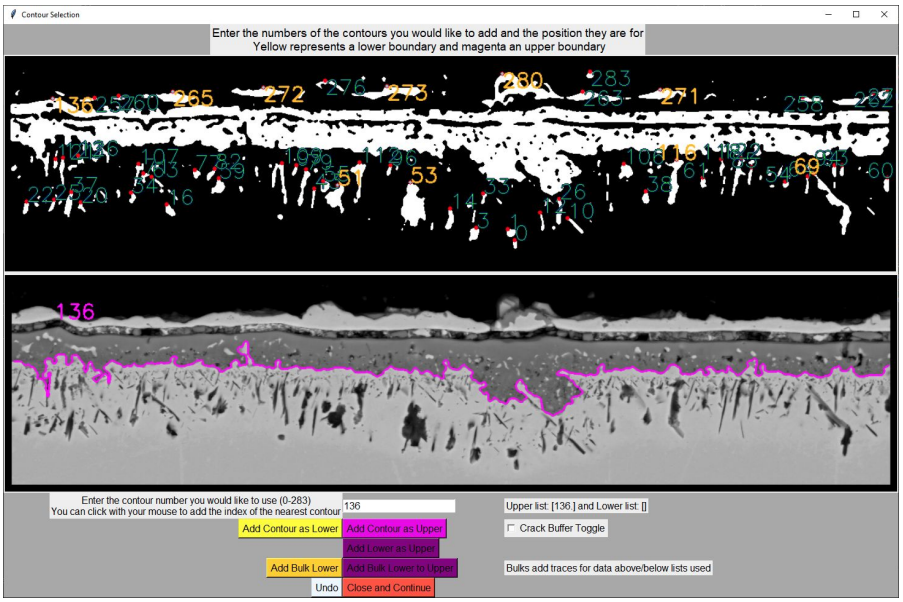


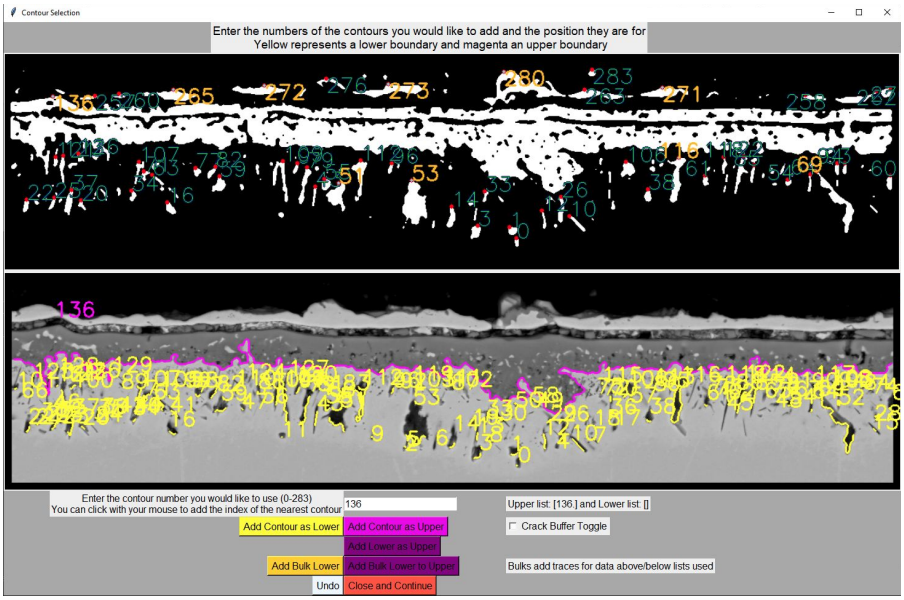
2. Setting the Internal Threshold is important to get the internal oxidation calculations to work properly. In the following image you can see the label update to show the settings used.



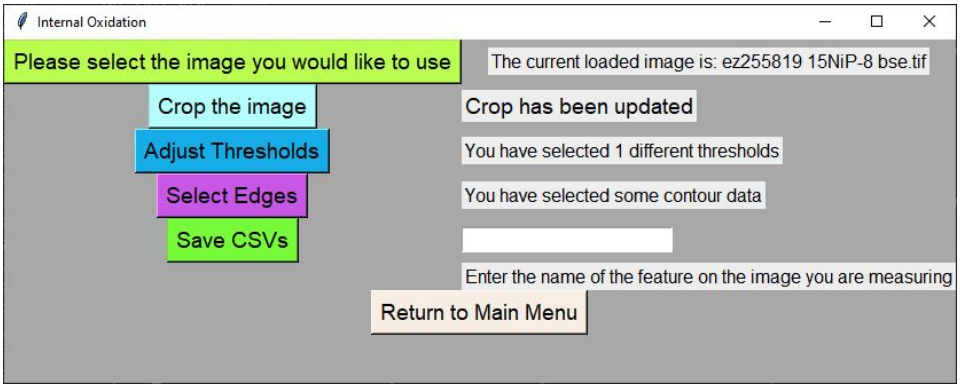
3. The contour selection menu will look identical to what we saw before, but we will be using different buttons this time. For reference, the ten largest labels are gold with a teal dot in the center of the red point while the rest of the labels are in green without the teal dot. The following images were obtained by clicking on label 136 which fills the entry box. This allows us to “Add Lower as Upper” and mark the bottom side of area 136 as the upper limit of the internal oxides. Next, we can press “Add Bulk Lower” to define everything below area 136 as an internal oxidation area.



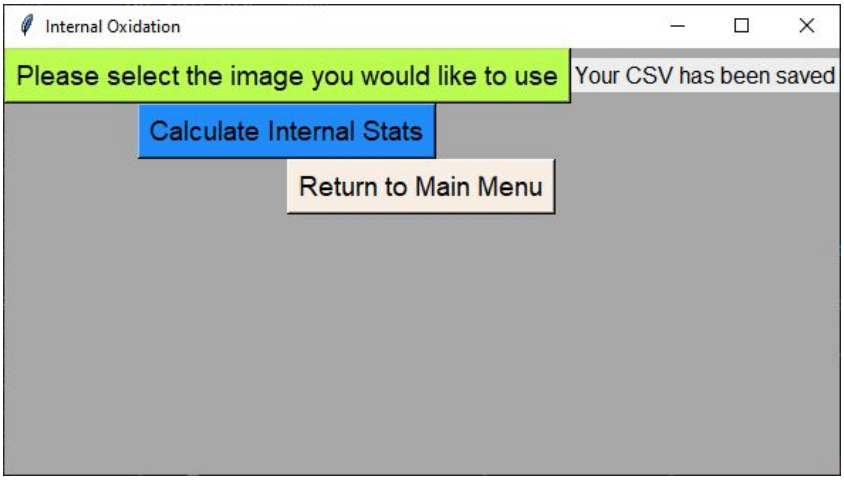




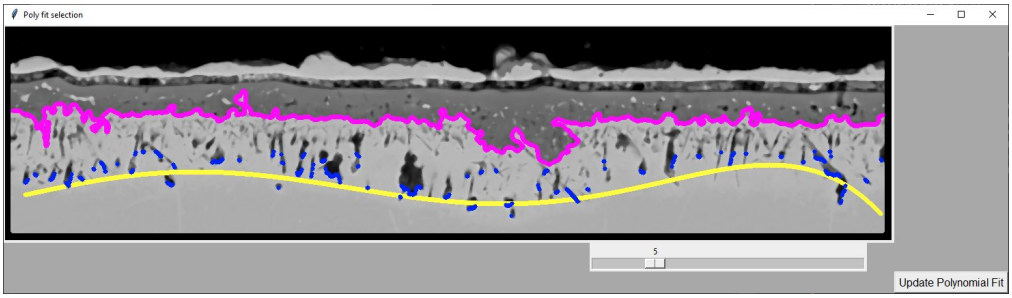
4. When we are done adding areas we can return to the main menu to save the data and give it an optional name.



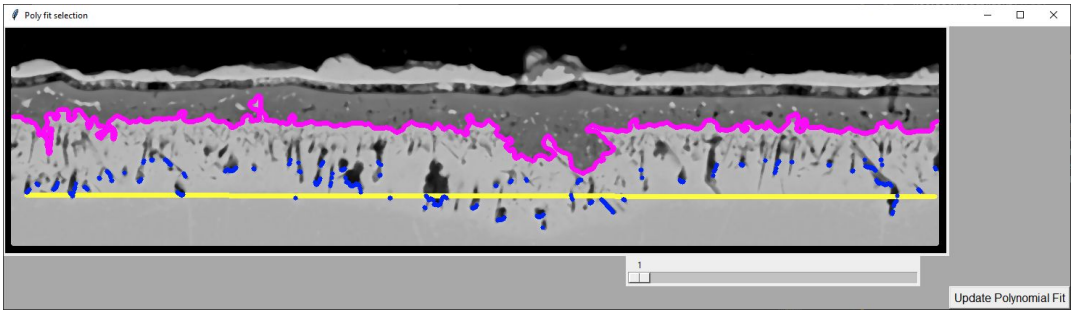
5. Pressing the save button will give us the option to save the data. Unlike the external oxidation, we can only do one calculation at a time.

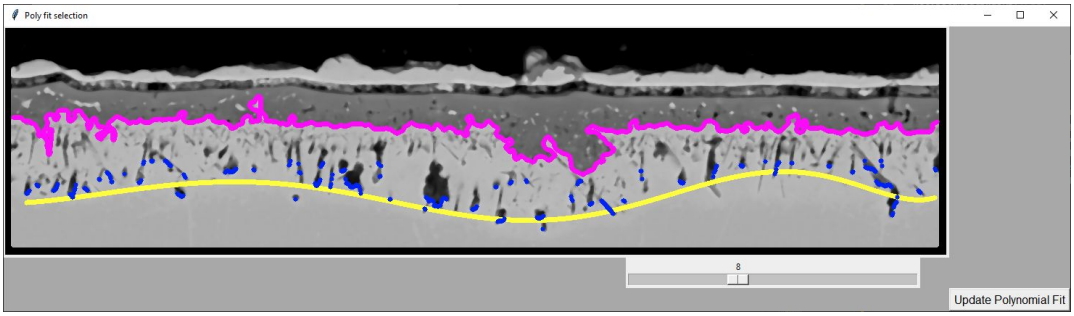


6. Pressing the button will open up a menu to select a polynomial fit for internal oxidation.



7. We can move the slider to change the degree of the polynomial. Adjust the slider to the desired fit.

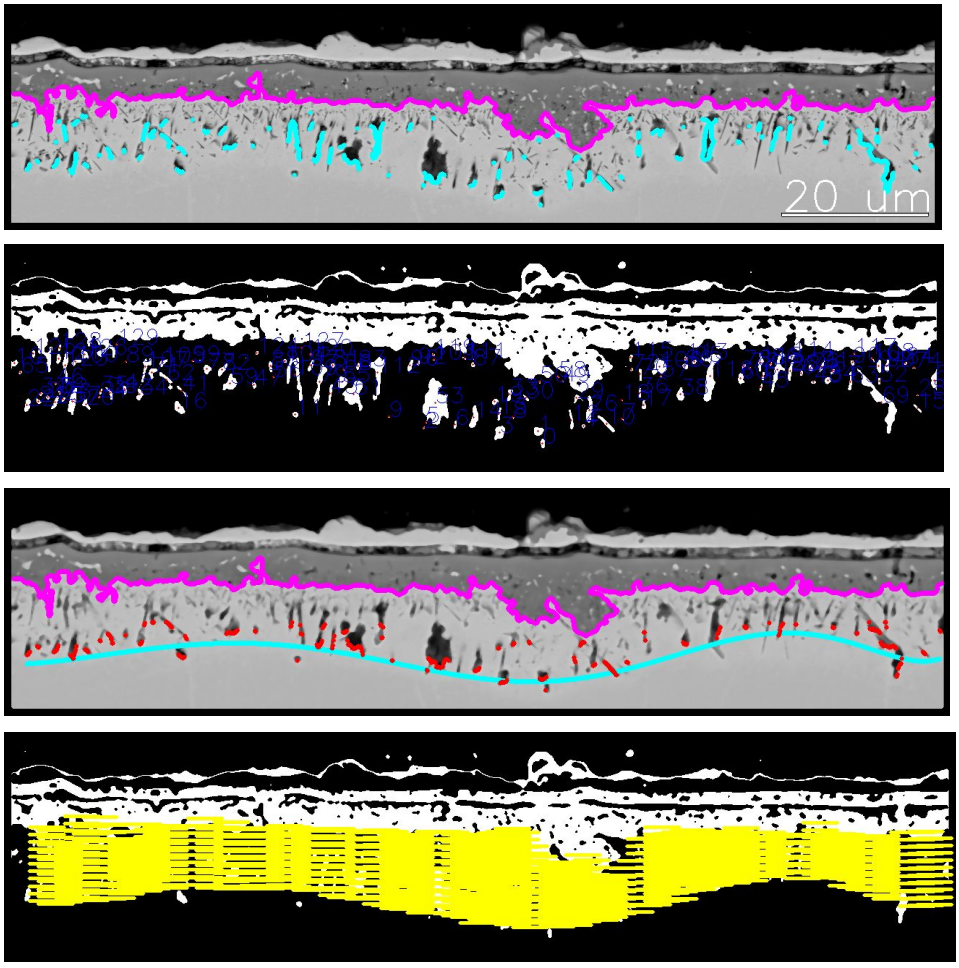




8. Press the “Update Polynomial Fit” button to finish saving the data

Data Acquisition (Internal)

1. The saved data can be found in a few locations. There is a summary csv for quick reference found in the same folder as SOFIA.py titled “Internal Oxidation Summary.csv”
2. Inside this file you can find mean, median, standard deviation, first and third quartiles, and the amount of data points used in the calculations.
3. The individual data can be found in the folder titled “worked-internalcsv.” Here you can find folders for all the images you have worked with so far, inside each folder you can find several documents. There are trace images, an image showing centroids, an image showing the polynomial fit, and an image showing the slice breakdown.



4. In addition to the images there are several csvs containing the data used and resulting from the calculations in the above images.
5. The csvs with “Upper” and “Lower” in them are the upper and lower data used to make the first image.
6. The “circularity.csv” contains a list of centroid numbers, distances from the centroid to the upper boundary and the circularity of the area the centroid is from.
7. The “Continuity.csv” contains 1 micron depth slices from the upper boundary to the lower boundary across about 100 width ranges to quantify the areas in the depths. This list contains the oxide area at the depth and the percentage of the total area.

8. The “Polynomail-Trace.csv” contains a list of shortest distance calculations from the polynomial fit to the upper boundary as opposed to using the internal oxide which could have multiple points with the same x value.