MSE360 - Digital Quantitative Metallography

Goals of Session

This session will give students a brief overview of how digital imaging techniques can be applied to Quantitative Metallography. Students will be guided through some example analyses, including coverage of some commonly-used image processing techniques, and will then be required to quantitatively analyze some micrographs to determine the following:

- Determination of the grain size of a standard steel sample
- Determination of the volume fraction of a phase within a 3-phase microstructure
- Determination of grain size distribution of each phase

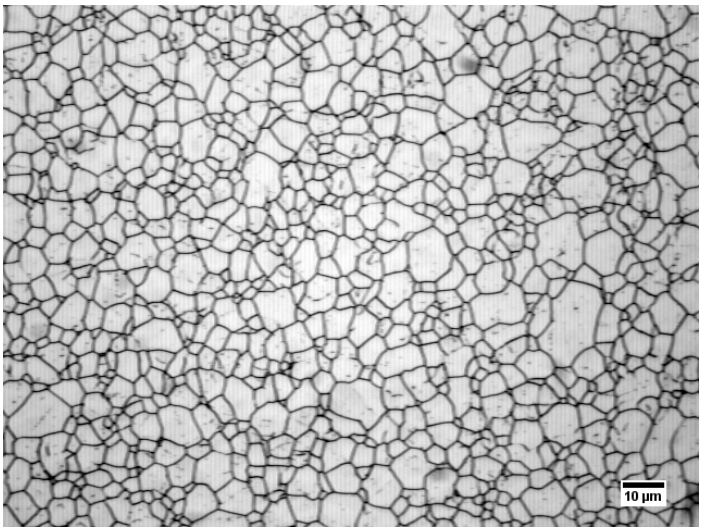
**The procedure for image analysis is spelled out below. The instructor will provide more information on WHY we are doing these steps as we go along. Keep in mind that the values quoted in the procedure are specific to these images ONLY and may not apply for all images you analyze.

1. Determination of the grain size of a standard Steel sample

As a general rule, grain size can be correlated to changes in several material properties (e.g. hardness and strength), so it is important to be able to provide a standardized way to describe the grain size. The ASTM standard E-112 provides a reproducible procedure for quantifying the grain size of a particular microstructure. The manual techniques described in the standard involve the use of statistical methods using overlaid or drawn lines and manual counting of intercepts with grain boundaries etc. Using digital techniques, a lot of the manual (and often tedious) work can be avoided. However, the computer may make assumptions that are not completely correct. Whichever method is used, it is necessary for the person to make decisions about accuracy.

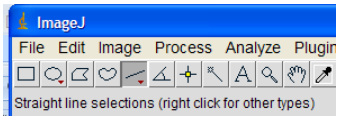
Start ImageJ 'Start | Programs | ImageJ | ImageJ'

Open image from 'Ctools | MSE 360 | Resources | Lab 1 | Gr_steel.tif'

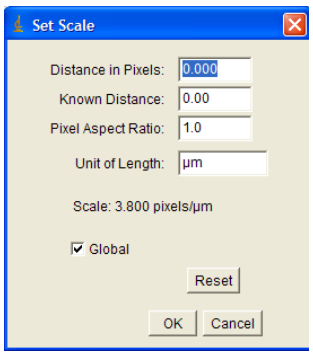


a.) Calibrating the magnification

- The first step is to calibrate the magnification by drawing a line with the "straight line selections"

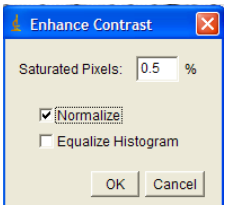


- Draw a line on top of the scale bar on the image and go to ‘Analyze | Set Scale…’ Remember to check the box for “Global”



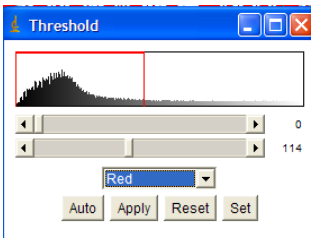
- The “distance in pixels” should be approximately 38. The “Known Distance” is 10. Do not change the “Pixel Aspect Ratio”. The unit of length should be in microns.

b.) Enhance contrast: go to ‘Process | Enhance Contrast’
Check the box next to normalize. Click OK.



c.) Sharpen: go to ‘Process | Sharpen’

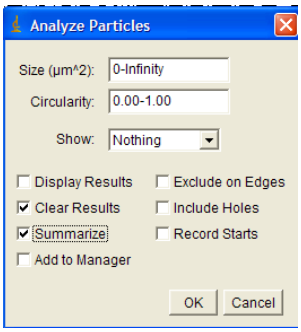
d.) Thresholding: go to ‘Image | Adjust | Threshold’
Set lower and upper thresholds to approximately 0 and 157 respectively, then click apply.



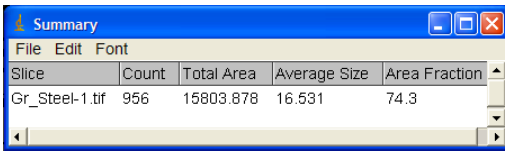
e.) Make image binary: go to ‘Process | Binary | Make Binary’ then ‘Process | Binary | Skeletonize’

f.) Invert: go to ‘Edit | Invert’

g.) Analyze particles: go to ‘Analyze | Analyze Particles’
Make certain the “Clear Results” and “Summarize” are checked.



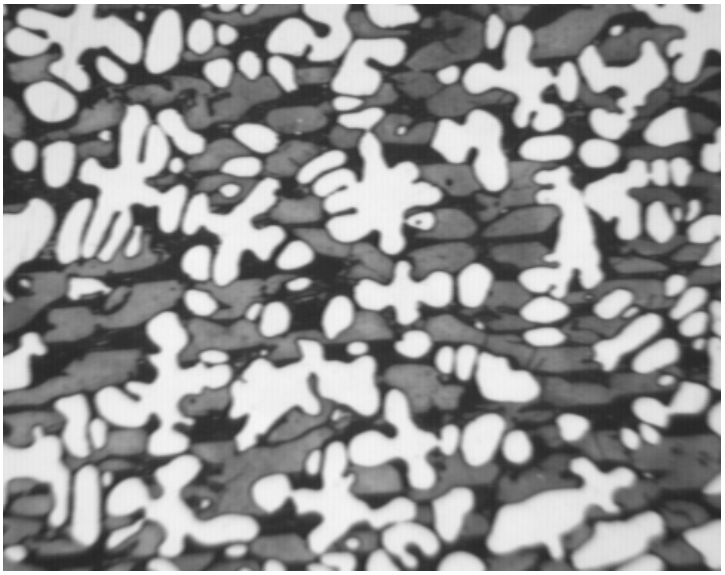
h.) Results should appear in a separate dialogue box
Results should be similar to the one shown below. Average grain size in this example is approximately 2.3 microns.



i.) Settings to alter:
- Try with a different threshold level
- Try with having “Exclude on edges” checked in the “Analyze Particles”

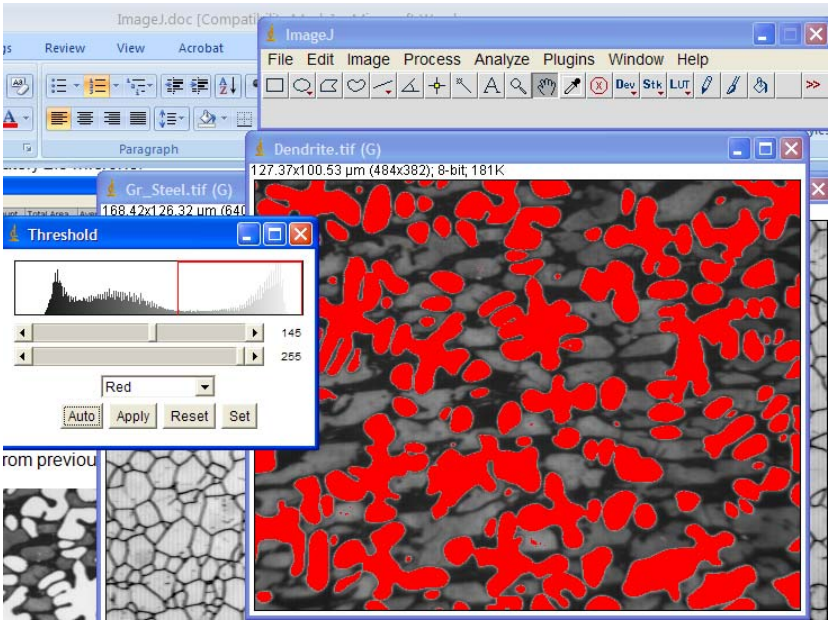
2. Determination of the volume fraction of Cementite (Fe3C) within a Cast Iron microstructure

Open image from ‘C: | Courses | image processing | Dendrite.tif
Use calibration from previous image.



a.) Thresholding: go to ‘Image | Adjust | Threshold’

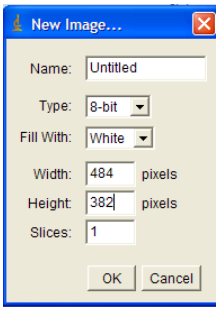
b.) Set levels so that the white phase is highlighted.
lower and upper thresholds should be approximately 145 and 255 respectively.



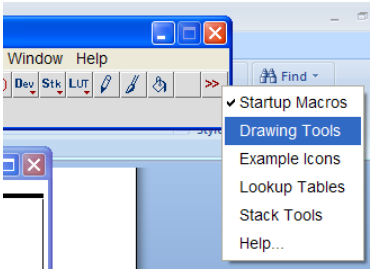
c.) Fill holes: go to ‘Process | Binary | Fill holes’

d.) Analyze particles: go to ‘Analyze | Analyze Particles’
This time looking at the area fraction, which should be approximately 39 percent.

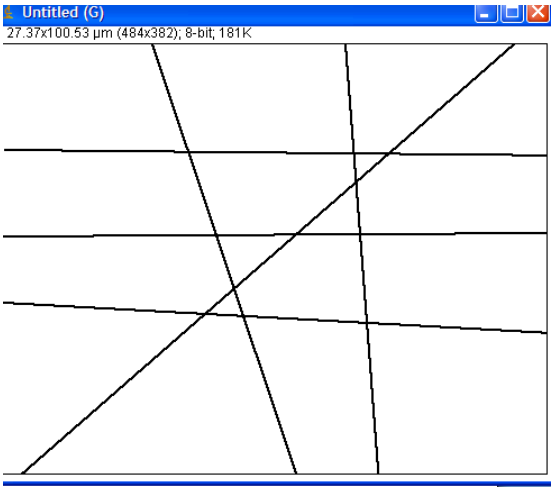
e.) Create a new image: go to ‘New | Image…’



f.) Click on the “Drawing tools” on the right hand side of ImageJ

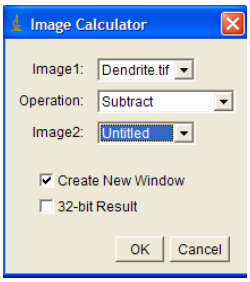


g.) Use the arrow tool and draw arrows with the arrowheads outside of the view. Draw at least 5 random lines.

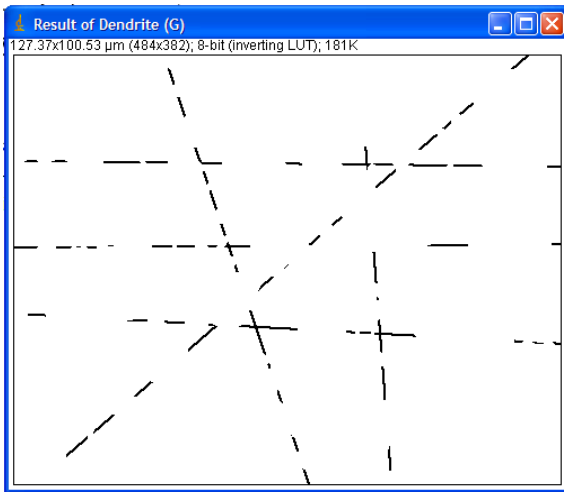


h.) Area fraction: ‘Analyze | Analyze Particles’

i.) Image calculator: go to ‘Process | Image Calculator’
Subtract the Untitled from the dendrite image and say OK

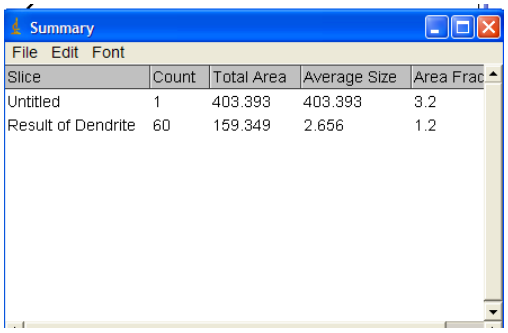


j.) Your new image should look like this:



k.) Area fraction of subtracted image: ‘Analyze | Analyze Particles’
make sure to turn off “Clear results” and

l.) Then take the ratio from the two area fractions. Your answers should be similar to the area fraction from step d



[Note that the Volume fraction is equivalent to the Area Fraction]

m.) Settings to alter:

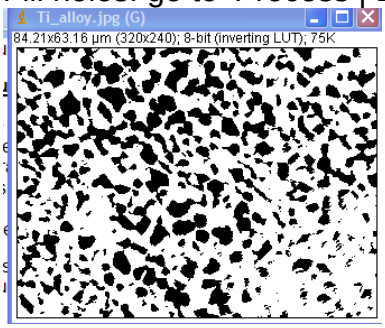
- Try with a different threshold level
- Try with having “Exclude on edges” checked in the “Analyze Particles”
- Different random set of lines

3. Determination of grain size distribution

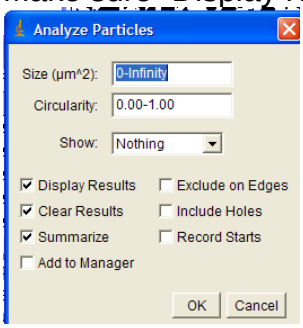
In order to differentiate and quantify the effects of processing (e.g. heat-treatment) of materials, it is sometimes necessary to measure and feature characteristics (e.g. area, length, width, perimeter) against frequency. The resulting histogram will reveal an informative graphical representation of the distribution and frequency of grain sizes present in your particular microstructure.

Open image from ‘Ctools | MSE 360 | Resources | Lab 1 | Ti_alloy.jpg’

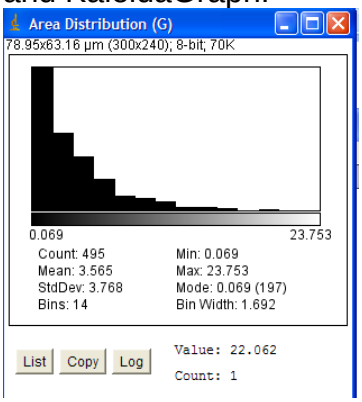
a.) Enhance contrast: go to ‘Process | Enhance Contrast’
b.) Thresholding: go to ‘Image | Adjust | Threshold’
select the white alpha phase
c.) Fill holes: go to ‘Process | Binary | Fill holes



d.) Watershed: go to ‘Process | Binary | Watershed’
e.) Size distribution: ‘Analyze | Analyze Particles’
Make sure “Display results”, “Clear Results” and “Summarize” are checked



f.) Distribution: in the “Results” window, go to ‘Edit | Distribution’ leaving the defaults
It is also possible to copy and paste the results in graphing programs such as Origin, Excel and KaleidaGraph.



g.) Settings to alter:

- Try with a different threshold level
- Try with having “Exclude on edges” checked in the “Analyze Particles”
- Change the bin size of the distribution