Watergate Image Segmentation for Properties Analysis of Silica Nanospheres

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Introduction

Motivation

Synthesis of mineral nanoparticles for uses in solar, medicinal, and cosmetic technologies has been researched extensively by a plethora of disciplines. Imperative to this research is the analysis of optical and electron microscopy images showing the morphology of the produced nanostructures. Historically, analysis of these images has been performed manually using software packages such as ImageJ to measure particle size distributions. This process is labor intensive, and leaves sample selection and analysis to user discretion.

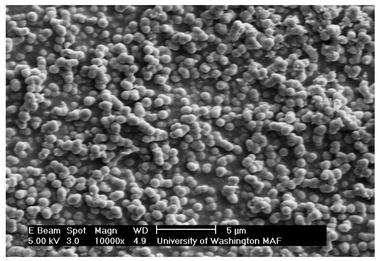


Figure 1: Representative SEM image of silica nanoparticles generated by the silicifying peptide R5. Image generated by Dr. Erika Buckle.

While it is possible to measure particle sizes and generate a mean radius and size distribution, it is difficult to attribute the spread of radial lengths to a distribution of particle sizes, or regular non-spherical morphology. A software package capable of reporting these properties would be of great benefit to researchers.

Project Goals

To decrease subjective and implicit bias in image analysis, our goal was to create a piece of software to run within the Python environment which would be able to parse individual, overlapping particles from the .tif SEM output and return the following metrics:

- Particle Count
- Mean particle size
- Degree of spherical character

Acknowledgements

Our team wishes to thank Prof. David Beck, Chad Curtis, and the rest of the DIRECT teaching staff.
Additional thanks goes to Kelly Thornton.
Data was acquired by Dr. Erika Buckle and provided by Prof. Gary Drobny and Prof. Jim Pfaendtner.
All used packages are open source. Documentation can be accessed through our GitHub at:
https://github.com/rgebhart/nanoBALLS
Sample image courtesy of CalTech: http://minerals.gps.caltech.edu/Silica_Polymorphs/index.html

nanoBALLS

Methodology

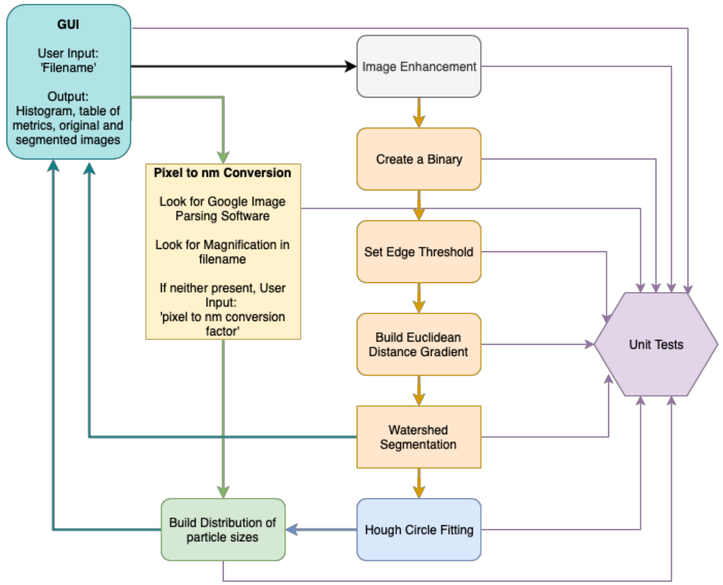


Image Enhancement

Toggle contrast and brightness settings until the mean and standard deviations of the image histograms are normalized to assist Canny edge finding method.

Image Segmentation

- Create image binary
- Locate center of particles via Euclidean distance calculations
- Fill particles out to edges using Watershed segmentation

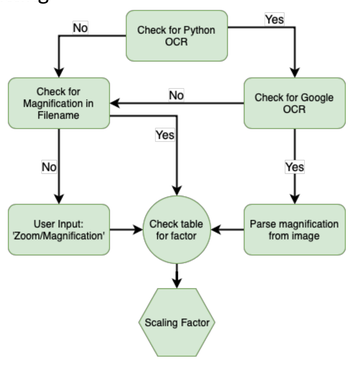
Circle Fitting

Exploring several pre-build methods of circle fitting

- Houghs method (OpenCV)
- Min Ellipsoidal fit (OpenCV)

Physical Unit Conversion Factor

Convert measured pixel lengths to relevant physical distances.



User Interface

Inputs:

- Image file
- Magnification factor (if needed)

Outputs:

- Mean particle size + standard deviation
- Histogram of particle size
- Plot of original and segmented image
- Plot of minimum radius vs maximum radius

Results

Image Enhancement

Drastically improves edge finding

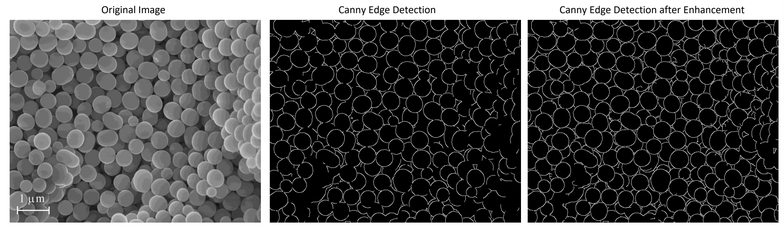
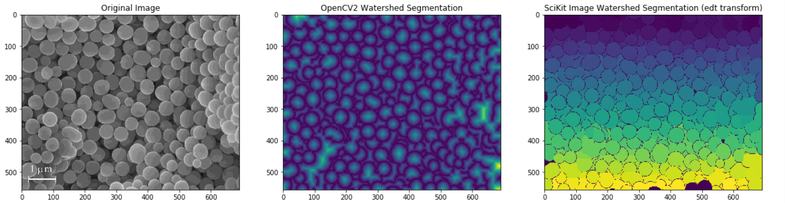


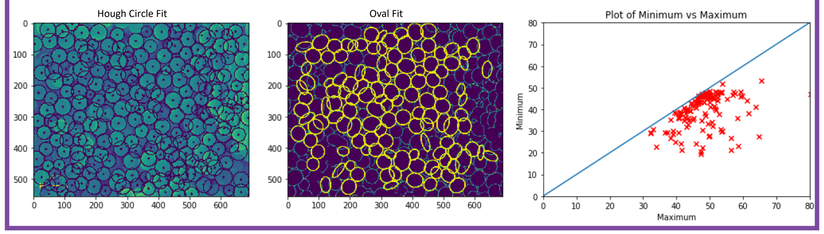
Image Segmentation

Combination of methods greatly improves ability to find multiple particles and segment them in a poorly bounded image.



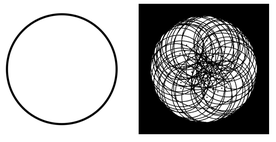
Circle Fitting

Able to detect multiple particles which are overlapping one another



Future Work

- Trouble scaling up the program to handle more fringe cases



- Still having issues with circle and ellipse fitting the test image.
- Real data images still proving difficult to fit