Synthetic Microstructure Generator Tool

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INTRODUCTION

This tool has been developed to examine the influence of particle aspect ratio, area fraction, and orientation on representative length scales in two-phase microstructures. This tool also includes the ability to generate particles with various distributions of particle sizes and orientations. Please cite reference #2 (Tschopp, Wilks, Spowart, "Multi-Scale Characterization of Orthotropic Microstructures," MSMSE 16 (2008) 065009) if you use this program in your research. Our previous MATLAB submission, where these synthetic microstructures were used, explains the application of these microstructures…

"When assessing structure-property relationships for various materials, it is often necessary to define a representative length scale or volume element for characterization or simulation. The Multi-Scale Analysis of Area Fractions (MSAAF) technique characterizes the representative length scale of a two-phase composite microstructure (1). A previous MATLAB submission shows how to apply this technique in an isotropic form and a directional form; the directional form is used to assess the directional dependence of the length scale of the underlying microstructure. The directional form of the MSAAF technique has recently been applied to synthetic composite microstructures with second phase particles of varying area fraction, aspect ratio, and alignment (2). Additionally, the directional form has been modified such that it can be applied to any vector within the 2D microstructure image, i.e., the *vector* MSAAF technique (3). A visual representation of the vector MSAAF results has been used to show the change in the directional length scale as a function of the orientation of the vector."

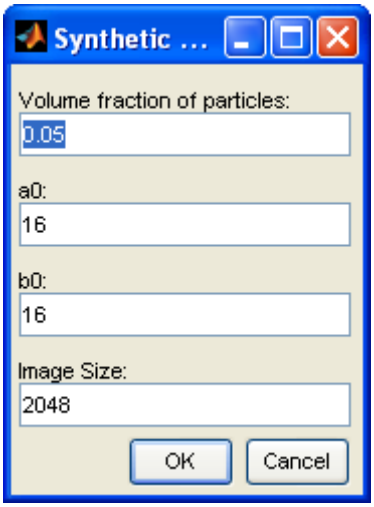
This MATLAB GUI script was developed as a computationally-efficient tool for researchers to design synthetic two-phase microstructures with elliptical particles in a voxelated image. This tool can be used to generate synthetic two-phase microstructures with little knowledge of the MATLAB programming required to obtain the results. For further information on the techniques or if you have comments, please contact Mark Tschopp at mark.tschopp@gatech.edu.

REQUIREMENTS

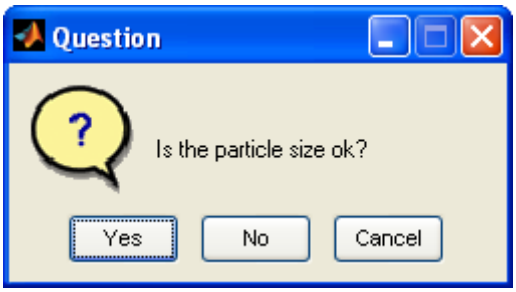
Software. This program was written using MATLAB R2007b with the Image Processing Toolbox. This was tested on MATLAB R2008a and MATLAB 2009a – works fine!

USING THE PROGRAM

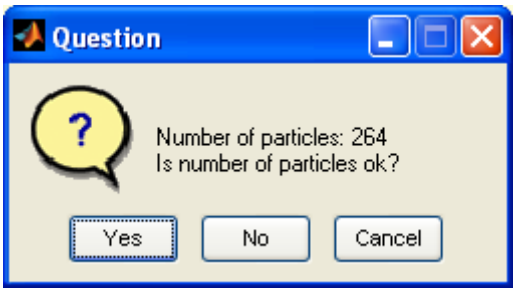
1. Open the program. The GUI screen should look like below. If it does not, the Image Processing toolkit may not be installed on your computer. The volume fraction is not in percentage, i.e., 0.05 = 5% particles, etc. The a0 and b0 define the major and minor axis of the ellipse. The image size is the dimensions of the binary image, i.e., 2048 = 2048 x 2048 image.



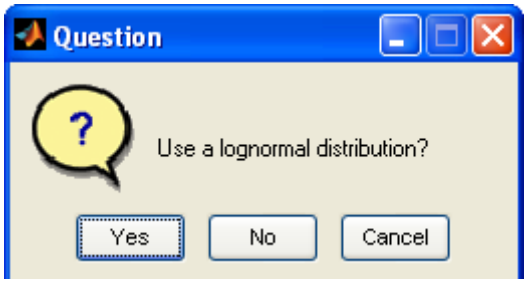
2. A window will open up with a binary image of the ellipse/circle shown. Use this window to check the resolution of the particle. A dialog box (below) will also open up and ask whether the particle size is ok. Select yes, no, or cancel. If no is selected, it will return to step #1.



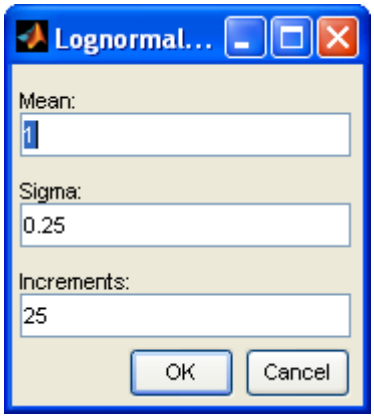
3. The program will compute the number of particles that will fit within the image given the particle size. A dialog box (below) will ask whether this number of particles is ok. If not, it will return to step #1.

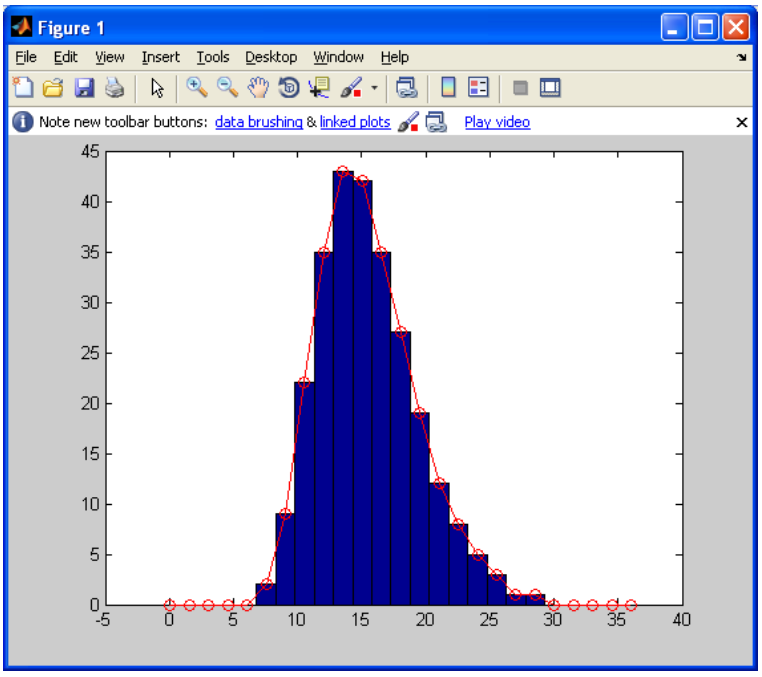


4. Size distribution. A dialog box (below) will then ask if you want to use a lognormal size distribution for the particles. Select yes or no.

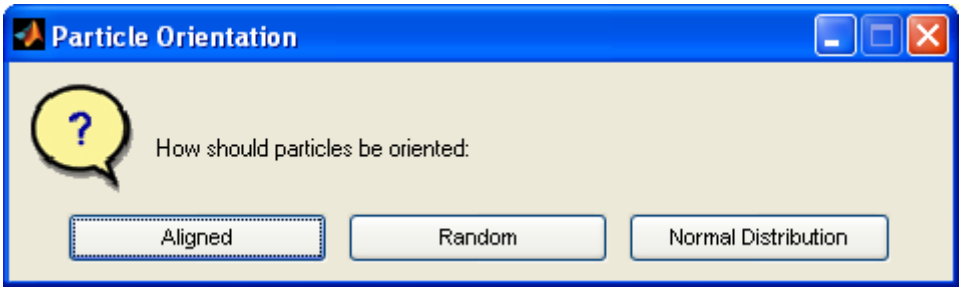


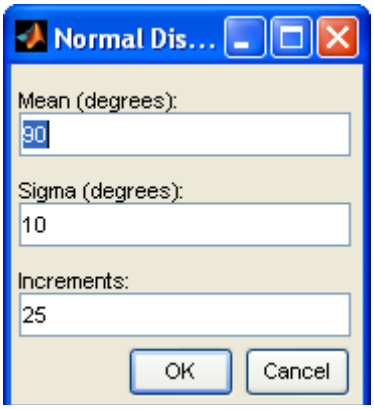
a. If yes, a dialog box (below left) will ask for the lognormal distribution parameters (mean, sigma). The increments parameter denotes the number of bins for the lognormal distribution (below right). The program will then randomly generate a list of particle sizes that best approximates the analytical form of the lognormal distribution and will plot a representation of this.



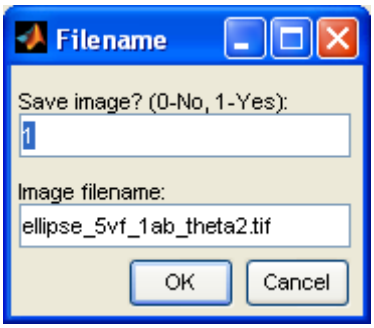


5. Particle Orientation Distribution. A dialog box (below left) will then ask how the particles should be oriented (for ellipses): Aligned, Random, Normal Distribution. Aligned is for the fully aligned case (select an orientation angle), random is for perfectly random oriented particles, and the normal distribution allows the user to input the mean and sigma parameters for a normal distribution about an orientation angle (below right).

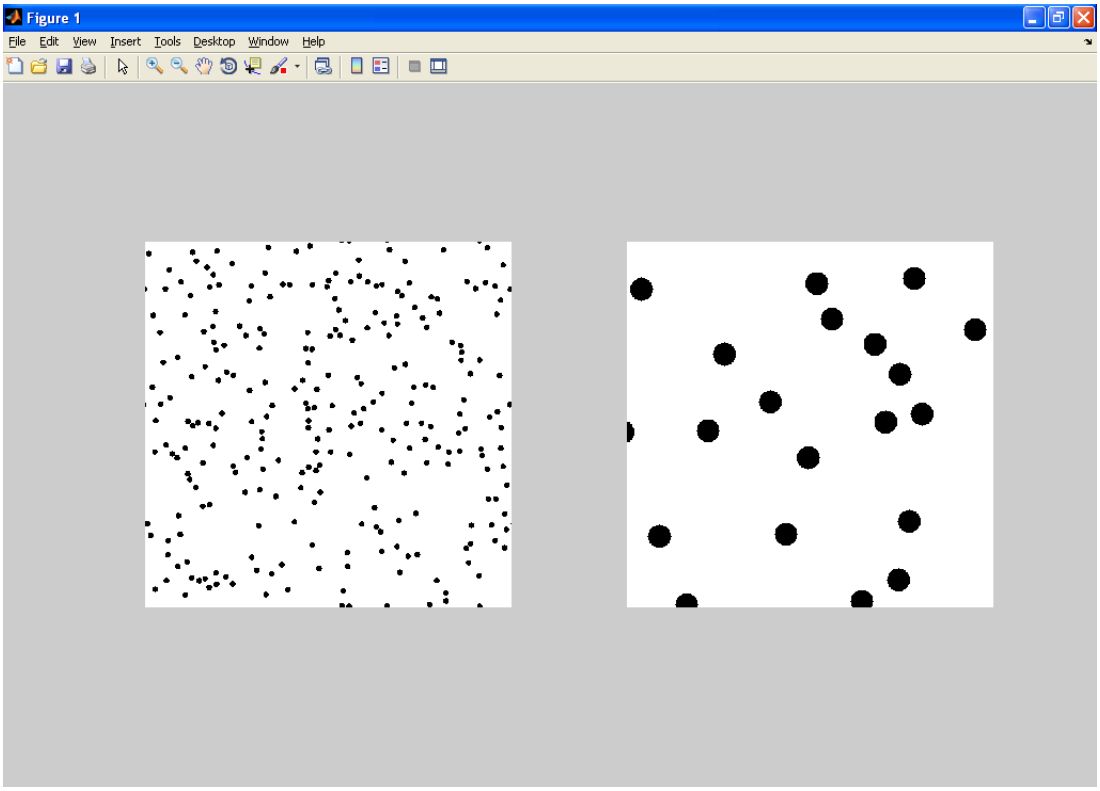




6. Filename. A dialog box (below) will prompt you for whether the completed binary image should be saved or not and what the image filename should be.



7. Subroutine Execution. The program will then generate the microstructure given these inputs. I have optimized the subroutines as much as possible and I have placed tens of thousands of ellipses in a random orientation in a 4096 x 4096 image in a matter of hours on a slow laptop. Once the program is done, it will display the microstructure (below): left - full microstructural image, right – closeup image of upper left corner. If the user has opted for image saving, the program will save the binary images at this point.



REFERENCES

For further information on the techniques used in this GUI script, see our publications. For journal publications that use this software for microstructural analysis, please cite our associated articles.

(1) Spowart, Maruyama, Miracle, "Multi-Scale characterization of spatially heterogeneous systems: Implications for discontinuously reinforced metal matrix composite microstructures," Materials Science & Engineering A 307 (2001) 51-66.
(2) Tschopp, Wilks, Spowart, "Multi-Scale Characterization of Orthotropic Microstructures," MSMSE 16 (2008) 065009.
(3) Wilks, Tschopp, Spowart, "Multi-Scale Characterization of Inhomogeneous Morphologically Textured Microstructures" (2009) accepted.