MECH 493 Project: Developing new approaches to analyzing TEM images of aggregates

Background and research goal

Soot is a carbonaceous particle often produced in combustion processes. Different combustion conditions result in particles of different sizes and morphology, with varying health and environmental implications. Transmission electron microscopy (TEM) is a common technique used to characterize the particles, yielding some of the most detailed information about the physical structure of the particles.

Currently, manual detection is the most reliable method to extract the primary diameter from TEM images. However, the process is time-consuming, such that automation is required to reduce the amount of time and effort spent on processing the image. Improvements would allow for processing of a higher number of images, increasing the number of data points and confidence in the data.

While there are already attempts at automating the process, most codes still require manual adjustments for the filtering thresholding values. The primary objective, then is to implement machine learning in the process so that it can adapt to new images without additional inputs from the user. This will be compared to previous available codes, which will provide the baseline to which results will be compared.

Tasks to be performed by the student

- Summarize previous research on TEM aggregate detection
- Perform manual detection for training data
- Develop a machine learning model in MATLAB that automatically segments the TEM images for input to the existing pair correlation method (PCM) analysis
- Perform manual detection for training data
- Develop or partially develop a machine learning model which uses feature recognition to detect soot particles from TEM images and produces the following measures of particle structure:
    - Aggregate area
    - Average primary particle diameter
    - Histogram of primary particle sizes within the aggregate
    - Fractal dimension and radius of gyration of aggregates.
- Test and document the effectiveness of various competing image processing methods
- Summarize previous research on TEM aggregate detection
- Write a paper on the developed model(s)

Facilities and team

The student will work in a team with Dr. Steven Rogak, Dr. Timothy Sipkens, and other graduate students. The student will have access to the existing database of images available in the aerosol laboratory and may have the opportunity to observe the collection of TEM images.