1 Background

As part of my PhD study, I spend a lot of time looking at high speed videos of ignition kernels, which are essentially tiny expanding fireballs generated in different fuel/oxidizer/diluent mixtures. I have developed a diagnostic technique that used infrared radiation intensity measurements to evaluate the temperatures of the ignition kernels over time. One of the conditions of this technique is that it requires the distribution of intensity within kernels to be relatively continuous and smooth. Generally speaking, the longer kernels persist, the more chaotic they become. Although we can plainly see the effect of smooth/rough intensity distributions in the final temperature data, it would be more rigorous to quantify the degree of chaos in the kernel, and develop a quantitative cut-off value after which the kernels would be considered "too chaotic" to accurately analyze. I am also interested in quantifying how long ignition kernels persist in time.

2 Proposed Work

For my class project, I propose developing a set of functions to address these measurement problems. These functions will perform the following operations (grade weight in parentheses):

1. Read in a series of paired images and spatial masks (5%)
2. Apply a spatial mask to the image, to differentiate between "kernel" and "background" (5%)
3. Evaluate the average (μ) and standard deviation (σ) of the intensity values within the "kernel" region, and outside of the kernel region, and use these values to calculate time-resolved signal to noise ratios $SNR_k(t)$, $SNR_{bg}(t)$ for the kernel and background (10%)
4. Evaluate the centroid ($I_{x,y}$) of the spatial mask, and calculate the spatial separation (Δ) between the observed maximum intensity value, and the centroid (25%)
5. Compare the changes in σ, SNR_k, and Δ over time as the kernel grows in size, using an appropriate plot (20%)
6. Compare the maximum intensity values observed for weakly igniting kernels to SNR_{bg}, and determine how long they persist above a multiple of SNR_{bg} (20%)
7. Save the SNR, μ, σ, Δ, and I values for each set of images to a file. (5%)

3 Evaluation

Items 1 and 7 are trivial to evaluate. Item 2 would be evaluated by writing test code that calls the function to apply a mask, and returns a binarized image representing the masked data. Items 3-5 would be evaluated by processing fake data with known σ, μ and $I_{x,y}$. Similarly, a data set with known kernel residence time could be used to evaluate item 6.

4 Deliverables and Grading

Milestones for this project will be completion of: (1) items 1-3 and (2) items 4-5. The deliverable for this project will consist of a set of functions capable of performing the proposed calculations, a script to call and test them, a set of example input and output files, and a set of test input files that can be used to evaluate the functions.