Image Enhancement Techniques for STEAM Microscopy

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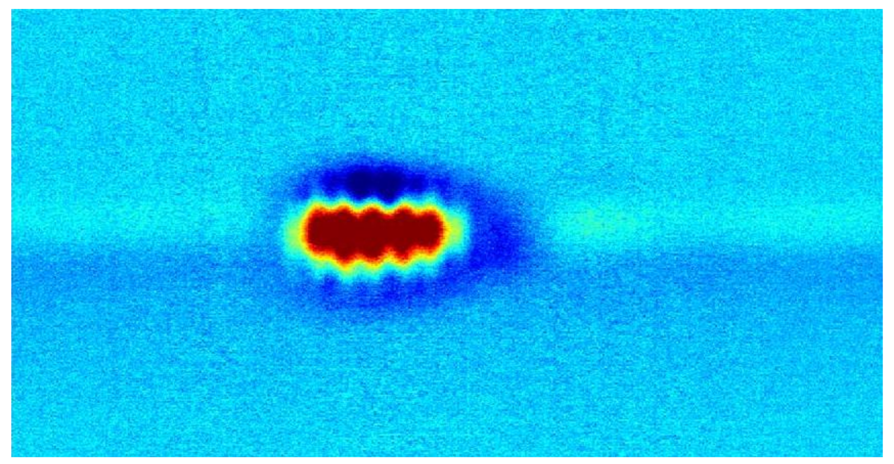
REU Site: Integrated Optics for Undergraduates

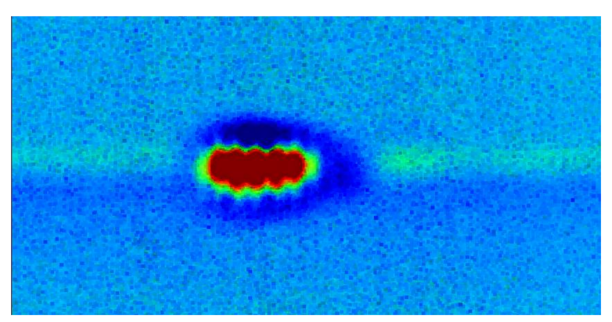
Abstract

As imaging capturing techniques become faster and more capable of detecting more information it becomes necessary to also be capable of processing such images so that valuable information can be obtained. STEAM is a technique that is being used to capture images of cells moving at high speeds. However, the images have problems with noise presence making the data presented unclear. Both spatial and frequency based filters and enhancements can be applied to the images so that the cell looks clearer and it is possible to use techniques to gain information from the image such as the location of the cell on the image, the area and perimeter of the cell, and the observation of other significant features or identifiers that may be present in the cell images. MATLAB's Image Processing Toolbox provides a great resource and is an excellent environment for processing images with powerful results.

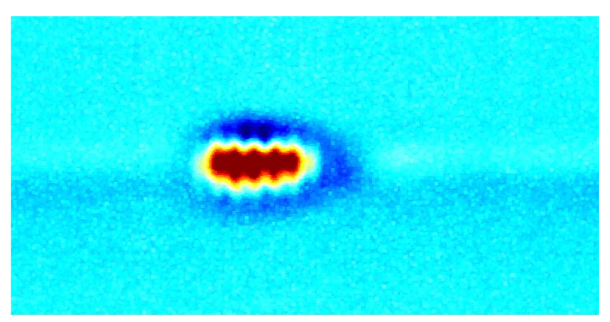
Original Image and Resulting Images from filters



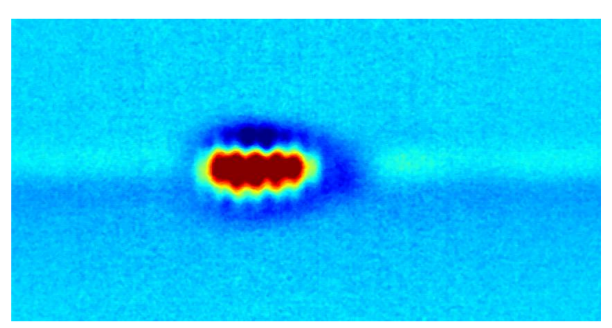
Original image captured by STEAM.



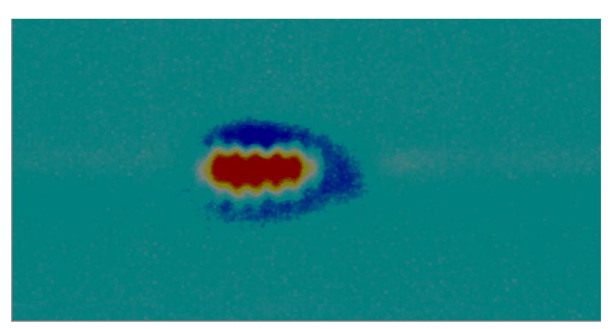
Order-Statistics Minimum Filter



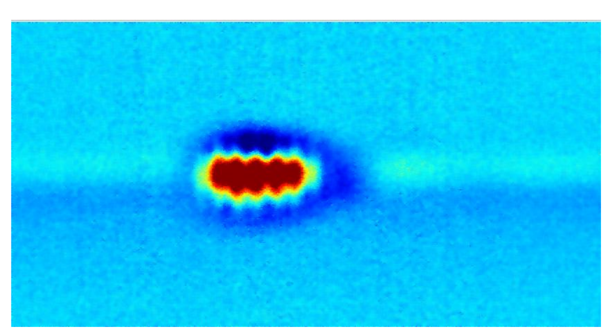
Order-Statistics Maximum Filter



Order-Statistics Median Filter



Order-Statistics Midpoint Filter



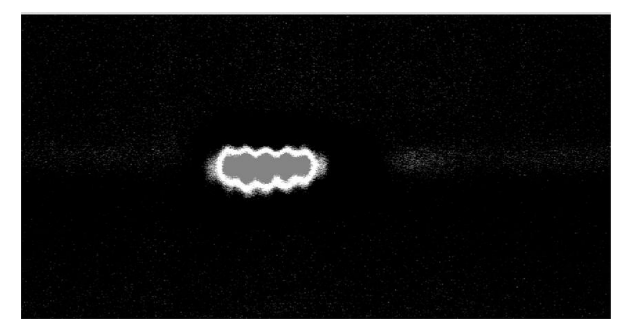
Wiener Filter

f(x-1,y-1)	f(x-1,y)	f(x-1,y+1)
f(x,y-1)	f(x,y)	f(x,y+1)
f(x+1,y-1)	f(x+1,y)	f(x+1,y+1)

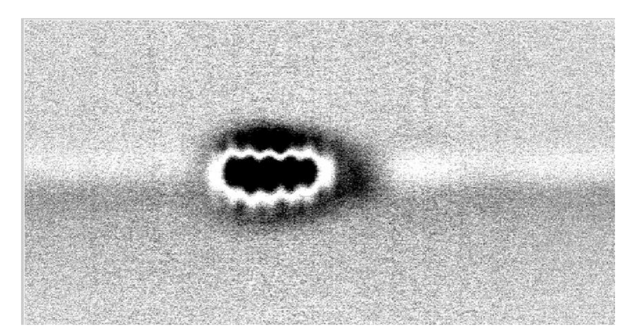
Example of pixel neighborhood surrounding center pixel at point (x,y). Spatial filters take the information in the neighborhood pixels and apply them to an algorithm for the output pixel.

- **Order Statistics Filters**
  - The results of the **median filter** come from taking the median of the neighborhood of pixel being filtered.
  - The **minimum** and **maximum** filters take the minimum and maximum of the neighborhood pixels.
  - The **midpoint filter** averages the minimum and maximum filter.
- **Average Filters** take the average or mean of the neighborhood pixels

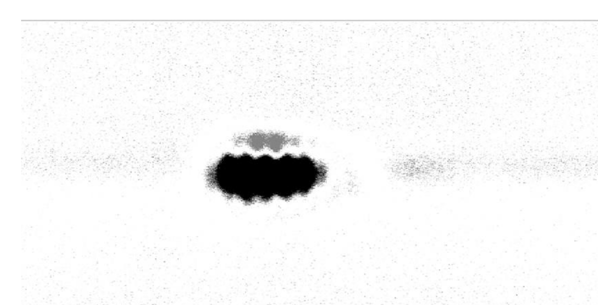
It became easier to apply filters to each of the separate leayers of the RGB image because most filters work well with two dimensional matrices.



The red layer matrix of the original noise image.

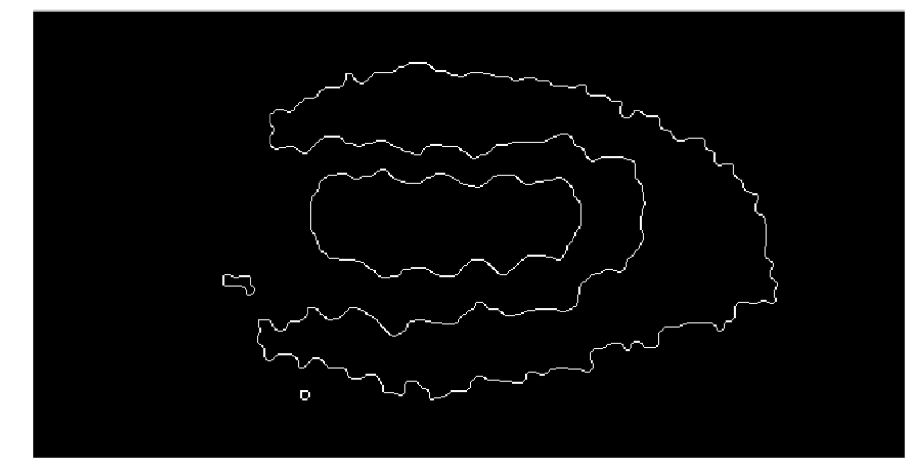


The green layer matrix of the original noise image.



The blue layer matrix of the original noise image.

Image Segmentation and Edge Detection



Define the edge of the cell using an edge detection process.

Sobel masks

$$\begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix} \quad \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

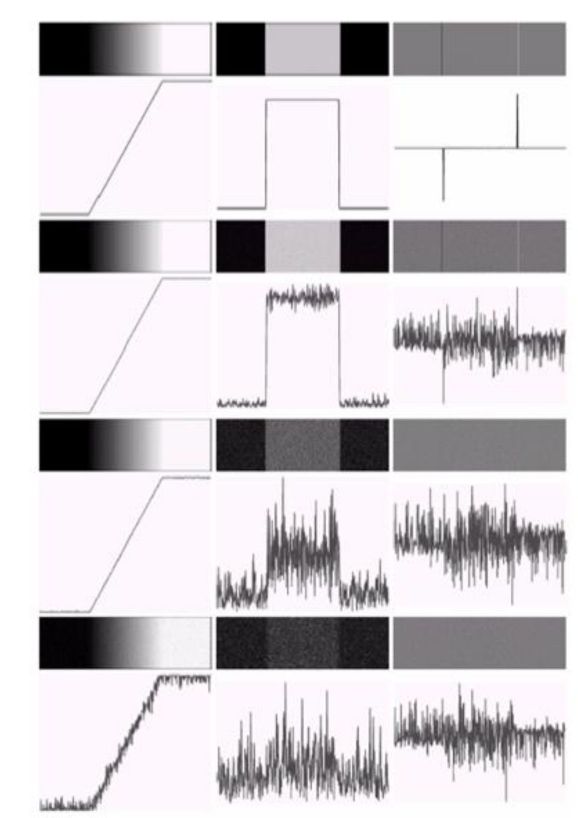
Prewitt masks

$$\begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix} \quad \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$$

Kirsh masks

$$\begin{bmatrix} 5 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & -3 & -3 \end{bmatrix} \quad \begin{bmatrix} 5 & 5 & 5 \\ -3 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix}$$

Different edge detection masks.



Gonzalez and Woods, Figure 10.7 Showing the effects of noise of a ramp edge (an edge that is blurred or an imperfect edge).

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