A3Q4

By: Ablokit Joshi
200030

Being from the branch Materials Science and Engineering, I will be talking about a software that is extensively used in this field to study and process microscopic images of various materials like alloys and polymers, **ImageJ** (Click here for its official webpage). It is also used in various other image processing requirements like smoothing, sharpening, edge detection, median filtering and thresholding on both 8-bit grayscale and RGB color images.

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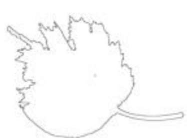
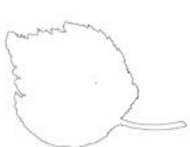
Some useful features

- Area Measurement for an arbitrary/complex figure (below examples gives the complete picture)

  The problem statement for below example is to find the fraction of leaf that is photosynthetic.

	◆ Convert scanned color image of leaf to grayscale: ***Image → Type → 8-bit*** ◆ Set measurement scale: Draw a line over a 50 mm section of the ruler then ***Analyze → Set Scale*** In *Set Scale* window enter 50 into the 'Known Distance' box and change the 'Unit of Measurement' box to mm , check 'Global' ◆ Draw a new line and confirm that the measurement scale is correct.
	◆ Threshold the leaf image using the automated routine: ***Process → Binary → Make Binary*** The automated threshold includes only the dark green areas.
	◆ Calculate area of green portion: Surround the leaf with the rectangular selection tool ***Analyze → Analyze Particles*** Enter 50 as the minimum particle size, toggle 'Show Outlines', check "Display Results' and click 'OK' Outline of analyzed area will be drawn. Data window gives an area of about 2000 mm^2 depending on the calibration setting.
(See bottom of page for an alternative method for measuring areas.)	
	◆ Threshold new image of leaf using manual settings: ***Image → Adjust →Threshold*** and play with sliders to include all of leaf in red and click 'Apply' The manual threshold setting includes all of the leaf area.
	◆ Calculate area of entire leaf: Enclose the leaf with the rectangular selection tool ***Analyze → Analyze Particles*** Use previous window settings and click 'OK' Outline of entire leaf is automatically drawn. Data window gives an area of about 2450 mm^2.

If we examine the results, the area having darker green color is 2000mm^2 and the complete are is 2450mm^2, hence the required fraction is $\frac{2000}{2450} \bullet 100 = 81.632653\% \approx 82\%$

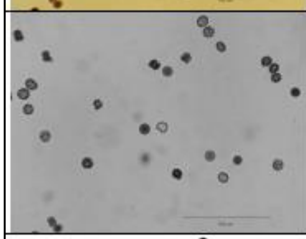
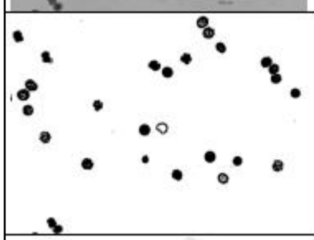
Another Method:

Analyze* → *Set Measurements, check 'Limit to Threshold'. After converting to a binary image, select ***Analyze* → *Measure***

This procedure is simpler but does not draw an outline of the measured area.

- Particle Counting and Analysis (extensively used in the Materials Science field)

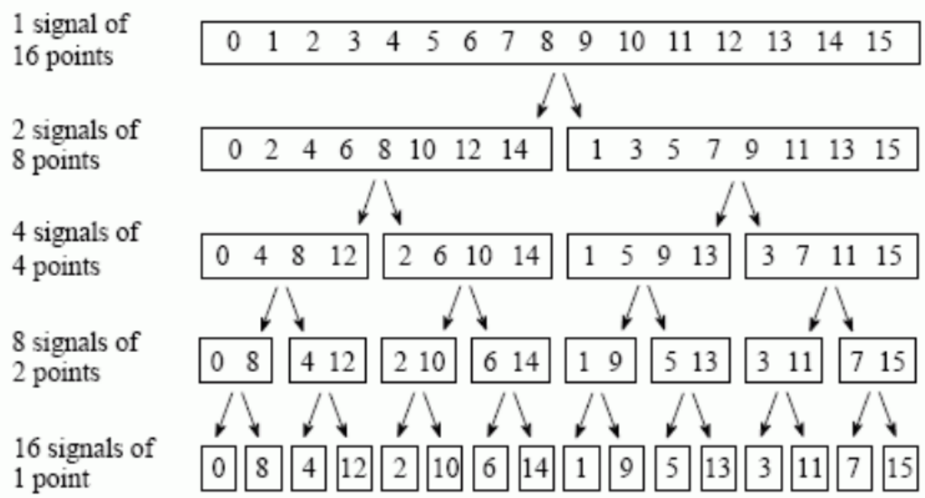
The Problem Statement for this is to find the number of particles, their size and fraction of area the particles hold.

	• Draw line over the scale bar and select ***Analyze* → *Set Scale*** In *Set Scale* window enter 100 into the 'Known Distance' box and Change the 'Unit of Measurement' box to um , check 'Global' • Confirm that the measurement scale is correct.
	• Convert the image to grayscale: ***Image* → *Type* → *8-bit***
	• Threshold the image using the automated routine: ***Process* → *Binary* → *Make Binary*** • Surround the scale bar with the rectangular selection tool and clear the contents (***Edit* → *Clear***)
	• Analyze Particles: ***Analyze* → *Analyze Particles*** Enter 20 as the minimum particle size, toggle 'Show Outlines', check 'Display Results', 'Summarize' and 'Record Stats' and click 'OK' Twenty five embryos are counted, numbered and outlined. The data window lists the area (in um^2) for each embryo. These data could be copied to a spreadsheet.
Threshold: 0-0 **Count: 25** **Total Area: 3177.6 µm^2** **Average Size: 127.1 µm^2** **Area Fraction: 3.72%**	A summary of the particle count is also shown in another data window.

- **The FFT Filtering (We'll be discussing its Image Processing function)**

FFT stands for Fast Fourier Transform and as the name suggested it uses the Fourier transform and inverse transform to filter an image/figure.

The FFT is a complicated operation and it uses the use of complex notations. The FFT works by breaking down a time domain signal with N points into N signals with N points each. The N frequency spectra that these N time domain signals relate to are calculated in the second step. The N spectra are then combined to create a single frequency spectrum.



The FFT decomposition. An N point signal is decomposed into N signals each containing a single point. Each stage uses an *interlace decomposition*, separating the even and odd numbered samples.

Figure shows an example of the time domain decomposition used in the FFT.
In this example, a 16 points signal is decomposed through four.

Let's see the how FFT works in ImageJ by taking an example shown below.

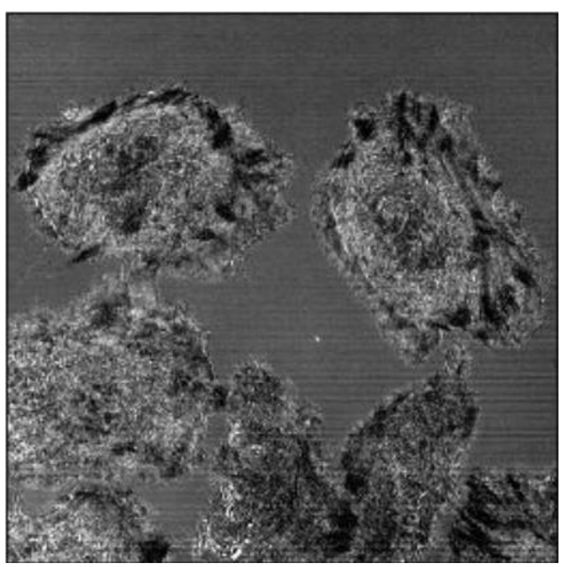
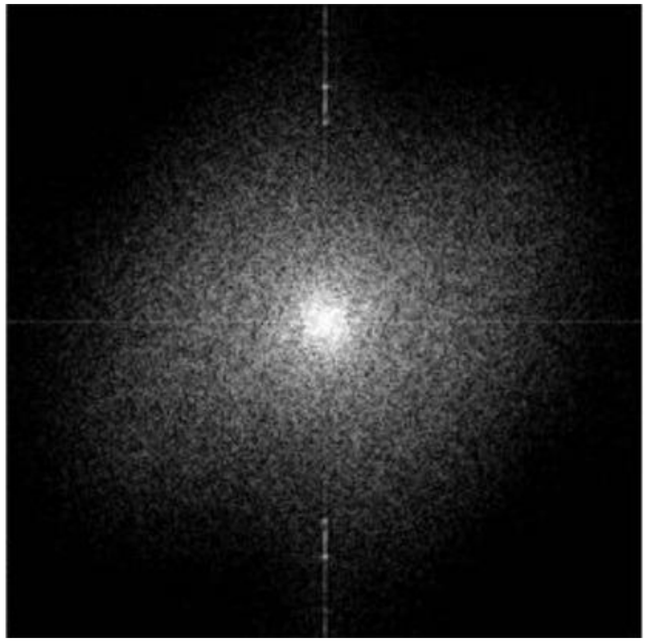
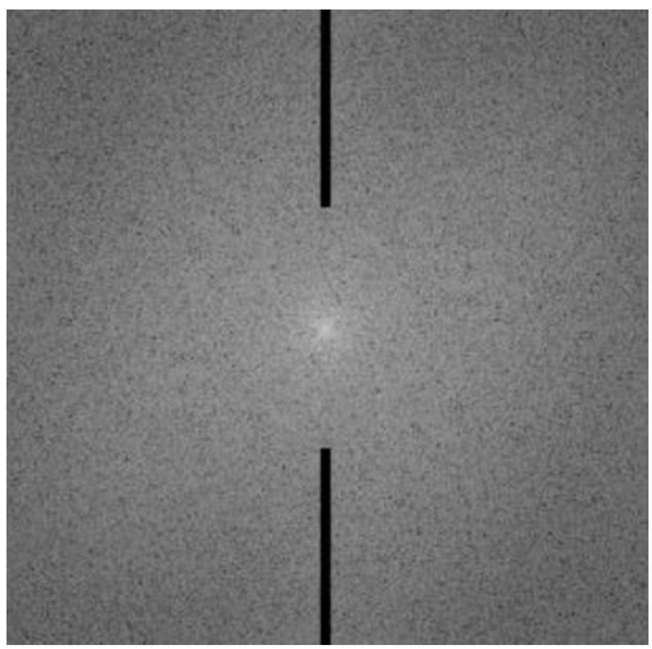


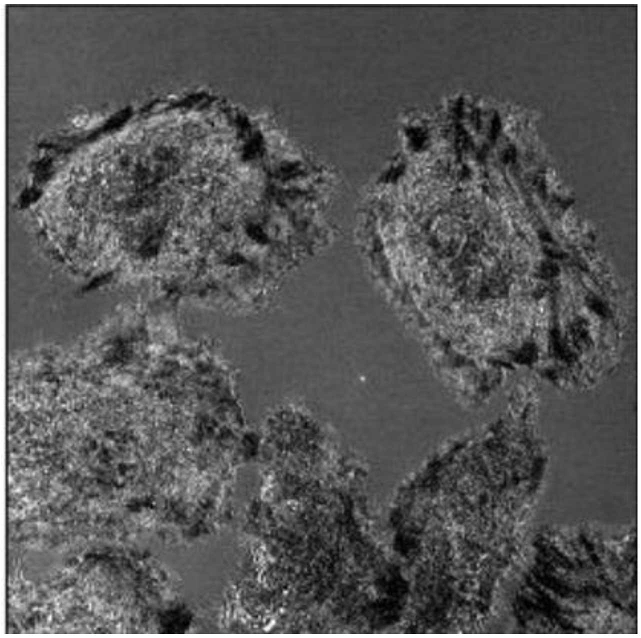
Fig: Given here a noisy image of a figure



The power spectrum calculated by ImageJ,
Contrast enhanced to show the bright spots
That represent the X axis fluctuation.

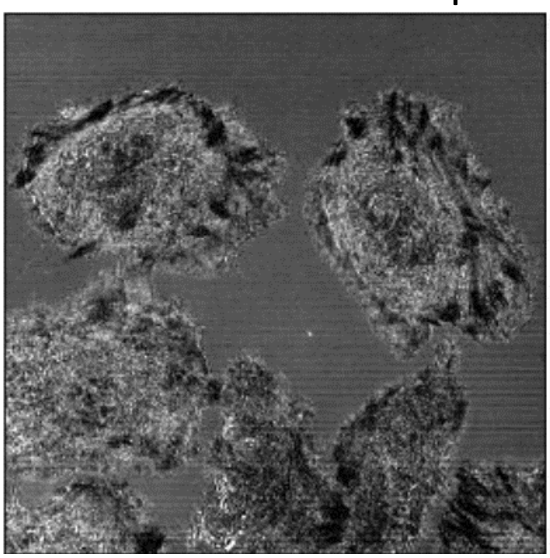


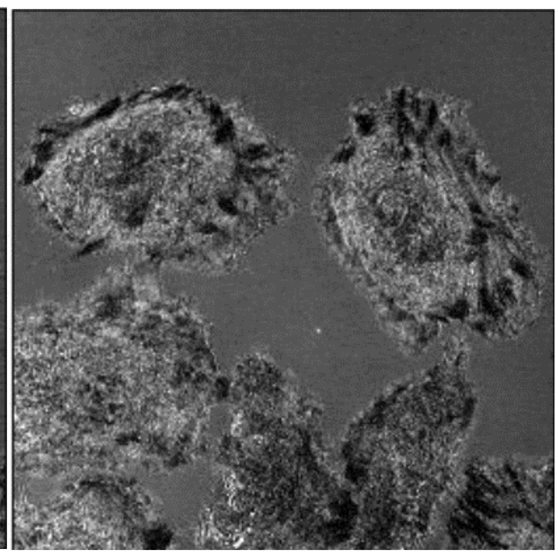
The Power spectrum with masks drawn on it



The inverse transform applying the masks

Comparison between both:





Original

After FFT Filtering

References

[1] Michael D Abramoff, Paulo J Magalhaes, and Sunanda J Ram. Image processing with imagej. *Biophotonics international*, 11(7):36–42, 2004.

[2] Michael Cammer. *FFT Filtering*.

[3] Sean M Hartig. Basic image analysis and manipulation in ImageJ. *Current protocols in molecular biology*, 102(1):14–15, 2013.

[4] Jose Marıa Mateos Perez and Javier Pascau. *Image processing with ImageJ*. Packt Publishing Ltd, 2013.

[5] Steven W Smith and Linearity. The scientist and engineer's guide to digital signal processing by steven w. smith, ph. d.

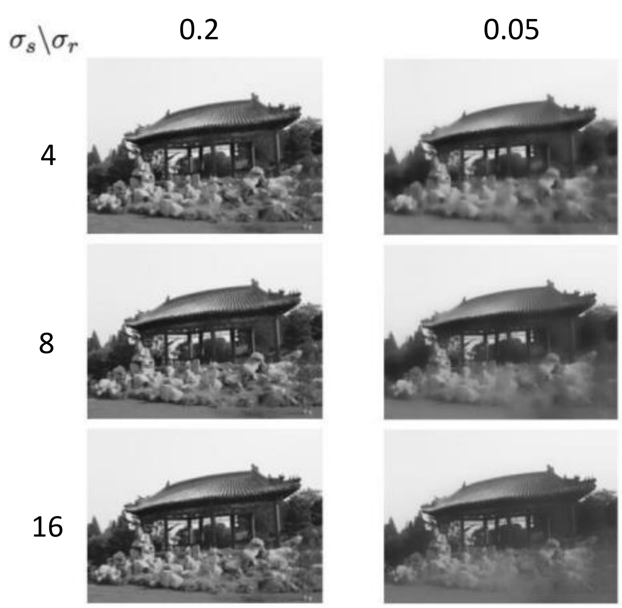
Q4Q- analytical:

While Ablokit was sleeping, Tushar tried to play a prank on him. He changed his mobile phone's PIN to a new 5-digit PIN, but being a responsible friend, he left him a clue. He left an image matrix (shown below) and said the password is the new value of pixel (2,2) if smoothening is done using a 3x3 neighborhood by Mean filter, Weighted Average filter, Median filter, Min filter and Max filter respectively. Tushar knew that Ablokit has skipped the class when this topic was taught and thus drafted such clue. Help Ablokit in finding the PIN to end his dilemma.

0	1	0	2	7
2	7	7	4	0
5	6	4	3	3
1	1	0	7	5
5	4	2	2	5

Q4Q-mcq- **One or more than one answers could be correct**

1. Which of the following is true about Bilateral filtering?
   A. kernel depends upon only spatial distance
   B. only pixels close in space as well as in range are the influencers
   C. can blur an image while respecting strong edges
   D. Is the following image true?



2. Which of the following is true about K-means clustering?
    A. unsupervised learning method: requires data and labels
    B. detects united patterns
    C. K is easily detected
    D. guaranteed to converge in a finite iteration
    E. convergence is given by: $\min_{z^{(1)},\ldots,z^{(k)}} \min_{C_1,\ldots,C_k} \sum_{j=1}^{k} \sum_{i \in C_j} \|x^{(i)} - z^{(j)}\|^2$

Answers:
45407
BC
ABDE