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Particle analysis
Image Segmentation
Binary Morphology
Particle Measurements

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Based on:

NI Vision Assistant Tutorial

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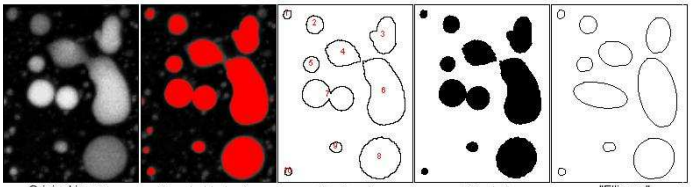
- You can use particle analysis to detect connected **regions or groupings of pixels** in an image and then **make selected measurements of those regions**.
- These regions are commonly referred to as **particles**.
- A **particle** is a **contiguous region of nonzero pixels**.
- **Zero valued pixels are in the background state**, and all nonzero valued pixels are in the foreground.
- **You can use particle analysis to find statistical information—such as the presence of particles, their number and size, and location.**



https://imagej.nih.gov/ij/docs/menus/analyze.html

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Image Segmentation

Thresholding segments an image into a particle region—which contains the objects under inspection—and a background region based on the pixel intensities within the image. The resulting image is a binary image.

Use ***thresholding*** to extract areas that correspond to significant structures in an image and to focus analysis on these areas.

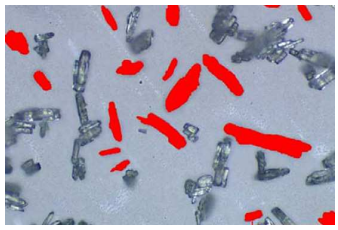

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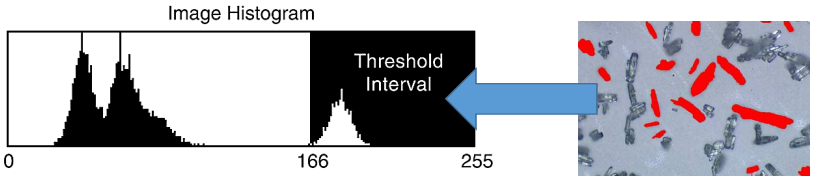
Image Segmentation

- ***Global Grayscale Thresholding*** includes manual thresholding and automatic techniques.
- Particles are characterized by an intensity range. They are composed of pixels with gray-level values belonging to a given ***threshold interval.*** All other pixels are considered to be part of the background.
- Thresholding sets all pixels that belong to a range of pixel values, called the ***threshold interval***, to 1 or a user-defined value, and it sets all other pixels in the image to 0.
- Pixels inside the threshold interval are considered part of a particle. Pixels outside the threshold interval are considered part of the background.



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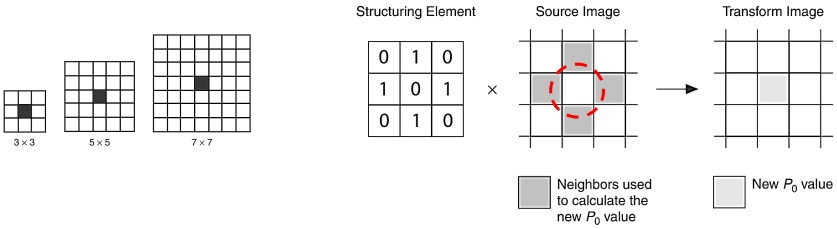
Binary Morphology

- *Because thresholding →* *noise particles,*
  particles touching the border of images,
  particles touching each other,
  particles with uneven borders.
- *Morphological functions can remove this unwanted information, thus improving the information in the binary image.*
- Morphological transformations use a 2D binary mask called a structuring element to define the size and effect **of the neighborhood on each pixel**.



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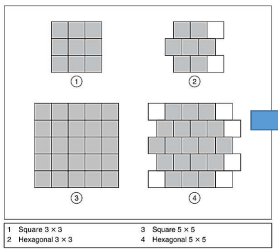
Binary Morphology

- *Picture frame - A digital image is a 2D array of pixels arranged in a rectangular grid.*
- *These pixel configurations introduce the concept of a pixel frame.*
- *Pixel frames can either be aligned (square) or shifted (hexagonal).*



Structuring Element Size	Square Pixel Frame	Hexagonal Pixel Frame
3 × 3		
5 × 5		
7 × 7		

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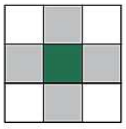
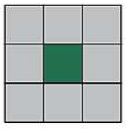
Binary Morphology

- *Connetivity - grouping proces.*
- connectivity-4, two pixels are considered part of the same particle if they are horizontally or vertically adjacent
- connectivity-8, two pixels are considered part of the same particle if they are horizontally, vertically, or diagonally adjacent.



Connectivity-4



Connectivity-8

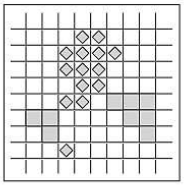


Figure 9-10. Connectivity-4

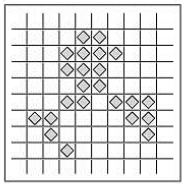


Figure 9-11. Connectivity-8

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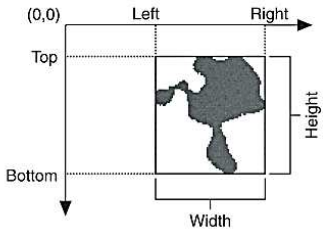
Paricle Measurement

- *Use particle measurements when you want to make shape measurements on particles in a binary image.*

Bounding Rect	Smallest rectangle with sides parallel to the x-axis and y-axis that completely encloses the particle.



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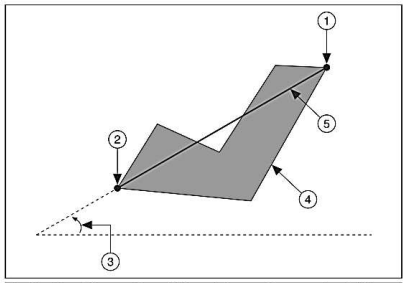
Paricle Measurement

- *Use particle measurements when you want to make shape measurements on particles in a binary image.*

Max Feret Diameter	Line segment connecting the two perimeter points that are the furthest apart.



1 Max Feret Diameter Start—Highest, leftmost of the two points defining the Max Feret Diameter
2 Max Feret Diameter End—Lowest, rightmost of the two points defining the Max Feret Diameter
3 Max Feret Diameter Orientation
4 Particle Perimeter
5 Max Feret Diameter

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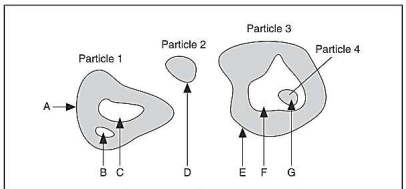
Paricle Measurement

➢ *Particle and holes*



Particle #	Area	Holes' Area	Particle & Holes' Area
Particle 1	A	B + C	A + B + C
Particle 2	D	0	D
Particle 3	E	F + G	E + F + G
Particle 4	G	0	G

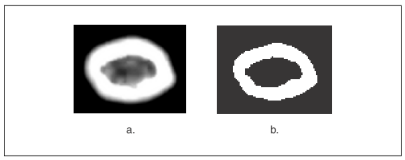


Figure 10-2. Holes' Measurements

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Paricle Measurement

➢ *Areas, Ratios:*

Table 10-4. Areas

Measurement	Definition	Symbol	Equation
Area	Area of the particle.	A	—
Holes' Area	Sum of the areas of each hole in the particle.	A_H	—
Particle & Holes' Area	Area of a particle that completely covers the image.	A_T	$A + A_H$
Convex Hull Area	Area of the particle Convex Hull.	A_{CH}	—
Image Area	Area of the image.	A_I	—

Table 10-7. Ratios

Measurement	Definition	Equation
% Area/Image Area	Percentage of the particle Area covering the Image Area.	$\frac{A}{A_I} \cdot 100\%$
% Area/(Particle & Holes' Area)	Percentage of the particle Area in relation to its Particle & Holes' Area.	$\frac{A}{A_T} \cdot 100\%$
Ratio of Equivalent Ellipse Axes	Equivalent Ellipse Major Axis divided by Equivalent Ellipse Minor Axis.	$\frac{E_{2a}}{E_{2b}}$
Ratio of Equivalent Rect Sides	Equivalent Rect Long Side divided by Equivalent Rect Short Side.	$\frac{R_a}{R_b}$

… and many others…