

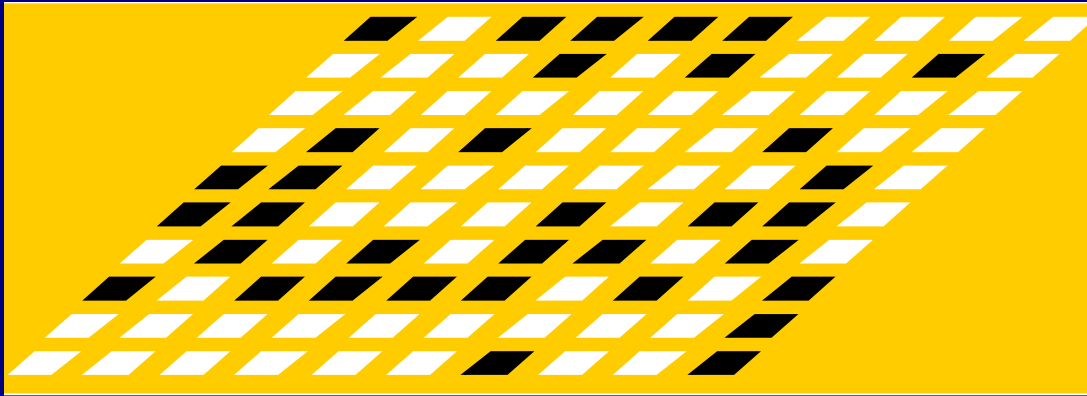
Image Processing and Visual Communications

Binary Image Processing

Zhou Wang

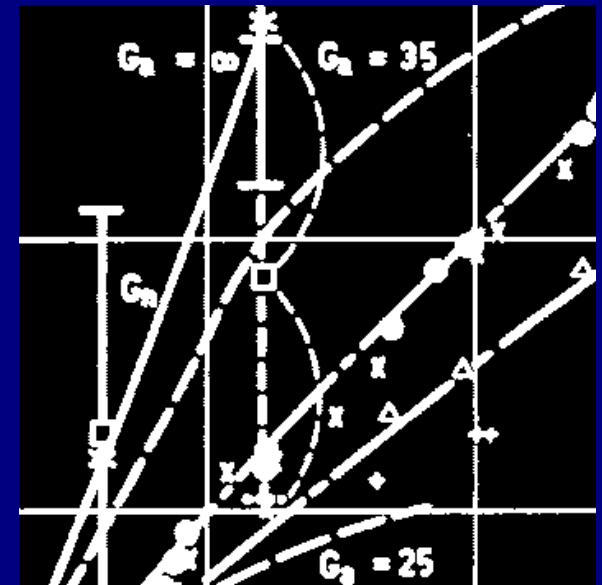
Dept. of Electrical and Computer Engineering
University of Waterloo

Binary Images



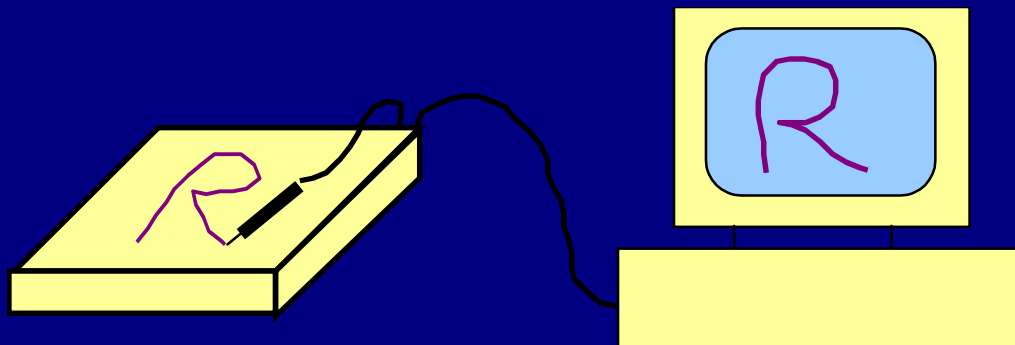
1 bit/pixel, "0" or "1"

在でも、その影響を受け、
起する問題の研究が多い。
配慮する距離は約2、50
である。
しかしながら、1956
電話通信の自動化および



Generating Binary Images

- Sensors with Binary Output



- Thresholding Gray-scale Images



gray-scale image
range: [0, 255]



Th = 60



Th = 80



Th = 100



Th = 120

Logical Operations

- Basic logical operators

$\text{NOT}(X)$ = **complement** of X

$\text{AND}(X, Y)$ = “1” if both X and Y are “1”;
= “0” otherwise

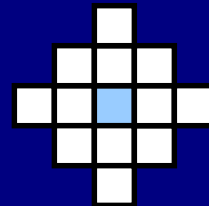
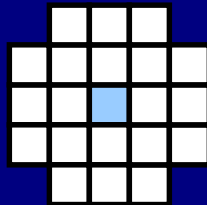
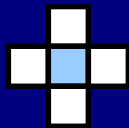
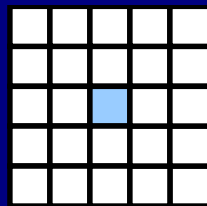
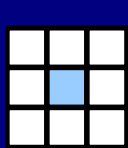
$\text{OR}(X, Y)$ = “1” if either X or Y is “1”;
= “0” otherwise

$\text{XOR}(X, Y)$ = “1” if X and Y are different;
= “0” otherwise

$\text{MAJ}(X_1, \dots, X_n)$ = “1” if most of X_1, \dots, X_n are “1”;
= “0” otherwise

Morphological Operations

- Morphological operators
 - Expand (dilate) objects
 - Shrink (erode) objects
 - Smooth object boundaries/eliminate small holes
 - Fill gaps and eliminate 'peninsulas'
- Implemented using *local logical operators* with *structural elements (windows)*



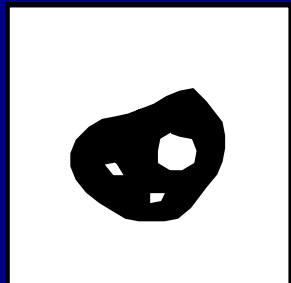
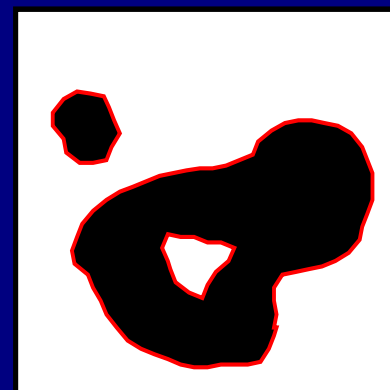
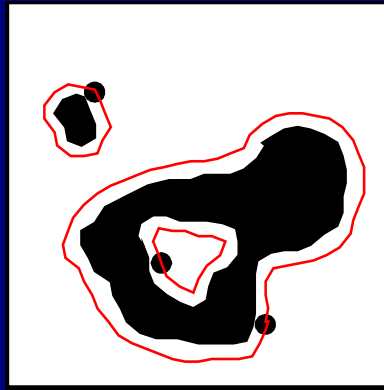
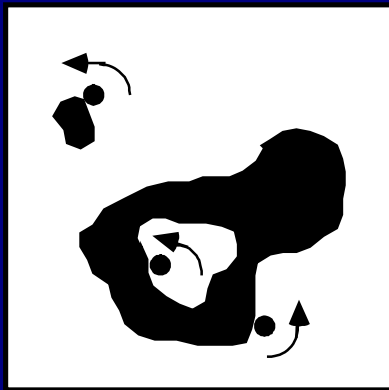
Used as sliding windows across the image space

Morphological Operators: Dilation Filter

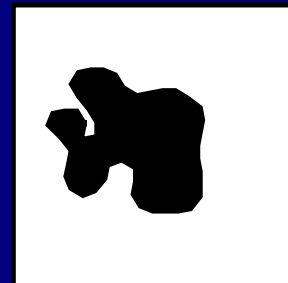
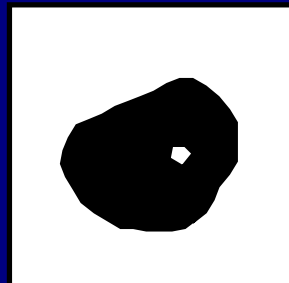
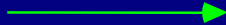
- Given Image I and Window B :

$$J = \text{DILATE}(I, B)$$

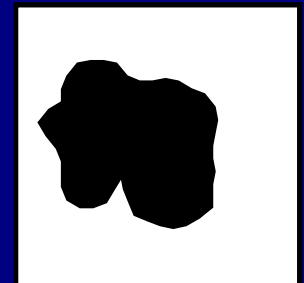
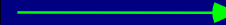
$$J(i, j) = \text{OR}\{I(i-m, j-n); (m, n) \in B\}$$



DILATE



DILATE

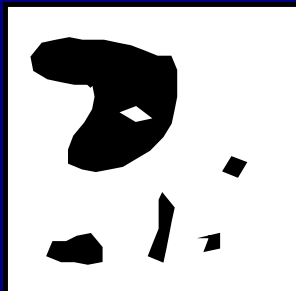
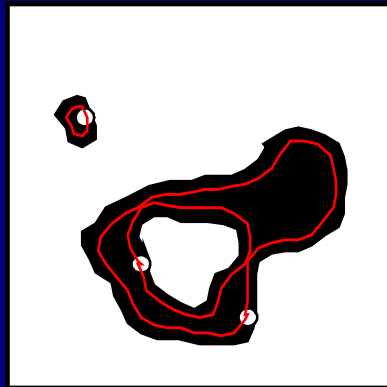
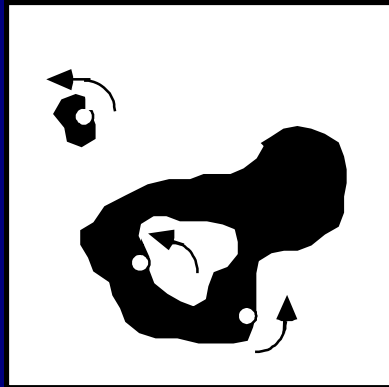


Morphological Operators: Erosion Filter

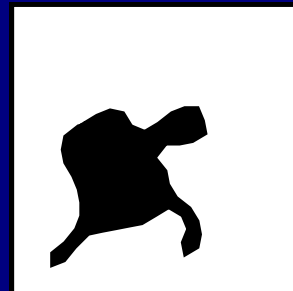
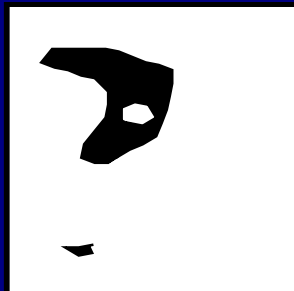
- Given Image I and Window B :

$$J = \text{ERODE}(I, B)$$

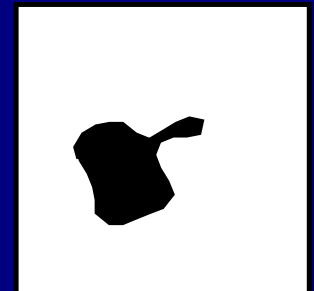
$$J(i, j) = \text{AND}\{I(i-m, j-n); (m, n) \in B\}$$



ERODE



ERODE



Morphological Operators: Median Filter

- Given Image I and Window B:

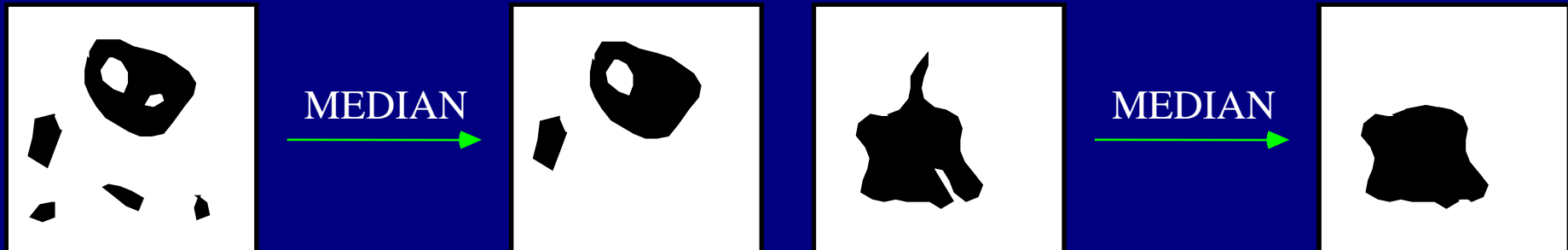
$$J = \text{MEDIAN}(I, B)$$

Or

$$J = \text{MAJORITY}(I, B)$$

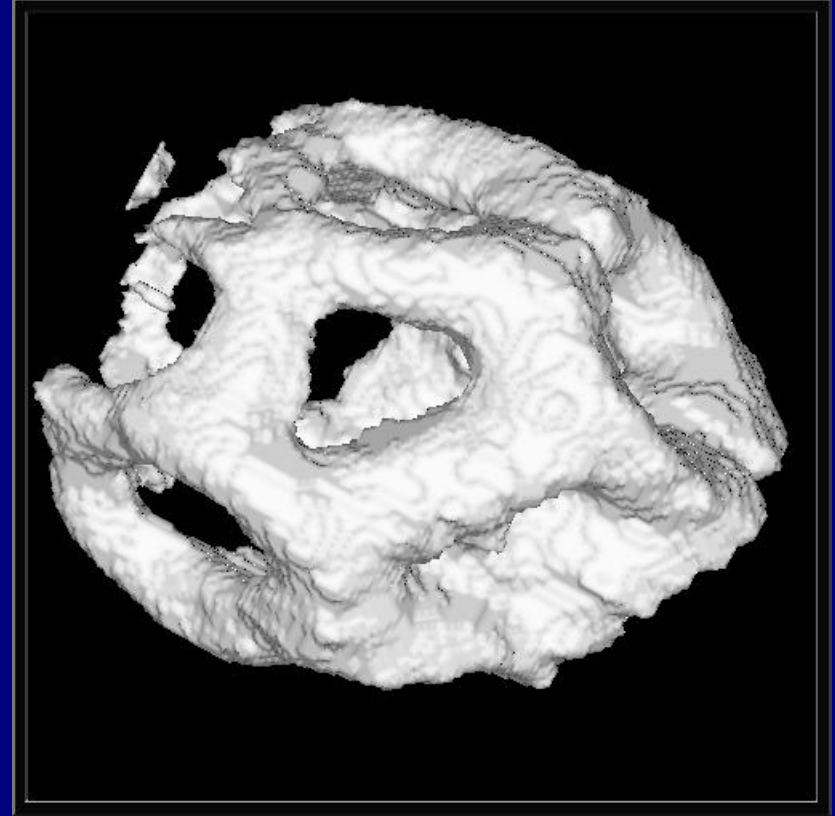
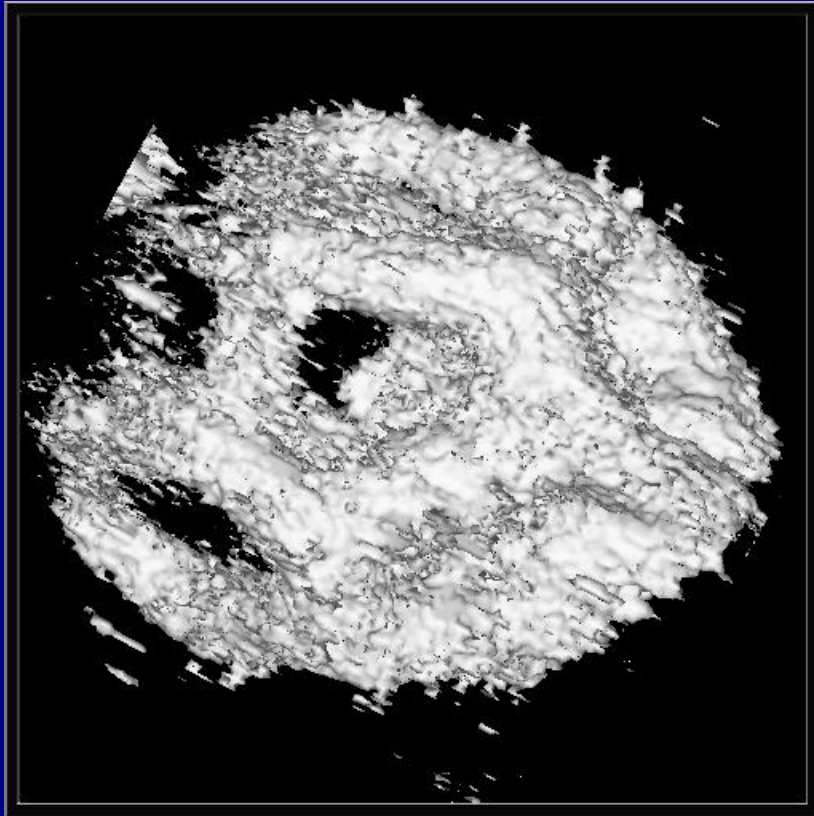
$$J(i, j) = \text{MAJ}\{I(i-m, j-n); (m, n) \in B\}$$

– Also called Majority filter



Morphological Operators: Median Filter

- An Example of 3-D Median Filter



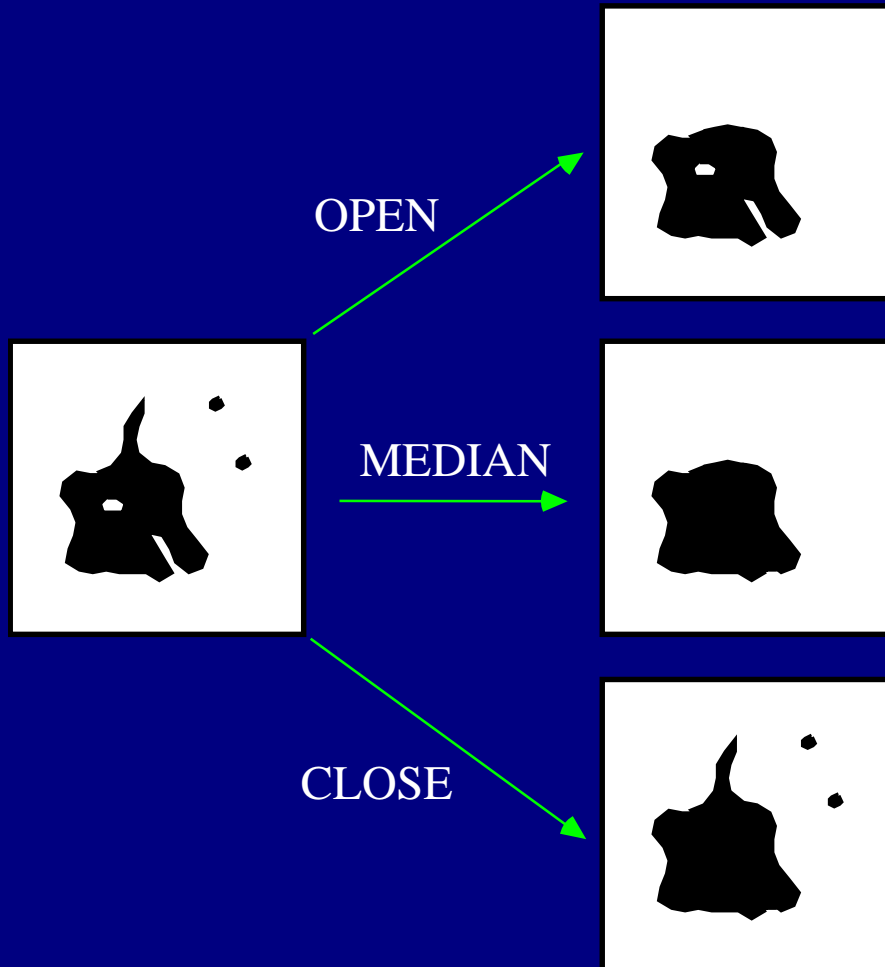
laser scanning confocal microscope
image of pollen grain

after binary median filtering

Morphological Operators: Open and Close Filters

$$J = \text{OPEN}(I, B) = \text{DILATE}(\text{ERODE}(I, B), B)$$

$$J = \text{CLOSE}(I, B) = \text{ERODE}(\text{DILATE}(I, B), B)$$



Further extensions:

$$J = \text{OPEN-CLOSE}(I, B) \\ = \text{OPEN}(\text{CLOSE}(I, B), B)$$

$$J = \text{CLOSE-OPEN}(I, B) \\ = \text{CLOSE}(\text{OPEN}(I, B), B)$$